



Techno-Economic Feasibility Report of Cable Car as Public Transport for Gangtok

Final Report

November 2019

Urban Development &
Housing Department

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Executive Summary:

Study Background:

Gangtok is the capital city and the largest town in the state of Sikkim. Gangtok is located in the eastern Himalayan range at an elevation of 1,650 m. The Gangtok Municipal Corporation has population of 100,286 of which 52,459 are males while 47,827 are females. The population of Gangtok has grown four folds between 1991 and 2011. The city is administered by Gangtok Municipal Corporation (GMC) and Urban Development & Housing Department (UDHD), Government of Sikkim. Gangtok has several tourist destinations and enjoys tourist influx round the year. Nested in the Himalayas, Gangtok offers breathtaking scenic beauty.

The total area of Gangtok City is approximately 19.28 sq. Km. but as per the City Development Plan (Draft CDP, 2015) area of Greater Gangtok is 76.95 Sq. Km. which includes urban and rural fringe around Gangtok. The total area comprises the surrounding satellite towns namely Bhusuk, Ranka & Luing, Penlong & Pangthang, Rumtek, Assam Lingzey and Pakyong. Most of the roads are steep, with buildings built on compacted ground alongside the roads.

Tourism is the major economic activity in Gangtok and the city is the main base for Sikkim tourism Industry. Many of Gangtok's residents are employed directly and indirectly in the tourism industry, with many residents owning and working in hotels and restaurants. Agriculture is the largest employer in Gangtok.

The Rapid urbanization characterized by the growth of personalized vehicles and migration has become a common phenomenon across all cities in India. As a result of this, cities are experiencing traffic congestion due to many factors, increase in number of private vehicles, reduced road space and longer trip lengths.

Hill cities too are facing similar challenges and Gangtok is one of them. Natural features especially topography and terrain in hill cities are limiting the expansion of infrastructure development like bridges and roads, not only due to high costs but also due to limited space. This is affecting the balanced growth of the city and putting pressure on the exiting services and infrastructure. In the absence of organized, safe and reliable public transport systems, the use of personalized vehicles increases leading to congestion and economic and environmental degradation.

The Urban Development & Housing Department, Government of Sikkim - the Nodal Department of the State to deal with issues relating to urban transport under the Ministry of Urban Development, Government of India has decided to undertake **"Techno-Economic Feasibility Study for Cable Car Technology for City of Gangtok".** Accordingly, Urban Mass Transit Company Ltd has been entrusted with the study.

The major tasks involved in the feasibility study are Data collection and interpretation, Demand assessment, Alignment options and network planning, basic environment and social impact assessment, economic and financial analysis, Institutional setup for operations and maintenance.

Data Collection and Analysis:

The primary and secondary data collection are done for the study. The earlier studies including City Development Plan (2006), Transport Study by Center for Indian Road Transport (2005), Performance improvement Measures for Sikkim Nationalized Transport (SNT) by CIRT, Pune (2008), Gangtok Structure Plan: Surbana (2009), Gangtok Master Plan 1997, NEURDP Study, Gangtok Integrated Development Plan 2000 Study and Comprehensive Mobility Plan, 2010 were reviewed.

Study Area Planning and Delineation:

The study area comprises Gangtok Municipal Corporation Area (GMC) having an area of 19.28 sq.km. It has been subdivided into smaller physical units, termed as Traffic Analysis Zones (TAZs) to facilitate understanding of travel pattern within the study area. The Gangtok Municipal Corporation (GMC) area is divided into 17 TAZs (17 Wards) as per prevailing demarcation of municipal wards. These wards are taken as internal zones. Regions beyond the GMC area have been delineated into external zones based on the catchment of the existing transport links feeding into the study area. Traffic coming from these areas are entering the study area from 3 points i.e. Ranipool, Burtuk and Chandmari. Year 2016 is considered as Base Year. The demand forecasts for the horizon years have been considered for 2051. Therefore, for the purpose of sequential planning and design of the systems, the travel demand forecasts have been presented for the years 2021, 2031, 2041 and 2051.

A set of primary traffic and other surveys such as House Hold Interview Survey, Origin – Destination surveys, Traffic Volume Counts, Speed and Delay Surveys, Vehicle Occupancy Survey, Tourist survey etc. were conducted in the study area (GMC boundary) during September -October 2016 to assess the demographics, employment, traffic and transport scenario in delineated study area. Table 4.1 provides details of the primary surveys such as type of primary surveys conducted and their purpose, no. of locations at which each type of survey was conducted, dates on which these surveys were conducted etc.

The inferences from the data analysis with regard to this study are listed as under;

- High share of shared taxis confirms the existence of substantial public transit demand and implies the need for an organized public transport system;
- Majority of the trips are daily work trips half of which are currently performed by share taxis, implying consistent public transit demands;
- Average trip cost of taxi users is Rs.22.5 for an average trip length of 2.9 km which is substantially high, which implies that the residents of Gangtok can afford and would comfortably pay for an organized and reliable public transit system;

- Uniform employment growth across all wards in Gantok implies uniformly distributed public transit demand along the entire high demand transit corridor
- Willingness to pay and shift in favor of Cable Car system is high even at same or slightly higher trip cost, inferring high acceptability of Cable Car system providing reliable, comfortable and fast services.

Travel Demand Modelling:

Travel Demand model is developed based on a conventional 4-stage transport modelling approach which includes; **Trip Generation -** calculation of the number of origins and destinations for each zone; **Trip Distribution -** attaching the origins and destinations for complete trips; **Mode Choice -** determination of the mode for each trip (TW, car, Intermediate Public Transport (IPT), Public transport); **Assignment -** assigning passengers to their respective highway and transit networks.

Three scenarios were prepared to evaluate the network. Base year Scenario describes the base year traffic characteristics and transit demand; Do nothing scenario describes the future year traffic characteristics and transit demand considering no major investment in transport infrastructure and Project Scenario describes the future year traffic characteristics with interventions such as introduction of Cable Car system as public transport mode in the city. This scenario is developed to understand how some interventions can impact the travel behaviour thus bringing much relief to the people in comparison to "Do Nothing Scenario", the possible solution thus considered must be focused on relieving congestion and transit demand management.

The projected population for future years 2021, 2031, 2041 and 2051 are presented in Table 1;

Table 1: Projected Population for 2021, 2031, 2041& 2051

SN	Year	Population
1	2021	2,00,805
2	2031	3,59,610
3	2041	6,44,007
4	2051	11,53,318

Proposed Cable Car Network:

Proposed Network:

Based on the primary data analysis done for demand feasibility, the conceptual alignment of Cable Car System along trunk network is identified. NH-10 is identified as the truck line and the proposed cable car system network is envisaged primary along it.

The total network length is 13 km (Approx.), with North-South Line from Ranipool Taxi Stand to Burtuk Ward. The west alignment connects Taxi stand north district to District administrative centre and Hospital at Sichey. The east alignment connects the 2nd Mile HFC Church to the Old STNM Hospital station. The stations are placed within dense built-up areas thus ensuring that maximum potential users lie within walkable distance. Locations of the stations are shown in Table 2.

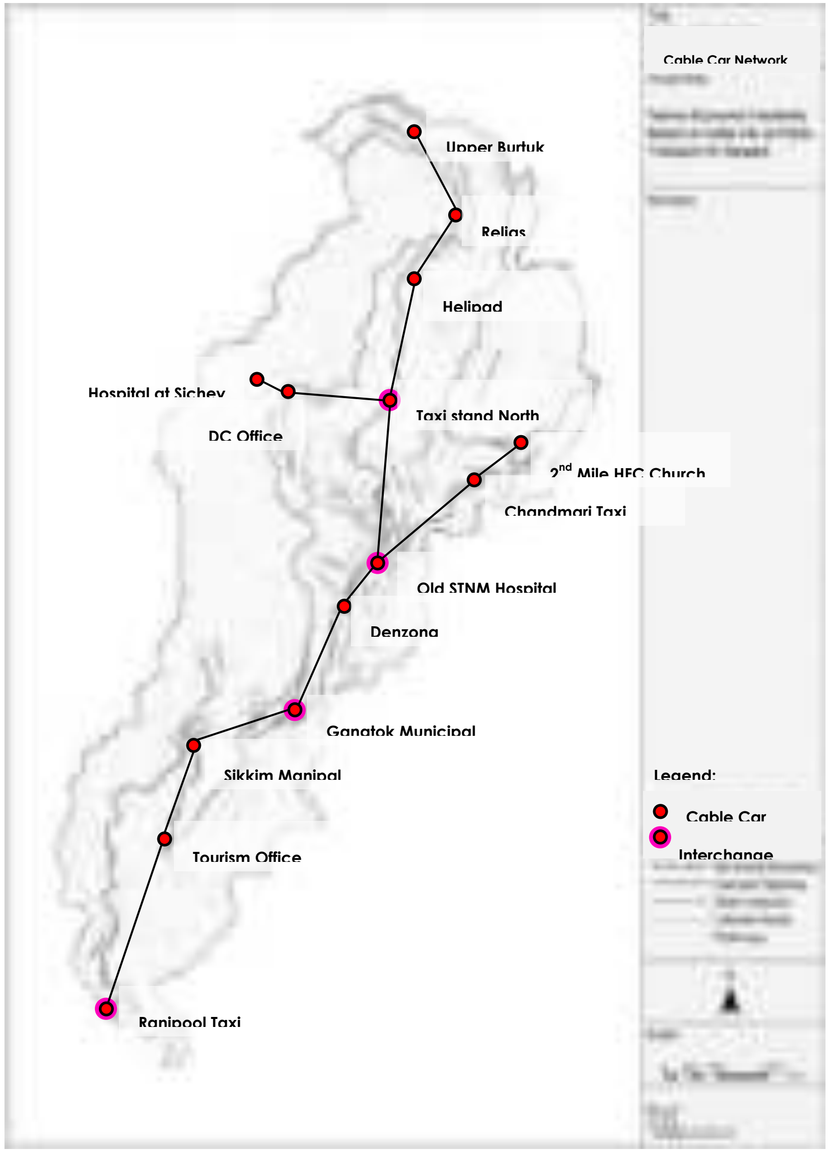


Figure 1 Conceptual Cable Car Alignment

Table 2: Cable Car Stations Proposed

SN	Station Location
North South alignment	
1	Ranipool Taxi Stand
2	Tourism Office Complex
3	Sikkim Manipal Hospital
4	Gangtok Municipal Corporation
5	Denzong Cinema/Supermarket
6	Old STNM Hospital
7	Taxi Stand North District
8	Station near Helipad
9	Station in Upper Burtuk
West alignment	
10	District Administrative center
11	Hospital at Sichey
East alignment	
12	Chandmari Taxi stand
13	2nd Mile HFC Church

Station at Taxi Stand North District, Sikkim National Transport, Gangtok Municipal Corporation and Ranipool Taxi stand can be developed as multimodal interchange hub (cable car to taxi/bus).

The "Project Scenario" represents the existing road network, proposed cable car network and travel demand of the city for future year (i.e. 2021, 2031, 2041 and 2051). The Project

Scenario can be compared with Do Nothing Scenario to ascertain benefits of cable car as main public transport in Gangtok. The road network length is 88 km and two lines of cable car have been considered. This scenario represents impact on city's transportation system in 2021 post implementation of Cable Car system.

All the three scenarios are compared with the volume by capacity ratios, average travel time and vehicle kilometres travelled by purpose (See Table 3)..

Table 3: Comparison of V/C ratios for three scenarios

V/C Ratio	% Network Length			
	Base Year	Do Nothing		Project Scenario
	2016	2021	2051	2051
0.00 – 0.25	21%	21%	13%	23%
0.25 - 0.50	42%	22 %	08%	3%
0.51 - 0.85	19%	26%	7%	0%
More than 0.85	18%	31%	72%	74%

Table 4: Comparison of Average Travel time during Peak Hours in Base, Do Nothing and Project Scenario

Average travel time - (Peak Hour) – in minutes	Base Year -2016		Do Nothing				Project Scenario	
			2021		2051		2051	
	Including outers zones	Excluding outer zones	Including outers zones	Excluding outer zones	Including outers zones	Excluding outer zones	Including outers zones	Excluding outer zones
Home based work trips								
Private Car	20	19.5	32	24	394	305	236	183
Taxi	20	19.7	36	25	402	276	241	166
Two Wheeler	18.5	18.3	33	23	414	314	248	188
Home based education trips								
Private Car	21.6	21.5	27	22.6	332	287	199	172
Taxi	22.6	22.4	28	22	313	243	188	146
Two Wheeler	19.9	18.3	27	21	339	287	203	172
Home based other trips								
Private Car	19.6	19.5	23	22	183	181	110	108
Taxi	20.6	20	24.4	24	190	187	114	112
Two Wheeler	18.38	18.25	23	23	210	209	126	126

Table 4 shows the average travel time for each type of mode with respect to the trip purpose and its comparison with the do nothing scenario.

Transit Technology:

Table 5 represents comparison of critical parameters of various top supported cable car transit technology options essential for selection of suitable technology w.r.t city's climate, topography, built-up and demography and estimated future transit demands. These parameters include tower spacing requirements, maximum wind speed tolerance, maximum system capacity, maximum operating speed etc. Based on the City context and the below parameter, the MDG system is considered for Aerial Ropeway system for Gangtok.

Table 5: Comparison of Critical Parameters of Various Top Supported Cable Car Transit Technologies

Parameters	MDG	BDG	TDG/3S	Funitel	Aerial Tram	Pulsed Gondola
No. of Cables	1	2	3	1 (Dual Loop)	3	1
Maximum Speed (Kmph)	22	25	27+	27	45	22
Maximum Capacity PHPDT	Up to 4000	Up to 4000	Above 6000	4000-5000	Up to 2000	Up to 2000
Maximum Wind Speed Tolerance (Kmph)	Up to 70	Up to 70	100+	100+	80+	Up to 70
Grip	Detachable	Detachable	Detachable	Detachable	Fixed	Fixed
Cabin capacity	Up to 15	Up to 17	Up to 38	Up to 24	Up to 200	Up to 10
Tower Spacing (m)	100-300	Upto 1500	Upto 3000	500-1000	NA	NA
Relative Capital Cost	Low	Low-Medium	High	Medium-High	Medium-High	Low

Case Studies:

Aerial Ropeways operating globally are studied to understand the Ropeway systems characteristics and their application. San Agustin Metro cable, Caracas-Venezuela, Metro cable-Medellin-Colombia, Teleferico's do Alemao-Brazil, Constantine Telecabine-Algeria are studied in detail. The important inferences are as under:

- Design Concept: As illustrated in San Augustine, the cable car was proposed along the congested areas to provide access to public transport; similarly, if the cable car system is provided as a formal mode of public transport along the congested central spine i.e. National Highway; the cable car system would be successful. Also this alignment will provide alternate mode to reach the employment establishments.
- General System Features and Capacity: as observed in case studies, the detachable grip technology (MDG/BDG/TDG) can be provided for high passenger comfort, safe loading and unloading at creep speed in the stations. Speeds of up to 8.5 m/s on the line enable transport capacities of up to 6000 PPHPD, depending on the cabin size. Since the peak demand in horizon year is 4000 PHPDT, the MDG system can be designed.
- Multi Modal Integration: as seen in Teleferico do Alemao, Brazil, Metrocable Line J, Medellin and San Agustin Metro Cable, Caracas; Cable Car can be integrated with existing public transport modes i.e. mass transit system or Bus (Local / Regional) as well as Intermediate para transit i.e. local and regional taxis. In Gangtok, it is proposed that the cable car is integrated with bus system and Taxis
- Transit oriented development/ Property development at Stations: As observed in San Agustin Metro Cable, Caracas; the cable car stations can be provided with additional activities: recreational/ social. Since the topography in Gangtok demands high rise construction. Similar activities can be provided in stations. This will lead to increase in revenue (Non fare box).

Cable Car Transit System Design:

Figure 2: Proposed Transit Locations

Based on the selected transit technology, the preliminary designs of the CCT systemare worked out based on the site visit and analysis. The land pockets/buildings were identified for CCT stations The proposed CCT system consist of total 14 stations with 10 stations in North South line, 2 stations in East line and 2 stations in West line. The proposed alignment follows the natural structure of the valley and Gangtok's residential topography. It also provides an incentive to extend settlements along its line, thus defining an axis for future urbanization.

Gangtok Cable Car Transit System Elements:

The proposed CCT system route connecting Gangtok from Ranipool Taxi Stand in the south to Upper Burtuk in the North and New Hospital at sichey in the West and Chandmari in the East, along a 13 km route with 13 sections and 14 stations, 13 of which are open for passenger service. The stations site proposal responds to the main landmarks and points of activity to connect within the city of Gangtok. Neuralgic points like Tourism Office Complex, Sikkim Manipal Hospital, New Hospital at Sichey and the Denzon Cinema/Supermarket Complex are considered as strategic because they are significant trip generators: Serving them has positive impact in the city mass transport system. The implementation of proposed cable car network shall be taken up in two construction phases:

Phase 1: Consists of the 6 lowermost sections, from Ranipool Taxi Stand to Old STNM Hospital in the North South Line.

Phase II: Consists of the following 3 sections;

1. North Link - 4 uppermost sections of Old STNM Hospital to Upper Burtuk and
2. East Link - 2 sections connecting STNM Hospital to Chandmari Area.
3. West Link – 2 Sections connecting Taxi Stand North District to Hospital at Sichey.

The detailed location and characteristics of the proposed 14 Stations are described in Heading 8.6.

All transport modes must function in a coordinated manner to provide seamless mobility to the people. Inter-modal integration is an essential component which is envisaged as part of Cable Car planning in Gangtok and will ensure efficient and effective coordination across various transport modes. Multi Modal Hubs are transit facilities provided at the interaction points of different modes to facilitate seamless transfer of commuters across different modes.

It is proposed to reorient the shared taxis in the city outside the cable car catchment area thus shall ply as feeder service to the proposed Cable Car lines. The shared taxis are proposed to be restricted on major arterial roads to avoid congestion and also to enhance the usage of cable car system. The reserved taxis shall be allowed to ply as usual as the fares for reserved taxis are already very high and shall only be chosen by the commuters only if unavoidable.

Table 6: Proposed Multi-Modal Interchanges

SN	Multi-Modal Cable Car Transit Stations	Local Shared Taxi	Regional Shared Taxi	Regional Buses
Phase-I				
1	Ranipool Taxi Stand	Yes	Yes	Yes
2	Gangtok Municipal Corporation	Yes	No	No
3	Old STNM Hospital	Yes	No	No
4	Taxi Stand North District	Yes	Yes	Yes
Phase - II				
5	DC Office	Yes	No	No
6	Burtuk	Yes	Yes	Yes
7	2nd Mile HFC Church	Yes	Yes	Yes

The regional shared taxis in Gangtok are widely used by tourist to access the nearby touristic locations and airport. It is proposed to develop a major multi-modal hub at the proposed Ranipool Taxi Stand station of Cable Car system which is the terminal station of the Cable Car system on the southern end of Gangtok. All shared regional services from the southern side shall terminate at this multi-modal hub and people shall take Cable Car Transit services for commuting to internal parts of the city.

On the Northern end of the city, proposed Taxi Stand North District station of Cable Car Transit System will be the first station, post phase–I implementation, while entering the city from northern side. This station already has a multi-level taxi stand and shall be further augmented as a multi-modal hub for terminating regional shared taxi and bus services from the north. This will again decongest central Gangtok due to restriction of regional shared services. Post phase-II implementation, Burtuk station of Cable Car Transit system shall be developed as a multi-modal transit hub

Cable Car Transit System Specification:

The proposed CCT system shall be operating in different weather condition throughout the year and also the reliability of system shall be ensured during peak requirements, hence the equipment proposed must ensure highest safety at extreme conditions and must fully comply with the latest international standards and stringent quality specifications.

The proposed MDG system shall be designed, manufactured and installed in accordance with the latest standards of ropeway technology, shall feature state-of-the-art equipment and operate automatically. The proposed system shall fully comply with the latest CEN standards (European standard) and safety requirements for Aerial Passenger Ropeways. CEN standards are most reliable in terms of technological and safety requirements.

The proposed MDG system shall be designed, manufactured and installed in accordance with the latest standards of ropeway technology, shall feature state-of-the-art equipment and operate automatically. The proposed system shall fully comply with the latest CEN standards (European standard) and safety requirements for Aerial Passenger Ropeways. CEN standards are most reliable in terms of technological and safety requirements.

- The system shall be designed to transport passengers upside and downside at a constant speed which can be selected by the operator(s) within the minimum and maximum range.
- The proposed system features friction sheaves at the incoming and outgoing sides of the stations. These sheaves transmit the speed of the rope via double V-belts to the conveyors which transport the carriers through the stations. This configuration ensures positive control and synchronization of rope speed and carrier conveying speed in each station in both forward and reverse directions, irrespective of the drive selected.
- Key functions of the ropeway, such as rope speed and grip opening and closing operations, shall be monitored and controlled by electronic safety circuits in order to ensure smooth operation and maximum safety.
- Fixed rope tensioning shall be achieved by two hydraulic cylinders in the tensioning terminal for each rope loop.
- The parking of cabins shall be carried out manually or automatically. The parking provided shall be sufficient for all cabins and shall be located in the drive station 2, 4, 6 and 8.

- The proposed MDG system is designed for one main direction of rotation. For special requirements, rescue and service purposes, reverse operation are permitted at a limited speed.
- All elements of the proposed CCT system shall be mounted onto a steel structure which is anchored on concrete foundations.
- In order to enhance system reliability, besides the electric main drive unit (AC motor), two independent hydrostatic emergency drive units allow for operation of the system at a reduced capacity and in emergency cases. A hydraulic emergency drive shall be installed to bring the passengers back to the station in case of a power failure.
- The rescue of stranded passengers shall be carried out by the following method:

Two independent hydrostatic emergency drives:

1) Hydraulic motor drive via gear rim on the bull wheel at the Drive station.
2) Hydraulic motor drive via gear rim on the bullwheel at the Return station. In emergency cases the passengers will normally stay in the cabins and will be brought back to the stations by means of emergency drives.

The innovative recovery concept which will be implicated in the Gangtok CCT project uses technical and organizational measures to ensure that all passengers can be safely returned to the stations in the carriers at all times. This concept enables you to offer your passengers maximum safety and comfort. This is achieved by duplicating all function-related parts and equipment, and making them independently operable, or ensuring that they can be restored to function at short notice so that the haul rope can always be moved. It shall be ensured that each tower is accessible for maintenance and rescue purposes.

The components and detailed specifications for stations-Drive stations, returns stations, Cabin Parking, cabins carriers, Haul Ropes, sheave assemblies, Towers, Electrical equipment's and Hydraulic Systems are detailed in the Report.

Cable Car Transit Operation Plan:

The operation plan has been worked out based on the demand calculated for the horizon years-2021, 2031, 2041 and 2051.

Based on the Table 10.2 it could be observed that the current planned network of cable car would cater to 40,300 passengers in the operational year of 2021 and would increase to 1,45,749 passengers in the year 2051. Cable car System in Gangtok would account for 15% of the passenger trips in 2021 and would increase to 20% by 2051. The total travel time on the North South Corridor from Ranipool Taxi Stand to Burtuk is 28 Mins, whereas on the West Corridor from North District Taxi Stand to Hospital at Sichey is 4 Mins and East Corridor from Old STNM Hospital to 2nd Mile HPC Church is 4 Mins.

The Peak hour peak direction traffic demands (PHPDT) along with Peak Hour & Daily Ridership for the North- South Corridor, West Corridor and East Corridor for the year 2021, 2031, 2041 and 2051 for the purpose of planning are indicated below.

Table 7: Section Wise Maximum Peak Hour Peak Direction Traffic (PHPDT) & Corridor Wise Peak & Daily Ridership – 2021, 2031, 2041 & 2051

Sl. No	Line Section	Corridor	Maximum PHPDT				Peak Hour Ridership				Daily Ridership			
			2021	2031	2041	2051	2021	2031	2041	2051	2021	2031	2041	2051
Section 1	Ranipool -Tourism Office Complex	North South	498	759	1144	1833	3,090	4,937	7,204	10,983	34,337	54,855	80,048	1,22,031
Section 2	Tourism Office Complex-Sikkim Manipal Hospital		896	1368	2113	3456								
Section 3	Sikkim Manipal Hospital -Gangtok Municipal Corporation		1007	1660	2547	4125								
Section 4	Gangtok Municipal Corporation-Denzong Cinema/Supermarket		647	958	1285	1877								
Section 5	Denzong Cinema/Supermarket-Old STNM Hospital		679	1062	1454	2026								
Section 6	Old STNM Hospital-Taxi Stand North District		695	1153	1676	2509								
Section 7	Taxi Stand North District-Helipad		809	1316	1903	2818								
Section 8	Helipad-Burtuk		572	866	1250	1862								
Section 9	Hospital at Sichey-District Center	West	60	81	232	355	184	494	852	1,066	2,044	5,485	9,463	11,841
Section 10	District Center-Taxi Stand North District		14	183	232	321								
Section 11	Old STNM Hospital-Chandmari Taxi Stand	East	34	759	174	242	353	588	848	979	3,919	6,533	9,427	10,876
Section 12	Chandmari Taxi Stand-2nd Mile HPC Chruch		82	125	182	258								
Total							**3,627**	**6,019**	**8,904**	**13,027**	**40,300**	**66,873**	**98,938**	**1,44,749**

The operation plan for 2021 and 2051 are given below ;

Table 8: Operation Plan for 2021

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
North South Line					
Ranipool -Tourism office	5	500	51	12	147
Tourism office-Sikkim Manipal Hospital	3	1000	28	11	84
Sikkim Manipal Hospital-Gangtok Municipal Corporation (GMC)	2	1000	25	9	70
Gangtok Municipal Corporation (GMC) –Denzong Cinema/Supermarket	4	1000	39	13	109
Denzong Cinema/Supermarket-Old STNM Hospital	2	1000	37	8	107
Old STNM Hospital-Taxi Stand North District	3	1000	36	9	106
Taxi Stand North District -Helipad	4	1000	31	18	89
Helipad - Burtuk	5	1000	44	14	129
West Line					
Hospital at Sichey-District Center	1	100	421	1	380
District Center-Taxi Stand North District	3	100	1802	1	1000
East Line					
Old STNM Hospital-Chandmari Taxi Stand	3	100	745	1	1200
Chandmari Taxi Stand-2nd Mile HPC Chruch	1	100	308	1	500

Table 9: Operation Plan for 2051

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
North South Line					
Ranipool -Tourism office	5	2000	20	30	59
Tourism office-Sikkim Manipal Hospital	3	3500	10	30	31
Sikkim Manipal Hospital-Gangtok Municipal Corporation (GMC)	2	4000	9	24	26

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
Gangtok Municipal Corporation (GMC) –Denzong Cinema/Supermarket	4	2000	19	25	57
Denzong Cinema/Supermarket-Old STNM Hospital	2	2500	18	17	50
Old STNM Hospital-Taxi Stand North District	3	3000	14	23	42
Taxi Stand North District -Helipad	4	3000	13	42	38
Helipad - Burtuk	5	2000	19	32	56
West Line					
Hospital at Sichey-District Center	1	400	101	2	190
District Center-Taxi Stand North District	3	300	112	3	333
East Line					
Old STNM Hospital-Chandmari Taxi Stand	3	400	149	3	400
Chandmari Taxi Stand-2nd Mile HPC Chruch	1	300	140	2	250

Cable Car Maintenance Plan:

The maintenance plan includes various checks and inspections as listed below:

- Various Checks (Pre Start checks, Daily, Weekly, Monthly, Quarterly, Half Yearly and Yearly checks)
- Preventive Maintenance Schedules
- Observations during plant running
- Monitoring Systems (Wear Debris Analysis, Sound-Temperature-Vibration Analysis)
- Various test (Nondestructive testing)

A thorough analysis of all the collected data should be done to chalk out the plan for carrying out activities. The analysis of the system has to be carried out by:

- By Plant In charge
- By Service & Safety and Design Team

The list of checks to be carried out of daily, weekly, monthly, quarterly, Half-yearly and yearly checks and maintenance guidelines are mentioned in Heading 11.2.

Environmental and Social Impact Assessment:

Aerial ropeway development will have a wide range of impact on the environment through activities like construction work, reclamation, excavation and other related activities. Aerial ropeway development and operation should therefore be planned with careful consideration of their environmental impact.

Land Environment:

The Project construction activities will minimally affect the topography (station sites only) and drainage pattern. Permanent land requirement for the project is 3.73 ha. Additionally, about 1.76 ha land is required temporarily. There will be requirement of 37300 sq.m. area for construction of 13 stations for Gangtok cable car project. Thus a total of 54930 m2 area would be affected due to the project.

The affected area is mostly green area. While finalizing the station sites care will have to be taken to minimize displacement of structures and felling of trees. As mitigation measures, Natural drainage patterns can be maintained by preparing sodden waterways or installing culverts; Engineering plans shall be drawn to reduce the area of earth cuts or fills, provide physical support for exposed soil or rock faces, concentrate or distribute - as appropriate the weight loading of foundations to areas able to support the weight, the top soil stockpile is to be protected and shall be utilized.

Water Environment:

For the water requirement during and for construction will be sourced from municipal water body and through bore well system with appropriate permissions. The efficient conservation technique are to be used during construction. The Sewerage collected is to be treated and connected to the city Sewerage system.

Air Environment:

There is be air pollution during construction and during system logistics. As a mitigation measure, there shall be provision for spraying water to reduce dust emissions during the construction phase. Proper maintenance of vehicles and DG sets shall be carried out as per manufacturer schedule.

Noise Environment:

Adoption of mitigating measures for noise abatement such as use of acoustic enclosures, use of ear muffs by workers and job rotation at places of high noise is suggested. Additionally, there will be use of noise barriers for point sources and line sources and the measures to minimize effect of vibrations due to construction activities shall be adopted.

Ecological Environment:

As mitigation measure compensatory plantation shall be undertaken and a minimum of three saplings against one tree felled shall be planted and maintained for 3 years for getting proper survival rates. It is suggested to bypass the forest and ecologically sensitive locations. An all-out effort shall be made to minimize disturbance to natural habitats.

Socio-Economic and Health:

It is observed that there will be no impact on any historical or cultural sites due to this project. Following are some of the recommendations to be followed:

- Comply with the safety procedures, norms and guidelines as outlined in IS 5228, IS 5229 and IS 5230, code of practice for construction of aerial ropeways, Bureau of Indian Standards
- Provide clean drinking water to all workers
- Provide adequate number of decentralized toilets and urinals to construction workers.
- Guarding all parts of dangerous machinery.
- Precautions for working on machinery.
- Maintaining hoists and lifts, lifting machines, chains, ropes, and other lifting tackles in good condition.
- Durable and reusable formwork systems to replace timber formwork and ensure that formwork where used is properly maintained.
- Ensuring that walking surfaces or boards at height are of sound construction and are provided with safety rails or belts.
- Provide protective equipment; helmets etc.
- Provide measures to prevent fires.
- Fire extinguishers and buckets of sand to be provided in the fire-prone area and elsewhere.
- Provide sufficient and suitable light for working during night time.
- Dangers, health hazards, and measures to protect workers from materials of construction, transportation, storage etc.
- Safety policies of the construction firm/division/company to be prepared.

Solid Waste Management

There will be impact due to non-hazardous and hazardous solid waste generated during the construction and operational stages. Options for minimization of solid waste and environmentally compacting/ recycling of waste to conserve natural resources should be planned. Management and disposal of temporary structures, made during construction phase should be planned. C& D waste should be minimized, reused and recycled within the project so far as possible. The excess C & D waste shall be disposed off at site allocated by Municipal body.

Risk Assessment and Disaster Management:

Personnel for disaster failure need to be identified and properly documented in the disaster management plan before start of any project activity. The various cells - technical, team for rescue (trained and skilled operators) are to be clearly indicated. Risks assessment associated with construction activities, for seismicity, slope stability, soil erodibility, and flood hazard are to be carried out. Disaster Management Plan must include emergency planning, emergency procedures, and details on safety measures adopted for the ropeway. Maintenance of the ropeway for all structural, mechanical, and electrical components has to be done regularly. A systematic maintenance needs to be followed. Procedures for maintenance and specific frequencies for periodic lubrication, inspection and adjustment are to be clearly mentioned.

Maintenance Personnel:

The training of the personnel should be recorded and standardised. Operations and maintenance log has to be maintained wherein the services carried out for each component is to be recorded.

Quantifiable Positive Impacts:

Travel Time Savings:

It could be observed that with the introduction of cable car system in Gangtok, there would be a significant savings in travel time from the year 2031, which would account for ~5% in 2021 to ~40% in 2051.

Savings of Vehicular Kms:

It could be observed from the table below that the total vehicular kms savings in project scenario works out to be 40,581 vehicular kms (including 2W, 4W (cars and taxis), Bus, Trucks etc) in 202, which would increase to 57333 vehicular kms in 2031 to 84, 717 vehicular kms in 2041 and 142650 vehicular kms in 2051, which would account for ~10% in 2021 and ~12% in 2051.

Saving of Fuel:

The project scenario can be compared with do nothing scenario to ascertain benefits of cable car as a transit mode. The road network length is 88 km and two line of cable car have been provided.

shows average travel time in do nothing scenario and introduction of Cable Car project in Gangtok and the savings of travel time with the project up to 2051.

Reduction in GHG Emissions:

According to preliminary estimates, this would lead to saving in Fuel and emissions from vehicular exhaust which have been worked out using ADB's "Appraisal of Road Transport Pollutant Emission" model. There will be Daily saving of 920 litre Petrol and 156 litre Diesel in 2021 and 5890 litre Petrol and 1051 litre Diesel in 2031 in the project scenario as compared to do nothing scenario. There will be significant reduction of Green House Gases from saving of fossil fuels spent on operation of vehicles. Moreover, there will be lesser congestion on roads. The noise on the roads will reduce which would significantly improve the environment.

Cost Estimate and Financial Feasibility:

The CCT service is expected to kick off in 2021 (i.e 2021-22, April 2022) after around 1 year of DPR preparation period and 2 years of construction period for Phase 1 and Phase 2 is expected to be operationalized by in 2025-26. The financial analysis for CCT project is carried for operation period of 30 years, starting from 2021and ending in 2051. The revenue, expense, taxes and cash flow are estimated for this period. (It may be noted that the reference to year 2021 refers to financial year 2021-22 and so on).

The total project cost is Rs.1023 Crores and the phase wise costing is listed in table below;

Table 10: Total Project Cost of CCT System for Gangtok along with Phase Wise Distribution of CCT

Sl. No	Components (September, 2018 Prices)	Total Project Cost (Cr)	Phase 1	Phase 2
1	System Mechanical & Electrical Component Cost	₹584	₹ 250.57	₹ 333.43
2	Station Civil Development Cost	₹152	₹ 86.78	₹ 65.22
	Sub - Total	**₹ 736**	**₹ 337.35**	**₹ 398.65**
3	Soft Cost - Project Development/Supervision/PMC	₹ 36	₹ 15.45	₹ 20.55
4	Freight Cost	₹ 10	₹ 4.29	₹ 5.71
5	Contingency (10% of System Cost)	₹ 85	₹ 36.47	₹ 48.53
	Total Project Cost (excluding GST)	**₹ 867**	**₹ 393.56**	**₹ 473.44**
6	GST on Taxable Components and Spares @ 18%	₹ 156	₹ 70.84	₹ 85.22
	Total	**₹1023**	**₹ 464.40**	**₹ 558.66**

Financial Returns:

The projected cash flow provides an IRR of 9.67% with the assistance of innovative financing from real estate development at stations and grants, but without supplementing income from the Urban Transport Fund (UTF).

Table 11: Project IRR and NPV (Rs.in Crores)

FIRR	**9.67%**
NPV @12% Discount Rate	**-₹ 354.24**

Economic Returns:

Considering the economic lifecycle cost and economic benefit. The economic internal rate of return (EIRR) for the Project comes out to be 21.7% for the duration of 32 years of project period which is above the established cut-off criterion of 14% as per Appraisal Guidelines for Metro Rail Project Proposals by MoHUA, GoI. This implies that the economic benefits accruing out of this project are substantial and will yield high savings to the economy as a whole.

Table 12: Outcomes of the Economic Analysis

Economic Internal Rate of Return	Economic Net Present Value (ENPV) @ 14% Discount rate (Rs in Crores)	Benefits to cost ratio
21.7%	446	1.57

Funding Options:

The following institutional structure is proposed

- Secretary UD & HD – Chairman
- Municipal Commissioner – Member
- Superintendent of Police – Member
- District Collector – Member
- Chief City Planner – Member
- State Pollution Control Board – Member
- Regional Transport Officer – Member
- Urban Transport Experts
- Legal Experts

The Technical Secretariat shall have the following structure:

- Executive Director
- Urban Transport Specialist
- Financial Specialist
- Transport Engineer

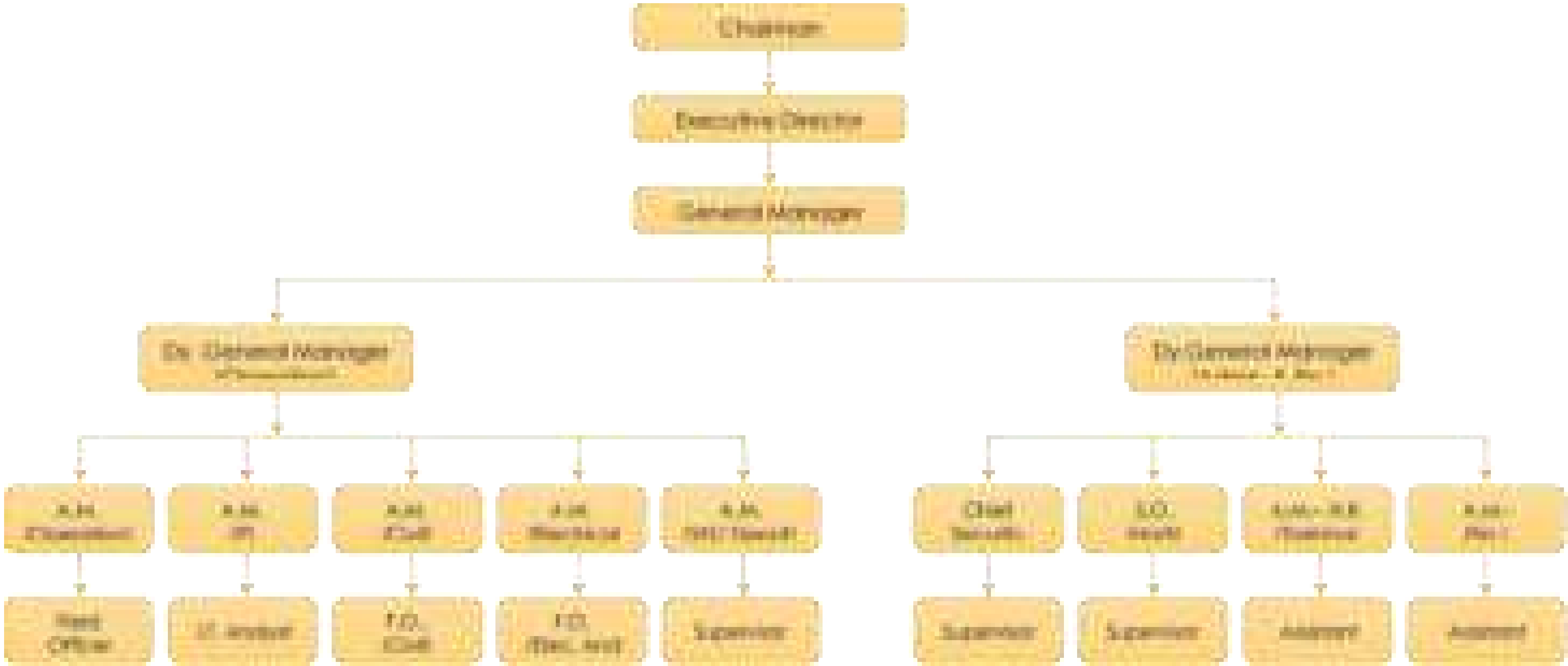
The UMTA shall have the following functions:

- Formulation of progressive land use and transportation policy for Gangtok Municipal corporation area
- Put down rules & regulations for the orderly conduct of urban transport and Service standards
- Formulation/revision in tariff policy time to time
- Routes structuring for various feeder modes to maximize the accessibility of the Metro Cable.

The functions of the Executive Council shall be as under:

- Provide assistance to UMTA in decision making on the various issues and give effect to all decisions of UMTA
- Notify the routes of public transport
- Recommend a rationalized tariff policy to UMTA
- Scientific assessment of demands and services contract for different operators
- Monitoring the service standards and operations of public transport modes
- Dispute resolution amongst various operators

For operations and maintenance, there is need of Special Purpose Vehicle for Gangtok cable car system. The typical structure of the SPV is as follows;



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ABBREVIATIONS

A &OE	Administrative and Office Expenses
AFCS	Automatic Fare Collection System
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BDG	Bi-Cable Detachable Gondola
BRT	Bus Rapid Transit
CBD	Central Business District
CCT	Cable Propelled Transit
CDP	City Development Plan
CGWA	Central Ground Water Authority
CIRT	Central Institute of Road Transport
CSS	Centrally Sponsored Scheme
EIRR	Economic Internal Rate of Return
FCI	Food Corporation of India
FIRR	Financial Internal Rate of Return
GBS	Gross Budgetary Support
GMC	Gangtok Municipal Corporation
HRIDAY	National Heritage City Development and Augmentation Yojana
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communications Technology
IPT	Intermediate Public Transport
ITS	Intelligent Transport System
MDG	Mono-cable Detachable Gondola
MoUD	Ministry of Urban Development
MRTS	Mass Rapid Transit System
NEDFI	North Eastern Development Finance Corporation Ltd
NEURDP	North Eastern Region Urban Development Programme
NH	National Highways
NMT	Non-Motorized Transport
NPV	Net Present Value
O&M	Operation and Maintenance
OD	Origin Destination
PAX.	Passengers
PCU	Passenger Car Units
PHED	Public Health Engineering Department
PHPDT	Peak Hour Peak Direction Traffic
PPHPD	Passengers per hour per direction
PPP	Public Private Partnership
PT	Public Transport
PWD	Public Works Department
RFP	Request for Proposal
RSI	Road Side Interview
SNT	Sikkim Nationalised Transport
SPV	Special Purpose Vehicle
TAZs	Traffic Analysis Zones
TDG	Tri-Cable Detachable Gondola
TFL	Transport for London
TIF	Tax Increment Financing
TOD	Transit Oriented Development
TW	Two Wheelers
UDHD	Urban Development & Housing Department
UMTA	Unified Metropolitan Transport Authority
UMTC	Urban Mass Transit Company Limited
UTF	Urban Transport Fund
VCR	Volume Capacity Ratio
VGF	Viability Gap Funding
VOC	Vehicle Operating Cost

Chapter 1 INTRODUCTION

1.1. Study Background

One of the main outcomes of the National Workshop on Cable Car for Hilly Areas held on 26th June 2014 at Shimla organized by MoUD was that like the practices in Latin America, Indian hill cities too can explore and leverage the cable car technology to cater to the mobility needs. In this direction MoUD, UT division has decided to support states that may like to undertake feasibility studies for their hill cities through part funding as per guidelines of Urban Transport Planning & Capacity Building Scheme.

The Urban Development & Housing Department, Government of Sikkim, the Nodal Department of the State to deal with issues relating to urban transport under Ministry of Urban Development, Government of India has decided to undertake **"Techno-Economic Feasibility Study for Cable Car Technology for City of Gangtok".** Accordingly, Urban Mass Transit Company Ltd has been entrusted with the study.

1.2. Need for Study

The Rapid urbanization characterized by growth personalized vehicles and migration has become a common phenomenon across all cities in India. Resultant of this, cities are experiencing traffic congestion due to many factors, increase in number of private vehicles, reduced road space and longer trip lengths.

Hill cities too are facing similar challenges and Gangtok is one of them. Natural features especially topography and terrain in hill cities are limiting the expansion of infrastructure development like bridges and roads, not only due to high costs but also due to limited space. This is affecting the balanced growth of the city and putting pressure on the exiting services and infrastructure

In absence of organized, safe and reliable public transport systems, the use of personalized vehicles increases leading to congestion and economic and environmental degradation.

The National Urban Transport Policy highlights that the public transport infrastructure should:

Focus on moving people and not vehicles and make our cities most liveable in the world and enable them to become the engines of economic growth.

Allow our cities to ***evolve into an urban form that is best suited for the unique geography*** of their locations and is best placed to support the main social and economic activities that take place in the city.

Keeping in view the aforementioned challenges to address the mobility needs for the Gangtok city, need has been felt to explore a suitable cable car technology as an alternate public transport system to connect various parts of the city.

Accordingly, with the objective of assessing the feasibility of cable cars as an alternative public transport mode for the efficient, reliable and safe movement of people, a detailed techno-economic feasibility study of cable car for Gangtok is been proposed to carry out as part of this project. The scope of work for the study is discussed in following section.

1.3. Scope of Work

The scope of work for preparation of ***'Techno-economic feasibility report of cable car as public transport for Gangtok'*** is disintegrated into three phases, each with series of tasks, start with the signing of contract, the subsequent stages will involve submission of reports and completion of relevant tasks for the same as per the RFP.

The major tasks involved in the feasibility study are:

- Data collection and interpretation
- Demand assessment
- Alignment options and network planning
- Basic environment and social impact assessment
- Economic and financial analysis
- Institutional setup for operations and maintenance

The following would be the deliverables

- Inception report with detailed work plan
- Interim report
- First draft report
- Second draft report
- Final report

The details of the deliverables are explained below:

Inception Report: The inception report covers the methodology along with timeframe for the study. The review of existing transport and urban planning related documents is also covered. The Detailed work plans would be formulated along with timeline of activities and tasks involved.

Interim Report: The interim report contains the data analysis of primary surveys along with the tentative proposals. The primary surveys exercise involves preparatory work for the same, pilot survey and detailed primary surveys. The data analysis involves demand assessment using modelling framework followed by integrated network planning as per the site suitability and technology available.

First Draft Report: The draft report is intended to be submitted after completion of all tasks listed in RFP. Apart from the detailed demand assessment and scenarios development, detailed structure of authority and institutional setup, Specification of legal framework for operations and maintenance (and agency responsible) would be provided. It will contain basic environmental impact assessment needs to be done to compare the emissions caused by cable cars and other means of transport. Also a general socio economic impact assessment to assess impact of the project to the residents of Gangtok would be included. The detailed Economical and Financial Viability Plan along with Work plan and specifications for implementation would be provided.

Second Draft Report: Second draft report is the revised version of first draft report and contains and recommendations given on first draft report.

Final Report: Final report is the revised version of second draft report and contains and recommendations given on second draft report.

1.4. Review of Past Studies

The Various Transport surveys and studies were conducted at Gangtok from time to time these are briefed as under:

1.4.1. City Development Plan (2006)

City development plan for Gangtok is prepared by Shristi Urban Infrastructure Development Ltd. The major findings regarding urban transport are as follows:

Gangtok is linear city and topographically also it has great difference in highest and lowest altitude. Topography acts as a barrier to road alignment. Most of the roads in Gangtok are two lanes, undivided and footpath on one side and drain on the other side. Roads in Gangtok are narrow in width. Gradient of roads are also slightly high.

Some areas in Gangtok are not accessible through vehicles. There are no designated terminal facilities for goods vehicles and goods are transported to the local sites in smaller vehicles. 90% of the traffic is intra-city and only 10% traffic is interstate traffic.

The pedestrian traffic volume survey shows high pedestrian volumes mainly on MG Road, Indira Bypass and Deorali Bazar Road.

Journey speeds vary from 11 kmph to 27 kmph. The traffic volume data shows that various locations experience a gush of more than 10,000 PCU, during the day, with maximum VCR along the primary spine of the city and commercial areas.

The acute traffic problems that Gangtok faces presently are in the areas of Metro-MG Marg Junction, Hospital junction, Community Hall Junction, Lal Bazar junction, Deorali Junction, Tadong (Daragaon) Bazar, Sikkim Govt. College entrance-exit point and Zero Point Junction. A special effort has to be undertaken to provide interconnecting road links between major arteries of the city.

1.4.2. Transport Study by Center for Indian Road Transport (2005)

A study on the traffic situation of Gangtok was carried out by CIRT, Pune in the year 2005. The findings of the study are:

The highest daily traffic in Gangtok is observed at Deorali, followed by Hospital junction and Denzong Junction.

The share of personalized vehicles and taxis combined was observed at 98% of the total vehicles in Gangtok, which is very high. The survey findings show among the taxi users 16% were tourist and 84% are local residents in which 36% are the daily commuters and 64% are occasional.

Keeping view the environmental, regional and tourism importance of the town need of mass public transport is felt. When asked during the survey 92% of persons interviewed were in the favor of the minibus services to be introduced with higher frequency.

1.4.3. Performance improvement Measures for SNT by CIRT, Pune (2008)

This particular report is prepared by CIRT Pune in December 2008. This report discusses about how SNT established and what is its present status. Suggestions for Fright operations, passenger transport services, basic infrastructure development, Fleet replacement and Augmentation and maintenance management were provided.

1.4.4. Gangtok Structure Plan: Surbana (2009)

Gangtok structure Plan was prepared in the year 2009. It was prepared for a span of 30 years, i.e. up to 2040.The structure plan has discussed about the existing linkages by roads in Gangtok. This included study of existing road network and also the existing ropeway system. The study concluded:

The NH 31-A acts as the spinal cord of the city, and it is highly congested.

Road Widening not possible due to steep terrain and space constraint and thus new Road Schemes to be explored

The ropeway service is commonly used by residents working within the CBD area, as it avoids road congestion and has shorter traveling time to work

In Proposed land use of Structure Plan area under circulation and transportation was not discussed or covered, which is important part of any land use plan.

The structure plan has also proposed a new road structure-

New inner and outer Ring road has been proposed

A new link in the west to connect the to-be-implemented new State highway.

A new junction in the south to link the outer ring road with a route to Pakyong Airport.

New Collector roads added as connectors between the ring roads and the national highway to enhance overall traffic circulation.

New road hierarchy is proposed with 6 levels.

1.4.5. Wilbur Smith Associates, 2008

In a recent study conducted by Wilbur Smith Associates in 2008, Gangtok was given a ranking of 1.1 on a scale of 5, meaning that pedestrian facilities are quite inadequate and there is scope for much improvement.

1.4.6. Transport Study by RITES

RITES had prepared the Gangtok Master Plan in 1997.The major contribution of the study is population projection for the year 2010 and 2020.Transport survey of Gangtok has been conducted by RITES and as an outcome of the survey proposal for pedestrian foot over bridges were suggested and built on various locations (Hospital Junction, Metro Junction 2 pedestrian cross over bridge, Lal Market Junction)

1.4.7. NEURDP Study

This study discusses about the change in land use in Gangtok for last 4 decades. As per the study, it is evident that the city area has consistently increased since 1975. Thereby the percentage for each land use has decreased, even though the population and density has increased over the years.

1.4.8. Gangtok Integrated Development Plan 2000 Study

This study was prepared in 1987 for the year 2000 and it was for an area of 725 Ha out of the 725 Ha 70% area is already covered, while the remaining area comprises of vacant land, agricultural land, Jhoras and area under tree cover.

1.4.9. Comprehensive Mobility Plan, 2010

The study was done by DDF consultants in 2010 provides analysis of Existing Traffic/Transport Situation. The vision as envisaged for comprehensive mobility plan for Gangtok Municipal area is as follows:

To improve connectivity and travel throughout the city and its region.

To improve mobility within neighborhoods, wards, zones and satellite towns to address inner- and inter-city transportation needs.

To achieve efficient arrangement of land use and transport systems to minimize overall travel cost.

To offer viable and reliable transportation options that aim at reducing dependence on cars, with widespread use of non-motorized modes and mass rapid transit system.

The travel demand model was developed in this study and it provided travel demand forecast also, which is based on future urban growth scenario and future transport network scenario.

The study provides public transport improvement plan and regulatory and institutional measures for the same. After assignment and scenarios development, it was concluded that many of the roads will still be overloaded in Scenario (where development of mobility corridors and bus route rationalization was proposed), thus ropeway transport network and road network was proposed on certain network. However, this was strategic level network design, thus the feasibility is required in order to ascertain the exact ridership. The demand generated which render ropeway functioning feasible would be done through detailed methodology as suggested in section 3.1.

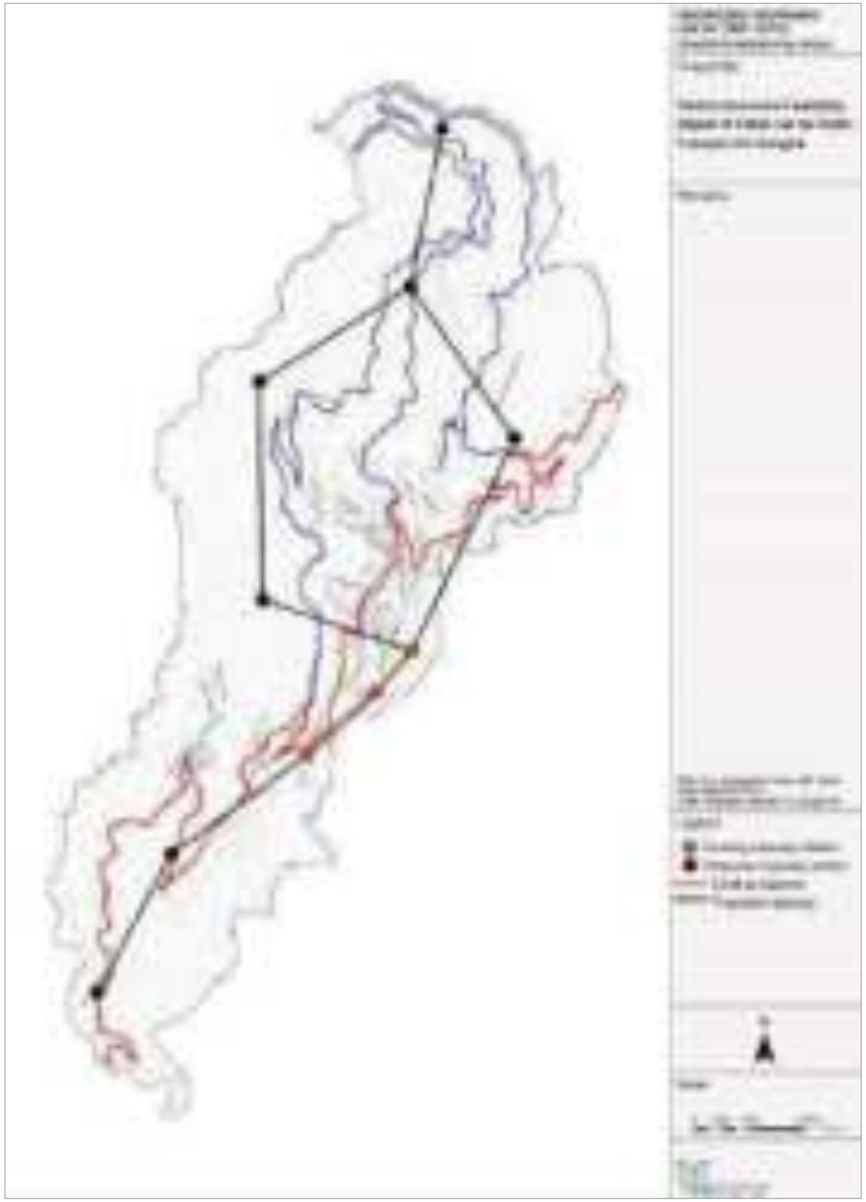


Figure 1-1: Cable Car Proposal as per CMP, 2010

Chapter 2 : STUDY AREA PROFILE

2.1. About Gangtok

Gangtok is a municipality, a capital and the largest town of the Indian state of Sikkim. It also is the headquarters of the East Sikkim district. Gangtok is located in the eastern Himalayan range, at an elevation of 1,650 m (5,410 ft). The city, with about a lakh population is administered by Gangtok Municipal Corporation (GMC) and Urban Development & Housing Department (UDHD), Government of Sikkim. People of Gangtok belongs to different ethnicities such as Sikkimese Lepcha, Bhutia, Nepalese and other communities. Gangtok has several tourist destinations and enjoys tourist influx round the year. Nested in the Himalayas, Gangtok offer breathtaking scenic beauty.

Figure 2-1: Geographical Location of Gangtok

2.2. Location

Geographical location of Gangtok is shown in Figure 2.1. The city acts as a gateway to Sikkim and a base point to explore the various exotic locations in North, East and West Sikkim. The population in north Sikkim and east Sikkim are dependent on the city for education and health care facilities. Gangtok is linked to various parts of the state through extensive network of roads enabling trade and commerce in the region and bringing economic prosperity to the city.

2.3. Geography and Terrain

Gangtok is located at 27.3325°N 88.6140°E (coordinates of Gangtok head post office). It is situated in the lower Himalayas at an elevation of 1,650 m. The town lies on one side of a hill, with "The Ridge", a promenade housing the Raj Bhawan, the governor's residence, at one end and the palace, situated at an altitude of about 1,800 m, at the other end.

Figure 2-2: Gangtok in Nature's Setting

The city is flanked on east and west by two streams, namely Roro Chu and Ranikhola, respectively. These two rivers divide the natural drainage into two parts, the eastern and western parts. Both the streams meet at Ranipool and flow south as the main Ranikhola before it joins the Teesta at Singtam. Most of the roads are steep, with buildings founded on compacted ground alongside.

2.4. Demographics

The Gangtok Municipal Corporation has population of 100,286 of which 52,459 are males while 47,827 are females. The population od Gangtok has grown four folds between

1991 and 2011. The population growth trend is presented in Table 2.1

Population of Children between age group of 0-6 is 9264 which is 9.24 % of total population of Gangtok (Municipal Corporation). In Gangtok Municipal Corporation, Female Sex Ratio is of 912 against state average of 890.

Table 2-1: Population Growth in Gangtok

SN	Year	Population	Decadal Growth (%)
1	1951	2744	
2	1961	6848	149..56
3	1971	13308	94.33
4	1981	36747	176.13
5	1991	25024	-31.90
6	2001	29354	17.30
7	2011	100286	241.64
8	2016	122013	21.6

Source: Census of India

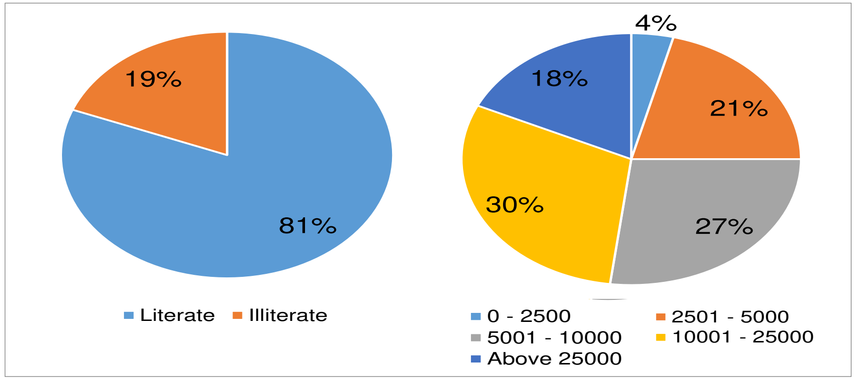


Figure 2-3: Literacy Rate & Income Distribution of Gangtok City

Moreover, Child Sex Ratio in Gangtok is around 932 compared to Sikkim state average of 957. Literacy rate of Gangtok city is 89.33 % higher than state average of 81.42 %. In Gangtok, Male literacy is around 92.77 % while female literacy rate is 85.54 %. Gangtok Municipal Corporation has total administration over 23,773 houses. Figure 2.3 shows literacy rate and income distribution and Figure 2-4 represents population density variation in Gangtok.

Figure 2-5 shows the altitude variations in Gangtok and Figure 2-6 shows municipal wards in the corporation area

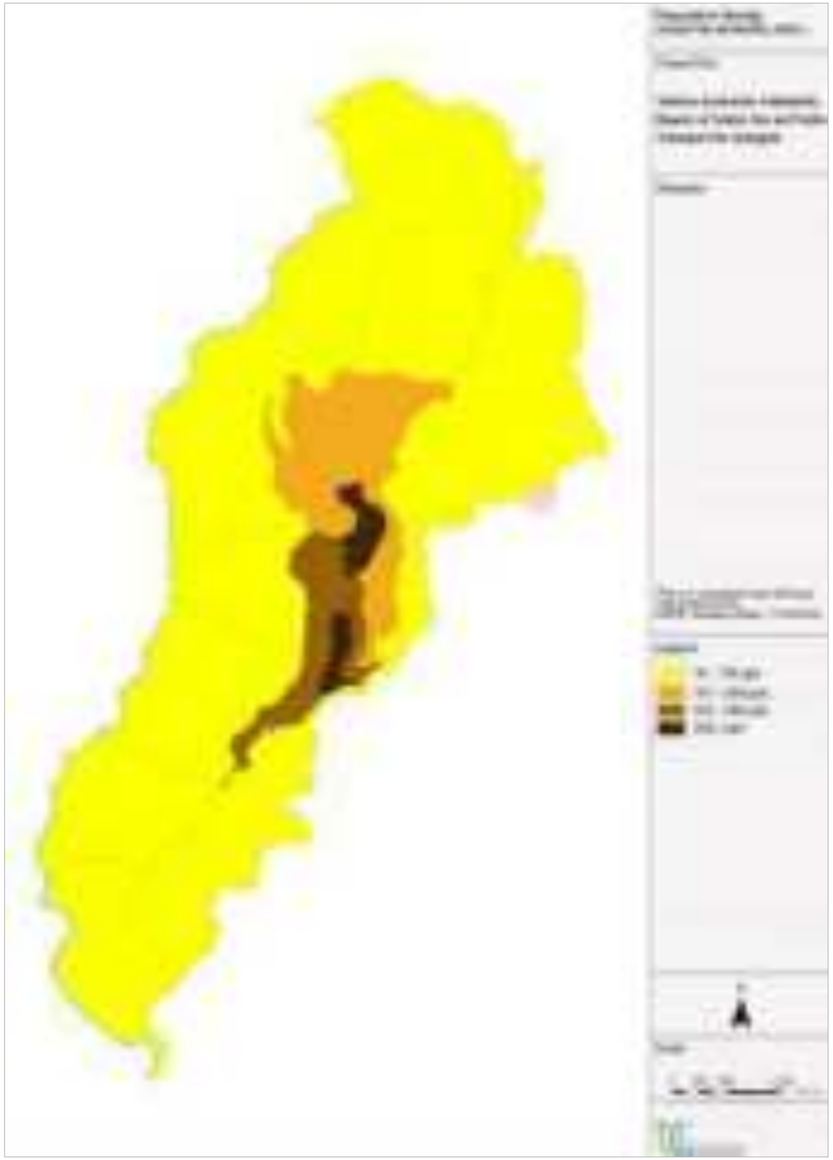


Figure 2-4: Population Density Distribution of Gangtok City

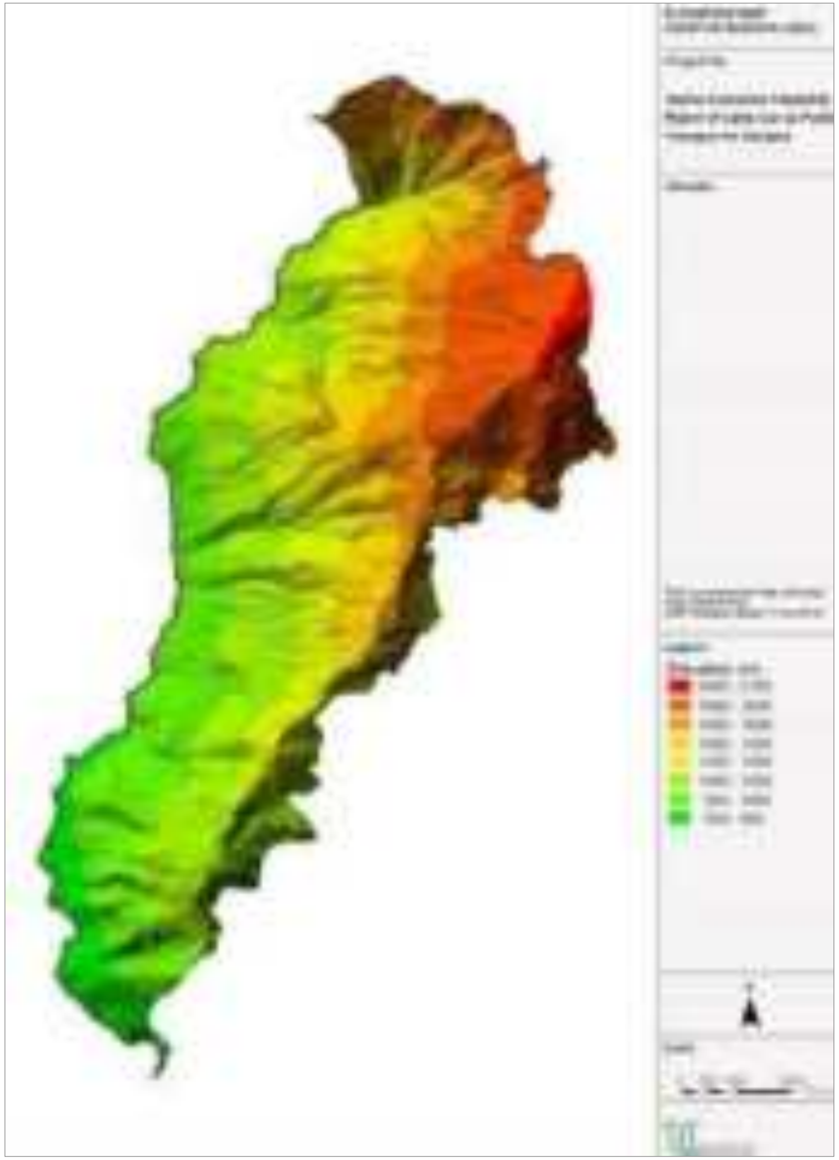


Figure 2-5: Physiographic Map of Gangtok

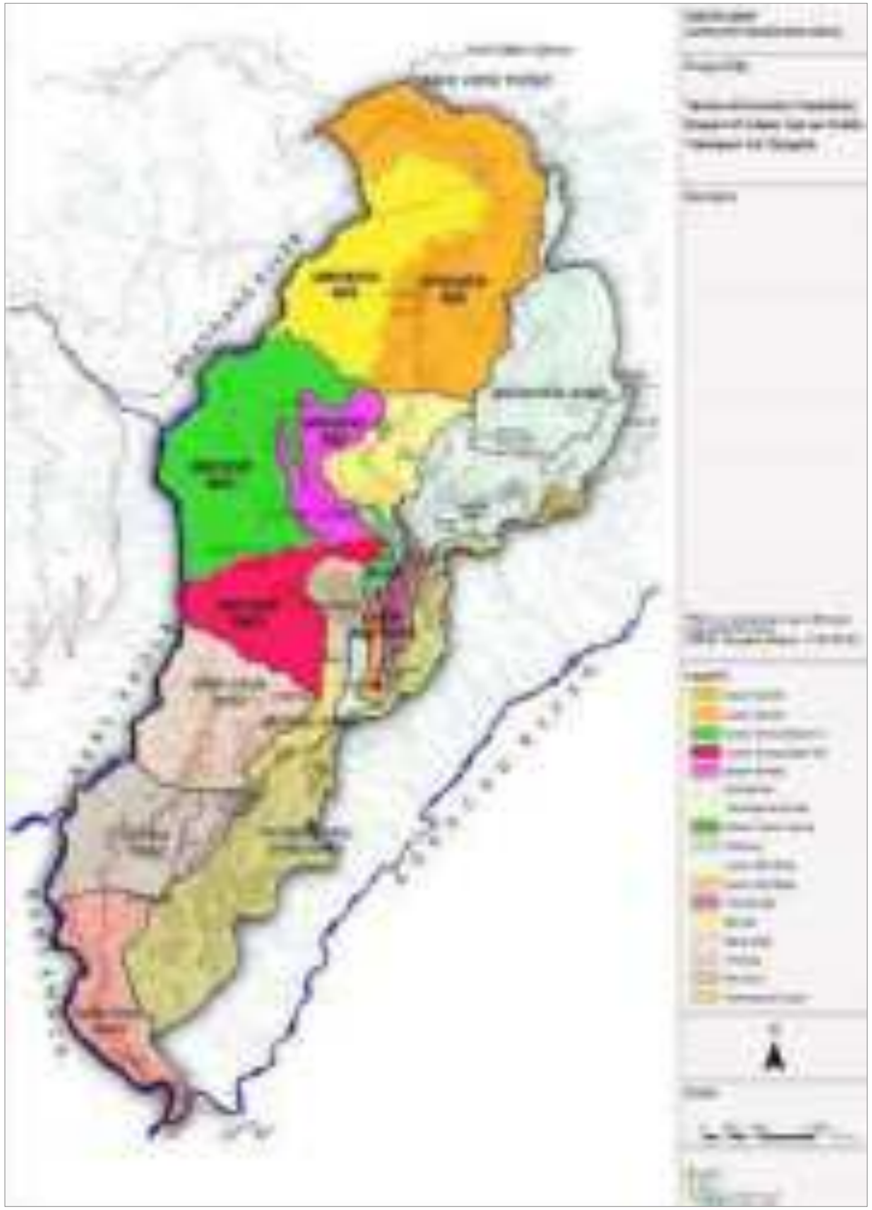


Figure 2-6: Gangtok Municipal Corporation Ward Map

2.5. Climate

Gangtok features a monsoon-influenced subtropical highland climate. Because of its elevation and sheltered environment, Gangtok enjoys a mild, temperate climate all year round. Like most Himalayan towns, Gangtok has five seasons: summer, monsoons, autumn, winter and spring. Temperatures range from an average maximum of 22 °C (72 °F) in summer to an average minimum of 4 °C (39 °F) in winter. Summers (lasting from late April to June) are mild, with maximum temperatures rarely crossing 25 °C (77 °F).

2.5.1. Average Temperature and Precipitation:

Figure 2.7 shows average temperature and precipitation in Gangtok. The "mean daily maximum" (solid red line) shows the maximum temperature of an average day for every month for Gangtok. Likewise, "mean daily minimum" (solid blue line) shows the average minimum temperature. Hot days and cold nights (dashed red and blue lines) show the average of the hottest day and coldest night of each month. Monthly precipitations above 150mm are mostly wet, below 30mm mostly dry.

Figure 2-7: Average Temperatures and Precipitation

2.5.2. Wind Speed and Direction:

Figure 2-8 shows how many days within one month can be expected to reach certain wind speeds. Wind speed is an essential factor for selection of a Cable Car System for a city.

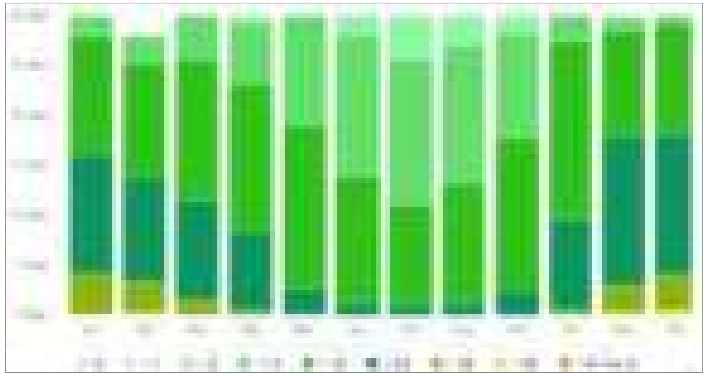


Figure 2-8: Wind Speed

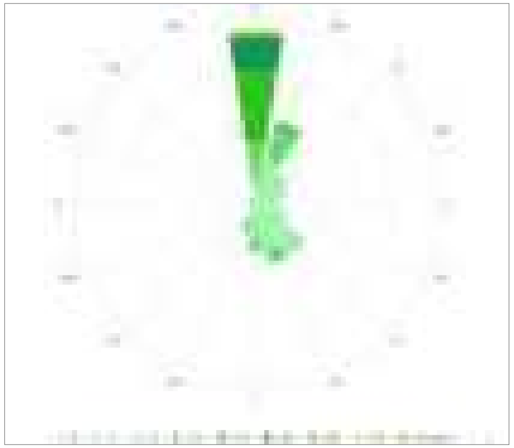


Figure 2-9: Wind Direction

Figure 2-9 shows wind rose for Gangtok showing how many hours per year the wind blows from the indicated direction.

2.6. Land Use and Urban Structure

The urban structure is expanding mainly along the major transport corridors. Total area of Gangtok City is approximately **19.28 sq. Km**. but as per the City Development Plan (Draft CDP, 2015) area of **Greater Gangtok is 76.95 Sq. Km**. which includes urban and rural fringe around the Gangtok. The total area comprises of the surrounding satellite towns namely Bhusuk, Ranka & Luing, Penlong & Pangthang, Rumtek, Assam Lingzey and Pakyong. The land use of the city area includes residential, commercial, public and semipublic use buildings. Banks, offices of FCI, NEDFI, PHED, PWD, Schools, Hostel, Center for blind, clinic and Himalayan Nursery are just few to name. The existing buildings have an average of 4-5 floors and maximum up to 7.

M.G. Marg, Tibet Road and Kazi Road are the core business district of Gangtok. These are major hubs for the tourists and employment. Service sector is the major employment sector in Gangtok. Several office buildings such as Birth & Death Registration Office, CA office, DAC, Education center, Health Center, LIC office, Police Station, State Excise office, tourism office, vigilance office and banks are located in these hubs. The buildings are pucca and semi pucca in nature. Figure 2-10 shows built-up in GMC area and Figure 2-12 represents settlement pattern based on regional land uses.

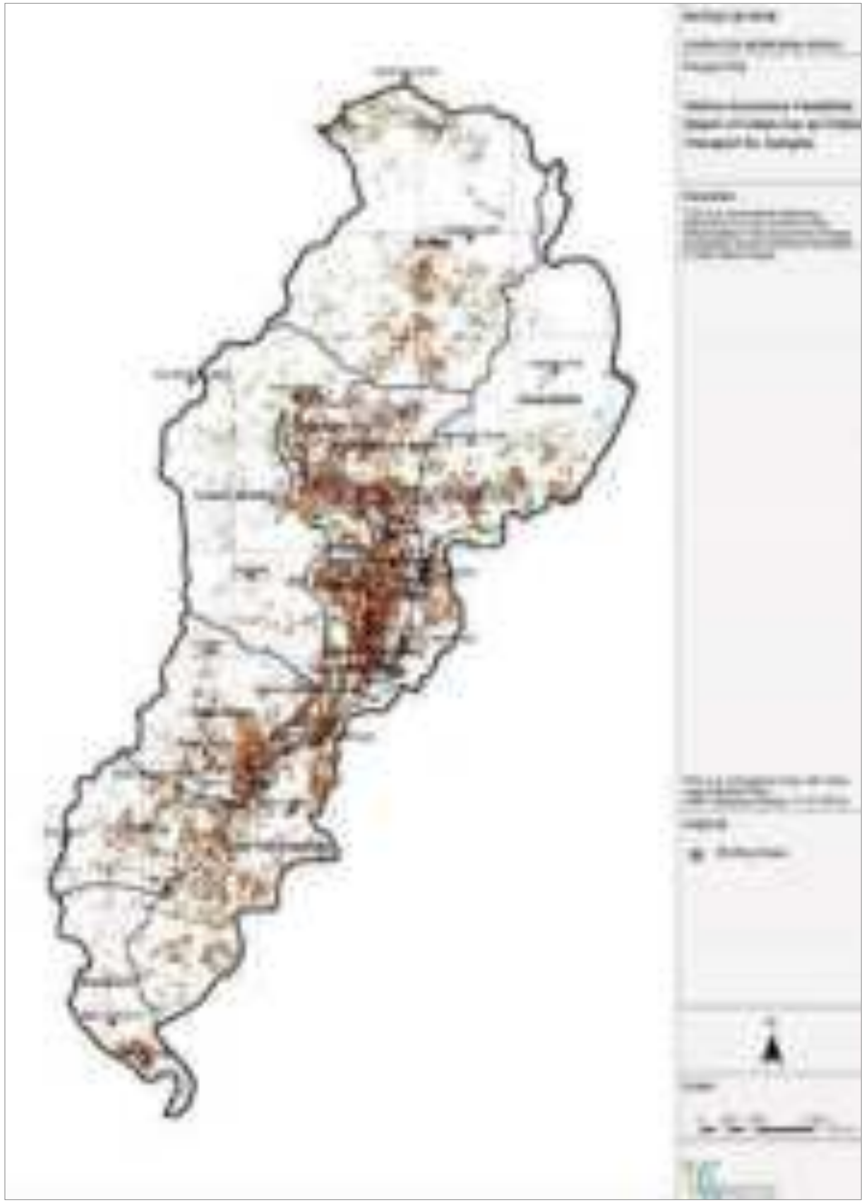


Figure 2-10: Built-up in Gangtok Municipal Corporation Area

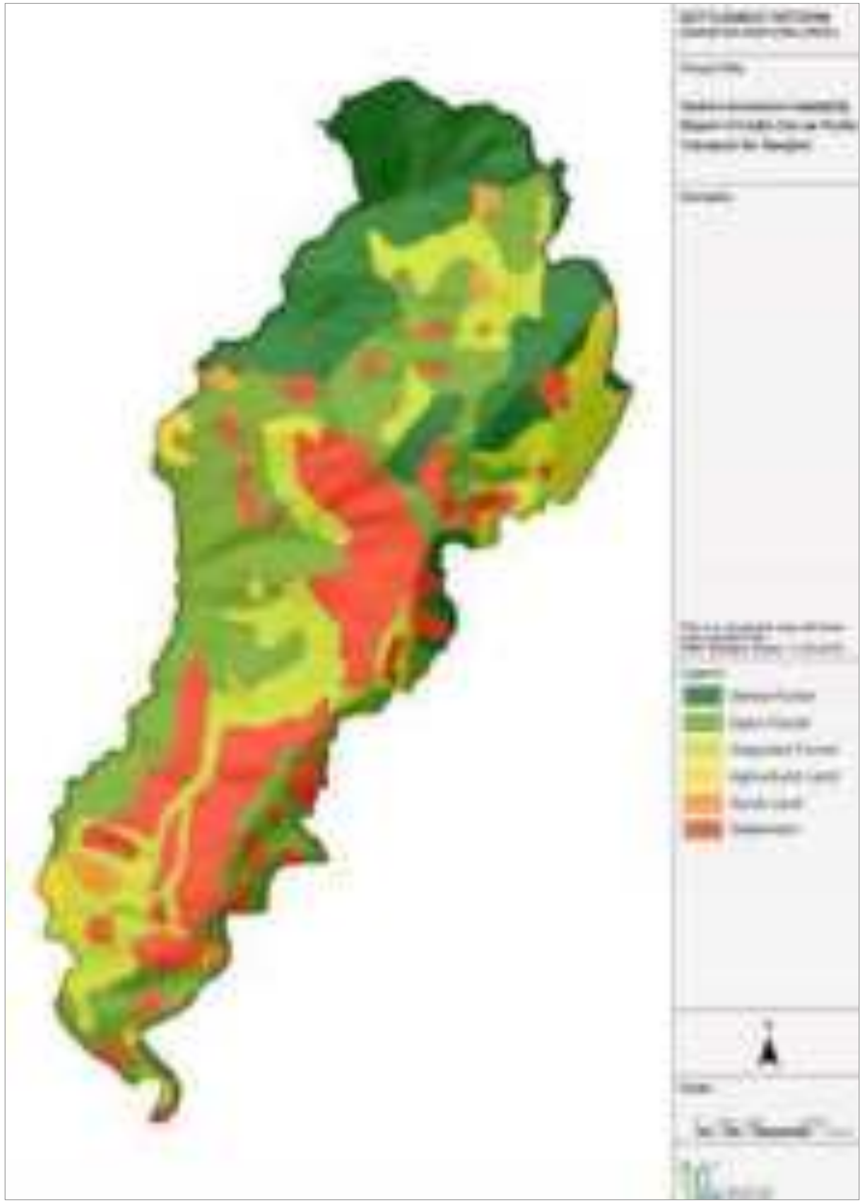


Figure 2-11: Settlement Pattern in Gangtok

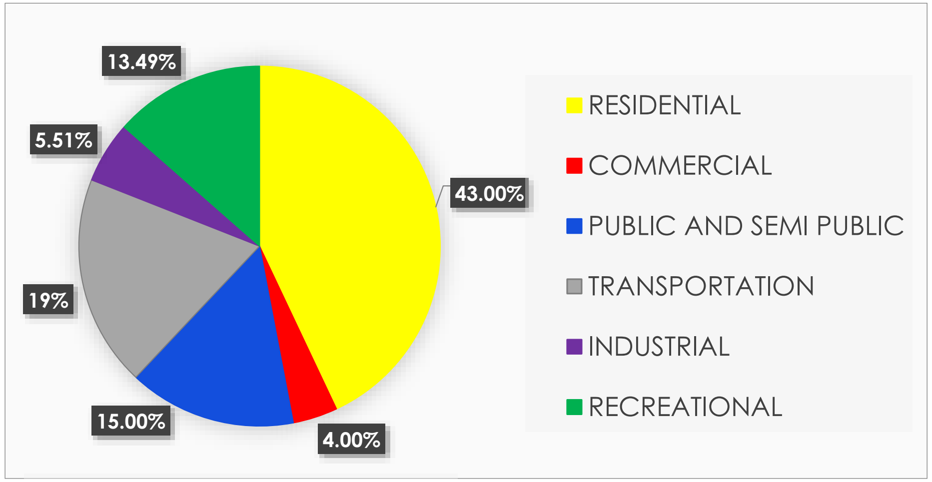


Figure 2-12: Land Use Distribution of Gangtok

Figure 2-12 shows land use distribution of built-up areas in Gangtok. 43% of the area is under residential use followed by 19% under transportation.

2.7. Tourism

Gangtok is famous for tourist destination hubs offering natural beauty, flora and fauna. Tourism is one of the main sources of income and livelihood for the city's inhabitants. The Tourism Department, Government of Sikkim is the government body responsible for taking care of the sectors and its allied activities such as tourism infrastructure development and management of domestic or international tourists.

As shown in Figure 2-13, 51% of the regional trips destined for Gangtok are "Leisure, Recreational and Holiday" trips, followed by 27% for "VFR, Pilgrimage and Health".

Domestic tourists are from all across India with major influx from West Bengal and Bihar due to its proximity and

International tourists are mostly from USA, European countries, South Asian and South East Asian countries visit Gangtok.

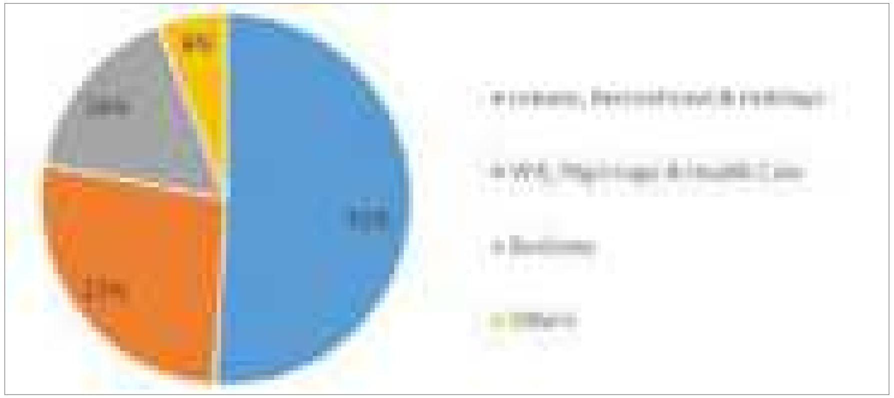


Figure 2-13: Purpose of Visits of Tourists visiting Gangtok

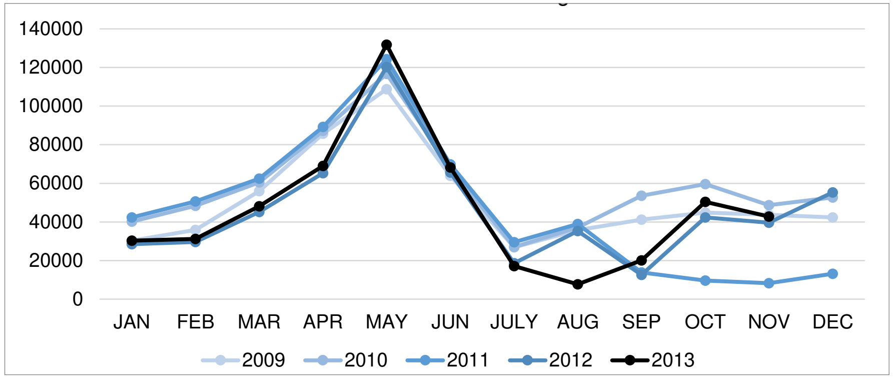


Figure 2-14: Domestic Tourist Flow Trends – Gangtok

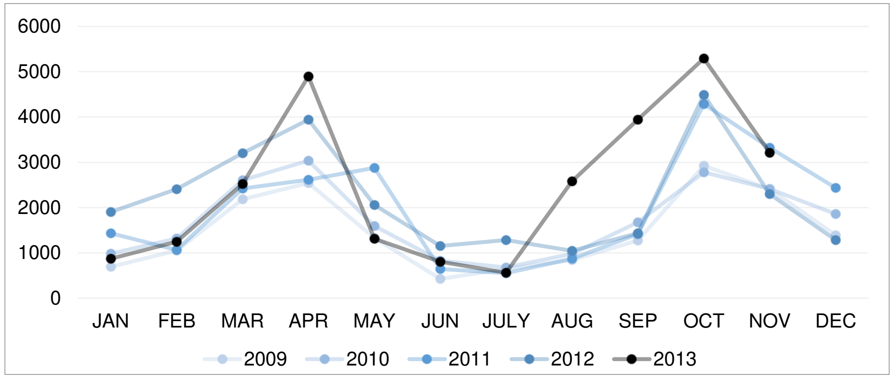


Figure 2-15: International Tourist Flow Trends – Gangtok

Figure 2-14 & Figure 2-15 shows domestic and international tourist flow trends in a year. Domestic tourists peak season is from March to June in summers and from October till December in winters. For international tourists, summer peak is from March to May and winter peak is from August to December. The maximum domestic tourist influx is around 1.2 Lakhs in the month of May and maximum international tourist influx is around 5000 in the months of April and October. Approximately, 4000 tourists visit Gangtok every day.

2.8. Transportation and Mobility

Gangtok is a linear city growing along the arterial roads, especially the NH-10. it has grown in the East, West and South direction due to good connectivity by road. It is well connected to the neighboring cities by road. The city is also accessible through airways and railways, which are available in close proximity.

2.8.1. Regional Connectivity

Figure 2-17 the connectivity of Gangtok with major regional transit nodes and nearby urban centers.

Airways: Nearest airport is Bagdogra Airport located near Siliguri town of West Bengal and lies around 126 km from Gangtok. Gangtok is linked to Bagdogra airport by a daily helicopter service that operates only once a day and carries four passengers. Helicopter service is highly dependent on weather conditions and operations disrupt very often. Other modes of reaching Bagdogra Airport includes private Taxis. Shared taxis Another airport which is coming up at Pakyong (under construction) is around 20 kms from Gangtok and is expected to be operational by 2017 (India Times, 2016).

Railways: Nearest railway station is at New Jalpaiguri in West Bengal situated around 124 km from Gangtok. Work has commenced for a broad gauge railway link from Sevoke in West Bengal to Rangpo in Sikkim and is planned for extension to Gangtok. New Jalpaiguri railway station can be reached via private and shared taxis and regional buses.

Roadways: Gangtok is connected to other parts of the country by an all-weather metaled national highway i.e. NH-10, linking Gangtok to Siliguri which is located at around 114 km away in the neighboring state of West Bengal. The highway also provides a link to the neighboring hill station towns of Darjeeling and Kalimpong, which are the nearest urban centers. Regular shared taxis (jeeps, vans etc.) and regional bus services provides connectivity to these and other towns near Gangtok.

2.8.2. Local Transportation System

Taxis are the most widely available mode of transport in Gangtok. Most of the residents stay within a few kilometers of the town center and owns a two-wheeler and/or a car. The share of personal vehicles and taxis combined is 98% of Gangtok's total vehicles. City buses comprise less than 1% of vehicles. Those travelling longer distances generally make use of shared taxis.

Figure 2-16: Dense Built-up (Aerial View of Core City Area)

The 1 km long cable car system shown in Figure 2-16, with two stops operates as tourist attraction.

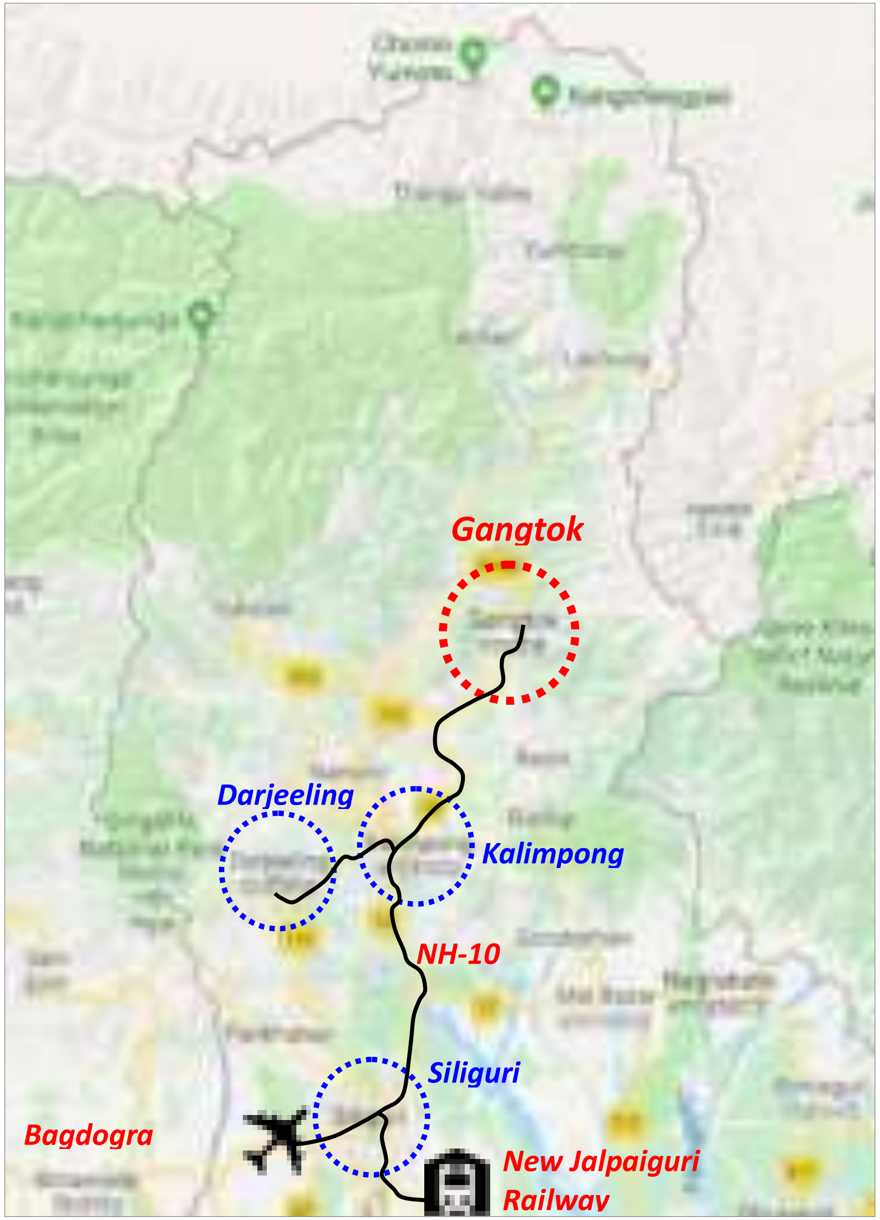


Figure 2-17: Regional Connectivity to Gangtok

2.8.3. City Road Network

Major roads are listed below and important road network characteristics are provided in Table 2-2 and Figure 2-18;

1) National Highway 10 – Gangtok to Siliguri
2) North Sikkim Highway – Gangtok to North District
3) Jawaharlal Nehru Road – Trade route to China

Apart from these, the other major city roads are Indra By-pass, Tibet Road, M.G. Marg, Kazi Road, Paljor Stadium Road, Indira by-pass and Namnang Road, that connects to the National Highway. In addition to these, there are several other roads in the city that provide internal accessibility. The road network of Gangtok is shown in Figure 2-19.

Table 2-2: Road Network Characteristics

SN	Classification		Road length (kms)	Percentage
1	National Highway (NH 31A)	NH	18.24	20.68
2	State Highway	SH	21.78	24.69
3	Major Roads	MR	32.1	36.39
4	Other Roads	OR	16.1	18.24
	Total		88.22	100

Source: CMP 2010

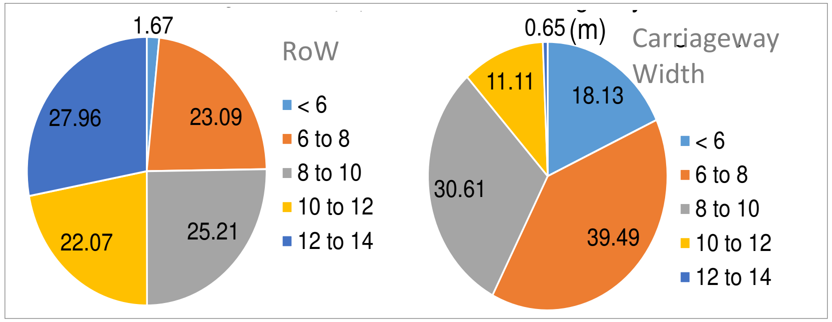


Figure 2-18: Distribution of Road Length by RoW and Carriageway Width

Figure 2-19: Road Network in Gangtok

2.8.4. Public Transportation System

Sikkim Nationalized Transport (SNT) provides public transport services to the people of Sikkim. The entire bus passenger transport service in the state is nationalized with no private bus operators. SNT operates on routes from Gangtok to Siliguri, Mangan, Jortang and Rangli. There are 3 depots at Gangtok, Jorthang and Rangpo.

SNT has about 10 buses catering purely to school trips, 5 catering to city bus service in Gangtok by the name of Red Panda City Runner. Currently city buses run on 5 routes with one bus on each route and at a frequency of 1 hour. 4 round trips are performed between 7 am to 6 pm. The city buses run with an average fuel efficiency of 4.08 kmpl. An EPKM achieved was around Rs. 18.45 on charging an average fare of Rs. 1.20 per km. The bus fleet has declined by 48.28% over the past decade.

Majority of public transport needs are sufficed by shared taxi services which act as a fast and cheap mode of transport. Taxi operations are effectively organized by city authorities by designating specific pick up/drop off points along major city roads. A flat average fare of Rs 10 per passenger is charged.

Figure 2-20: Sikkim Nationalized Transport Bus

Figure 2-21: Personalized and Shared Taxis in Gangtok

2.8.5. Mode Share

The share of personal vehicles and taxis combined is 96% of Gangtok's total vehicles. City buses have a share of less than 1%. The share of goods traffic is about 3.7%.

Chapter 3 : APPROACH AND METHODOLOGY

3.1. Study Approach

The study has been divided into three phases

1) Inception Phase
2) Interim Phase
3) Project Findings and Recommendations Phase

The tasks to be performed under various phases are shown in Figure 3.1 and described in the following sections:

3.2. Inception Phase

The inception report covers the methodology along with timeframe for the study. Review of existing transport and urban planning related studies shall also be conducted in this phase. Collection and Analysis of secondary data, Reconnaissance Survey and stakeholder consultation shall be done in this phase. The inception report contains detailed work plan.

3.2.1. Review of Past Studies

The inception phase consists of reviewing past studies related to urban planning and transport (refer section 1.5). Followed by review of past studies is the task of secondary data collection through various sources and reconnaissance survey.

3.2.2. Secondary Data Collection

The secondary data collection will involve collection of

- Area profile topography: The profile of the project area: The topographical characteristics to be studied which includes the topographical base map, land cover, elevation map, relative relief map, degree slope map etc.
- Socio economic profile: Population density, spatial distribution of population, working population and all other socio economic indicators (spatial temporal distribution).

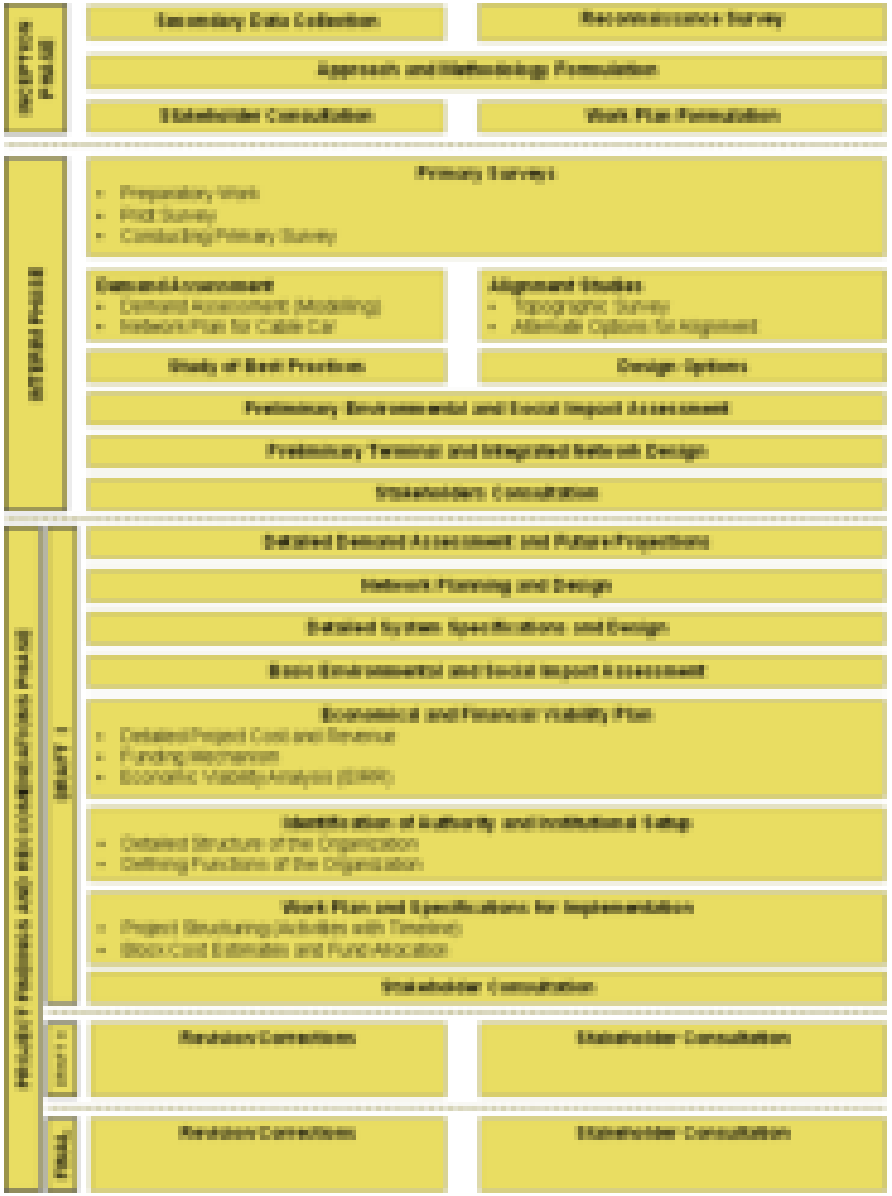


Figure 3-1: Detailed Study Methodology

- Land use: The Land use pattern and development.
- Road network and mode share (secondary sources)
- Master plans or development plans

The secondary data collection is followed by completion of detailed methodology and initial discussion with the officials/stakeholders.

3.3. Interim Phase

The interim phase consists of traffic surveys and analysis, alignment study and system selection followed by basic environment and social impact assessment for the same. Also the preliminary terminal designs and feeder network planning would be done.

3.3.1. Primary Surveys

The primary surveys exercise involves preparatory work (i.e. preparation of survey formats, data collection techniques, team building etc.), pilot survey (i.e. pilot survey at site for rectification of forms/ data collection technique etc.) and detailed primary surveys (data collection as per rectified data forms and its digitization etc.). The purpose of Primary surveys is to ascertain traffic and travel behavior related information (refer table 5).

A) Traffic surveys:

- The primary data collection involved collection of
- Traffic volume count (on links) and vehicle composition
- Travel pattern (Roadside interview for OD matrix) and Occupancy

- Speed and delay
- Willingness to pay and shift (Survey for willingness to pay for new mode and shift).

B) Other surveys:

- Household Survey
- Tourist Surveys

C) Alignment surveys:

Alignment Surveys are required to be done to identify and map the contours of the ground and existing features on the surface (i.e. trees, buildings, streets, walkways, manholes, utility poles, retaining walls, etc.). The purpose of the survey is to serve as a base map for the alignment finalization.

The surveys required for ascertaining site suitability of Alignment include

- Reconnaissance survey and
- Topographical surveys (which will provide contour map, relative relief map etc.)

3.3.2. Data Analysis

A) Travel Behavior and Pattern: The data analysis from 'Traffic volume count' and 'Road side interview' is done to obtain mode-wise volume of traffic, composition, hourly variation, directional flow and preferred route and mode of people.

The travel pattern is ascertained by trip origin-destination details of both regular commuters and tourists from the household survey. Also the cost and time associated is analyzed, followed by analysis of 'willingness to Pay and shift to new transit mode i.e. Cable car from the 'Willingness to pay' survey.

B) Identification of Gaps and Issues: Followed by the preliminary analysis and identification of issues and gaps is done by the analysis of primary data to ascertain:

- Mobility issues (level of service by public transport services i.e. lack of infrastructure etc., problems faced by private vehicle like congestion, delay etc.)
- Accessibility issues (Service coverage of public transport (bus) in the city, Transit-transfer issue, Fare issue and affordability etc.)

C) Preliminary Demand Assessment: The travel demand estimation is done by 'four-stage transport demand modelling' for estimating future travel demand. The normal and easily available planning variables at zonal level (zonal here refers to traffic analysis zone) such as population, employment and student enrolment would be used for transport demand analysis. The basic functions in the transportation planning process are:

- Trip-end prediction or trip generation and attractions – the determination of the number of person trips leaving a zone irrespective of destination and the number of trips attracted to a zone, irrespective of origin.
- Trip distribution – the linking of the trip origins with their destinations.
- Modal split – the separation of trip by public transport modes or by private modes.
- Assignment – the allocation of trips between a pair of zones to the most likely route(s) on the network.

The base-year transport demand model is developed using the results of the travel diary in household survey. Modeling provided a quantitative and scientific approach to improving mobility.

The modeling will emphasize person-based travel patterns, along with vehicle movements and include impact of mode shift rather than conventional predict and provide strategy. Alternate scenarios were developed with different alignments and demand projections. The alignment suited to cater the public transit trips is taken further for technical evaluation.

3.3.3. Network Planning/Alignment Finalization

The process for developing the cable car routes consisted of: Identifying the important nodes and connecting all the nodes at the minimum distance and then evaluating the technologies. The network planning is done on the basis of:

- Demand along the alignment
- Integration with other service i.e. Bus services and Regional Taxi service (development of multi modal interchanges if possible)
- Optimum technology (as per current and projected demand).

The alignment options and respective block cost(s) associated would be provided both subject to scrutinized and approved by the stakeholders. The major activity nodes as per discussion with officials are:

- Tashiling Secretariat
- PWD Complex
- Hospital at Sichey
- District Administrative Complex
- Helipad
- Sikkim Manipal Hospital
- Tourism Office Complex
- Taxi Stands (Ranipool, North District)
- Denjong Cinema (and MG Road)

3.4. Study Findings & Recommendation Phase

The 'study finding and recommendation phase include detailed demand estimation for finalized alignment, network and system specification, Identification of authority and institutional setup which includes detailed structure of authority and institutional setup, Specification of legal framework for operations and maintenance (and agency responsible). Also, environmental impact assessment is done to compare the emissions caused by cable cars and other means of transport. A socio economic impact assessment to assess impact of the project to the residents of Gangtok is also included. The detailed Economical and Financial Viability Plan which include detailed project cost and revenue, funding mechanism, economic viability analysis (EIRR) etc is also provided. The work plan and specifications for the implementation include project structuring (activities along with timeline and block cost estimation and fund allocation).

3.4.1. Rationale for System selection and Design Principles

A) Best Practices: The analysis of various technologies used in cable cars in India and abroad and suggestions are given for the best suited technology for the cable cars as per design standards that can be easily integrated with the existing stations and the city.

B) Design Options and Operational Characteristics: The system selection is done on the basis of Technologies available (Monocable Gondola System, Bi-cable Gondola System or Tri-cable Gondola System (3S) etc.) and as per site suitability the design and area requirement of network components i.e. stations / terminals etc. is determined.

The system design, fleet requirement (Gondolas), line speed, frequency, operating hours etc. is determined after the primary data interpretation and demand assessment.

3.4.2. Terminal Design

This stage involved identification of areas, planning and designing of new multimodal interchanges, stations and also integration of existing public transport services with cable car. The integration is suggested on the basis of various parameters:

- Physical Integration by Mode: Connectivity with other transport services i.e. Bus and regional taxi services. Multimodal interchange station is developed for the same.
- Barrier free circulation
- Incorporation of ICT facilities.
- User information: Passenger information data available at multi modal station.

3.4.3. Feeder Network design

The feeder network is suggested for the proposed alignment. The feeder network is having coordinated time tables, convenient transfer facility for network to be effective. The feeder network design depends upon the availability of suitable feeder public transit / para-transit system.

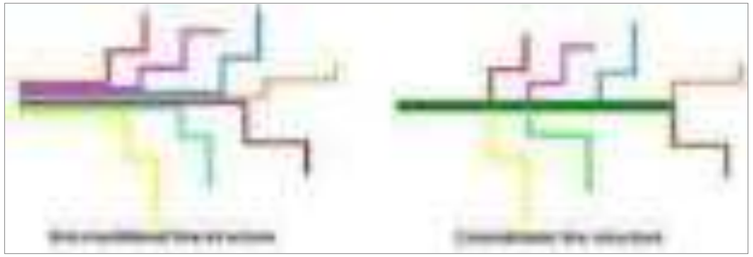


Figure 3-2: Trunk Feeder Network Concept

3.4.4. Environmental and Social Impact Assessment

The basic environment and social impact assessment on the environmental & social elements would be carried out. The implementation of a system like the cable car will not only dramatically help decrease the carbon emissions in Gangtok, but also will lead to a better urban transportation planning in the city that will catalyze the economic and social development. The internal vehicular traffic of the city will decrease along with the carbon emissions and resulting in environmental improvements. The emission reduction, economic development opportunities and areas etc. are ascertained.

Introduction of Cable car system and provision of commercial activity within the station area will bring about a number of socio-economic benefits to the residents of Gangtok such as better urban mass transit facility, better quality of life and employment generation through economic development. The basic impact analysis is done.

The terminal / stations etc. are sited on land under public domain (preferably) or vacant sites. Hence there is less impact envisaged due to land acquisition of private land. However temporary loss of livelihood, relocation during construction, demolition of government properties (if any), removal of encroachers etc. are foreseen during various stages of project implementation. The impact assessment of the same is done after the finalization of the alignment and evaluation of the stakeholders.

3.4.5. Detailed Economic and Financial Analysis

A financial model is prepared to estimate the fiscal implications on the implementing agency (in terms of capital and operating cost) and various ways to decrease the financial risks through various innovative methods of funding like property development, advertisement revenue, third party funding, viability gap funding etc. The financial viability of the proposed system in terms of FIRR and NPV is ascertained. The economic viability in terms of EIRR is ascertained to evaluate the economic benefit of moving people via cable car in the city.

3.4.6. Institutional Framework

This involves identification of the authority and institutional setup for the cable car system infrastructure. For efficient implementation and long term regulation of the project, a regulatory authority needs to be set up. The authority will govern the functioning of the Metro Cable system at a policy and regulatory level. Prominent positions in the government's institutional framework pertaining to transport, need to be a part of the authority.

The Study Findings & Recommendation Phase is followed by consultation with the officials/stakeholders and finalization of final report.

Chapter 4 PRIMARY DATA COLLECTION AND ANALYSIS

4.1 Primary Data Collection

A set of primary traffic and other surveys such as House Hold Interview Survey, Origin – Destination surveys, Traffic Volume Counts, Speed and Delay Surveys, Vehicle Occupancy Survey, Tourist survey etc. were conducted in the study area (GMC boundary) during September -October 2016 to assess the demographics, employment, traffic and transport scenario

Table 4-1 provides details of the primary surveys such as type of primary surveys conducted and there purpose, no. of locations at which each type of survey was conducted, dates on which these surveys were conducted etc. Further details of these surveys are provided in the Annexures. Summary of the analysis with regard to each type of survey is presented in the following sub-sections;

Table 4-1: Details of Primary Surveys Conducted during the Study

SN	Type of Survey	Location/ Sample Size	Day of week	Purpose	Pilot Survey Date	Final Surveys Date
1	Classified Traffic Volume Count	8 Locations (At Mid Blocks and outer cordon)	Normal Working Day (16 Hours)	To obtain mode-wise volume of traffic, composition, hourly variation, directional flow and preferred route and mode of people.	27-Sep -2016	29-Sep -2016
2	Road Side Interview (OD Survey)	8 Locations (At Mid Blocks and outer cordon)	Normal Working Day	To gather information on travel characteristics, trip origin-destination details, Travel preferences (in group/individual)	29-Sep -2016	30 Sep-2016
3	Household Survey	In selected TAZs. Sample size of 5 % of the total population using Simple random sampling technique	Normal Working Day	To gather information on Household characteristics, socio-economic characteristics and travel characteristics such as trip origin-destination details, travel characteristics	24-Sep -2016	24 Sep to 1 Oct -2016
4	Establishment Survey	In all/selected TAZs. Sample size is 20 % of the total establishments using Simple random	Normal Working Day	To gather information on the establishment type & size, employees details etc.	24-Sep -2016	24 Sep to 1 Oct - 2016

SN	Type of Survey	Location/ Sample Size	Day of week	Purpose	Pilot Survey Date	Final Surveys Date
		sampling				
5	Willingness to Pay Survey -	500 Samples At selected activity centers only	Normal Working Day	To obtain data pertaining to respondent profile, trip origin-destination details, And other travel characteristics. To gather information of willingness to pay and shift to the new mode	25-Sep -2016	30 Oct, 3 Oct - 2016
6	Speed and Delay Survey	30 kms for each mode (selected major roads)	Normal Working Day	To collect data of travel speed and delay, travel time.	27-Sep -2016	28 Sep, 30 Sep -2016
7	Tourist Survey	Major attraction points	Weekends	To obtain, trip origin-destination details, travel preferences.	25-Sep -2016	1 Oct, 2 Oct-2016
8	Reconnaissance Survey	GMC area	Weekday	To obtain topographical details, Line of Sights etc		
9	Topography Survey	10		Detailed topographic and Physical Characteristics		

4.2 Summary of Primary Data Analysis

4.2.1. Classified Traffic Volume Count

- The share of taxis is observed to be maximum in the city ranging between 45 % to 60 % at different locations.
- The share of private cars is also significantly high, the range observed was between 26 -33%.
- The share of two wheelers range of 7 – 11%.
- The morning peak hour is observed between 09:00 am to 10:00 am which accounts for 8.4% of the total daily traffic.

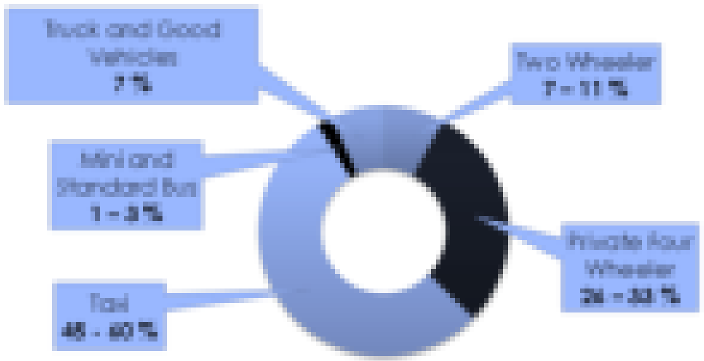


Figure 4-1: Vehicle Composition in Gangtok

- The evening peak hour is observed between 5:15 pm to 06:15 pm which accounts for 8.6% of the total daily traffic.
- The inner city area (Areas adjoining the MG Marg, SNT bus stand etc) experience maximum flow i.e. more than 1200 PCU in Peak hour. The points at the outer cordon have a traffic volume of 400- 600 PCU in peak hour.

4.2.2. Road Side Interview (At outer cordon and Mid-block)

- Trip frequency: It was observed that 94% of the trips are daily trips whereas 6% are weekly or monthly trips.
- Trip Purpose: It was observed that at outer cordon points, 80% of the trips are work based trips, 7% are education based and 13% trips are miscellaneous.
- Occupancy: The average occupancy of two wheelers, cars and Taxis observed at the mid blocks (traffic flowing within GMC area) was 1.71, 2.24 and 2.32 respectively.
- The average occupancy of two wheelers, cars and Taxis was at the outer cordon (Traffic from external zones to GMC area and vice versa) is 1.59, 2.01 and 2.16 respectively.
- **Average Trip Length**: The average trip length of car, taxi and Two wheelers (Traffic from external zones to GMC area and vice versa) is 9.2 km,10.7 km and 9.5 km respectively.
- **Average Trip Cost:** The average trip cost of work based trips and education based trips of traffic flowing within GMC area – Internal to Internal zones is Rs. 45 and Rs 30 respectively.
- The average trip cost of work based trips and education based trips for traffic flowing to GMC area – Internal to External zones is Rs. 275 and Rs. 67 respectively.

4.2.3. Household Survey

- The average household size is 4.98
- 16% of surveyed population is below the age of 18, 44% are in the age range of 18-35.
- 26% out of total income distribution is in the of range Rs. 0 – 10,000 (from slum dwellers, Muster roll workers etc). Around 48 % varied between Rs. 10001- 20000 (government salaried) whereas 13% residents have average salary of Rs. 20000 -25000 comes from business sectors. Almost 13% above 25000 is from section of government contractors and bureaucrats.

- 44% of home based work trips are made by walking, 43% are made using taxi whereas the car users are 8% only
- 53% of home based education trips are made by walking, 40% are made using taxi whereas the car users are 3% only.
- The average trip length of car, taxi and Two wheelers (traffic flowing within GMC area – Internal to Internal zones) is 3.1 km, 2.9 km and 3.7 km respectively.
- The average trip length of car, taxi and Two wheelers (Traffic from external zones to GMC area and vice versa) is 5.1 km ,10.8 km and 2 km respectively
- The average trip cost of taxi user (traffic flowing within GMC area – Internal to Internal zones) is Rs. 22.5.

4.2.4. Establishment Survey

- 23% of the total establishments can be seen in Upper and Lower MG Marg.
- 80 -90% of the establishment developed in last decade are of commercial typology, whereas other categories i.e. education, office (government/semi government) have grown uniformly.
- 80% of the commercial establishments are of retail typology (eg. Sale of domestic goods and grocery), restaurants and hotels. Very few are providing service/consultancy but all zones are well served by all types of commercial activities and services.
- More than 40% (of the total establishment) have come up in the last ten years (15% in last five years). This shows a slightly higher growth rate in comparison to the previous decade.
- 67% of the establishment that have come up in last decade are of 'rental' typology, Rental properties in general has increased over time as compared to the owned ones.
- All the wards have experienced employment growth in last decade as a result of area development and demand of commercial sector. Maximum can be observed in Diesel Power house, Lower and Upper MG Marg, Development area and Lower Sichey ward. Employment is generated even in establishments older than 5 years.
- The maximum footfall i.e. 12000 persons/day is observed in Upper and Lower MG Marg followed by Tadong and Tathangchen Syari.

4.2.5. Willingness to pay

The willingness to pay surveys shows that

- More than 27% commuters are willing to pay 25% more than their existing travel cost (for travel time saving of 5 -10 Mins)
- 53% commuters were willing to shift, provided the cost of travel is same as their existing mode
- 63% commuters expect a travel time saving of 5 minutes in their total journey time, whereas distant commuters wanted a saving of 5 – 10 minutes.

- Sensitivity of travel time saving was high and commuters are Willing to pay for travel time saving of 5-10 minutes.

4.2.6. Speed and Delay Survey

- The average speed of Taxi, private four wheelers and two wheelers is 22kmph, 18kmph and 26 kmph respectively.
- The road sections on the national highway 10 i.e. along Deorali, Upper and Lower MG Marg are critical, the average speed being 15 kmph – 18 kmph.

4.2.7. Tourist Survey

- Gangtok attract tourist from all over India, but major incoming is from West Bengal, Uttar Pradesh, Bihar and Delhi, followed by Rajasthan, Gujarat and Punjab. The Tourist are majorly in groups of two to five persons, the average group size being 3.5.
- The average stay duration of tourist group is more than 2.65 days.
- All the tourist trips are planned keeping in mind one major tourist destination while covering to adjoining sites as well.
- The mode of travel in all the cases was found to be Shared taxis (For smaller commute) and Reserved taxis (reserved for one full day) for 9:00 am to 6:00 pm.
- Trip(s) cost for reserved taxi varied between Rs. 500 and Rs. 5000 (for 5 to 9 hours) with average cost being Rs. 2300 (Approx).

4.3 Inferences

The inferences from the data analysis with regard to this study are listed as under;

- High share of shared taxis confirms the existence of substantial public transit demand and implies the need for an organized public transport system;
- Majority of the trips are daily work trips half of which are currently performed by share taxis, implying consistent public transit demands;
- Average trip cost of taxi users is Rs 22.5 for an average trip length of 2.9 kms which is substantially high, which implies that the residents of Gangtok have a good paying capacity and would comfortably pay for an organized and reliable public transit system;
- Uniform employment growth across all wards in Gantok implyies uniformly distributed public transit demand along the entire high demand transit corridor
- Willingness to pay and shift in favor of Cable Car system is high even at same or slightly higher trip cost, inferring high acceptability of Cable Car system providing reliable, comfortable and fast services

Chapter 5 NETWORK PLANNING & DEMAND ASSESSMENT

5.1. Introduction

An urban transport model to replicate the GMC area transportation system (roads, congestion delays, transit system, etc.) is developed with a state-of-the-art software and modelling technology. This model can be used for forecasting, using altered model inputs to reflect future year conditions. By simulating roadway conditions and travel demand on those roadways, deficiencies in the system can be assessed. Potential major future network enhancements such as introduction of Public Transport, land use modifications and Other Transport Strategies can be analyzed by this tool and its efficacy can be established at a planning level.

Several software programs are available for developing travel demand models. The Gangtok transport model is developed using PTV VISUM (Version 14) software (a state-of-the-art Travel Demand Modeling software).

5.1.1. Study area and its delineation

The study area comprises of Gangtok Municipal Corporation Area (GMC) having an area of 19.28 sq.km. It has been subdivided into smaller physical units, termed as Traffic Analysis Zones (TAZs) to facilitate understanding of travel pattern within the study area. Consultant have chosen current municipal wards as TAZs for which demographic, socio-economic and other planning data is readily available from secondary sources.

5.1.2. Internal zones

The Gangtok Municipal Corporation (GMC) area is divided into 17 TAZs (17 Wards) as per prevailing demarcation of municipal wards. These wards are taken as internal zones

5.1.3. External zones

Regions beyond the GMC area have been delineated into external zones based on the catchment of the existing transport links feeding into the study area. Traffic coming from these areas are entering the study area from 3 points i.e. Ranipool, Burtuk and Chandmari.

5.1.4. Horizon period

Year 2016 is considered as Base Year. The demand forecasts for the horizon years have been considered for 2051. Therefore, for the purpose of sequential planning and design of the systems, the travel demand forecasts have been presented for the years 2021, 2031, 2041 and 2051.

5.1.5. Preparation of Data Base

Data required for the analysis of travel demand can be categorized into three types.

- Planning variables
- Transport network
- Travel Demand and Characteristics

The base year data is summarized in the following sections.

A. Planning Variables

Planning variables i.e. population and employment are some of the important data required for estimating the travel demand generated at zonal level. Base year demographic data is obtained from the Census and GMC database. Zone wise employment is collated from various published reports and primary surveys.

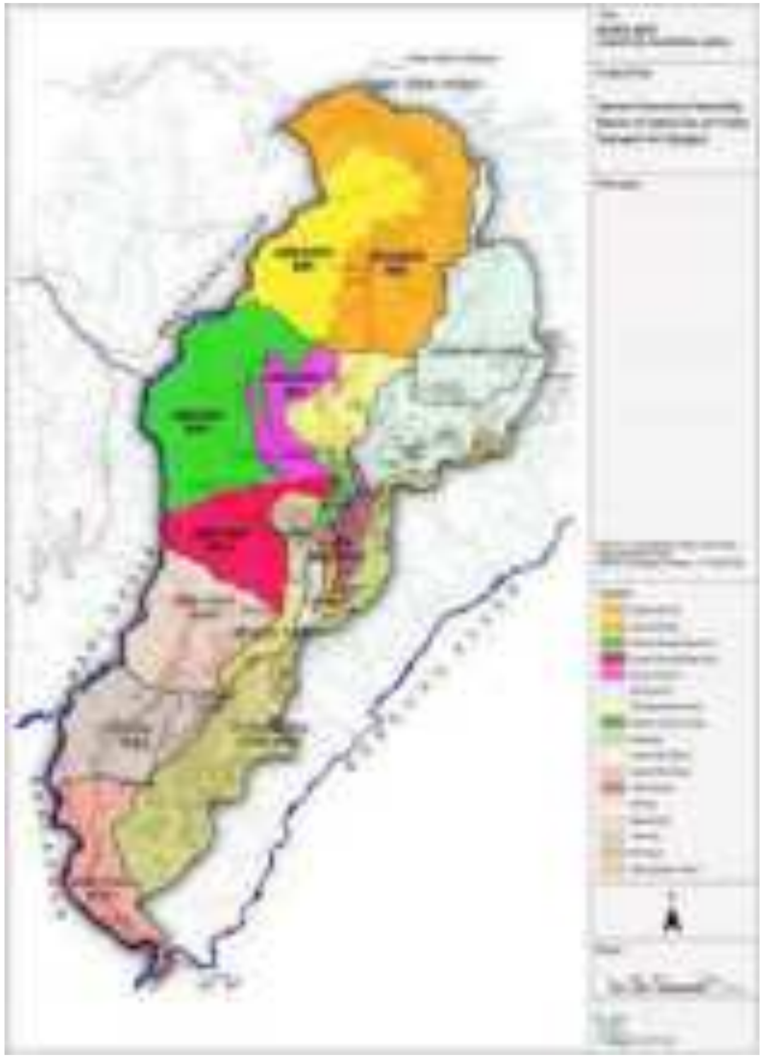


Figure 5-1: Traffic Analysis zones in study area

B. Transport Network

The transport network in the study area includes road network and public transport network. All the characteristics of the road links are coded i.e. length, carriageway type (divided/ undivided), type of circulation (one-way/ two-way), number of lanes, average speed, capacity etc.

Public Transport Network includes all roads on which public transport buses operate. Details of bus routes, frequencies, seating capacities and fares have been collected and coded. In addition, in this study, Taxi is considered as an intermediate public transport and is made available on the road links. The road network is properly connected to all zone centroids by means of dummy links.

5.2. Strategic Model development

The model is based on a conventional 4-stage transport modelling approach which includes:

- **Trip Generation -** calculation of the number of origins and destinations for each zone.
- **Trip Distribution -** attaching the origins and destinations for complete trips.
- **Mode Choice -** determination of the mode for each trip (TW, car, Intermediate Public Transport (IPT), Public transport).
- **Assignment -** assigning passengers to their respective highway and transit networks.

5.2.1. Trip Generation

The analysis and the model building phase starts with the step commonly known as Trip Generation. This is the term used in the transportation planning process to estimate the number of trip ends in a given area (i.e., how much travel; for example, either from homes or workplaces). The objective of the trip generation stage is to understand the reasons behind the trip making behavior and to produce mathematical relationships to synthesize the trip making behavior and to analyze the trip making pattern on the basis of observed trips, land use data and the household characteristics.

For this study:

- All the existing trips on the project stretch have been considered for the base year. This is arrived through the Household Survey (travel diary), Volume count survey and Road side interview conducted in the study area.

- All the proposed developments and their scale of developments have been captured to estimate future trip generations within the study area.

Trips are usually divided into two types i.e. home-based and non-home based trips. Home-based trips are those having one end of the trip either origin or destination at home, of the persons making the trip, the home based trips are further classified as home based work trips, home based education trips and Home based other trips. Non home based trips are those having neither start nor end at home of the person making the trip. (The volume of non-home based trips was less than 1%, therefore these trips are not considered in regression exercise). The base year planning variables and Trip generated are shown in Table 5-1.

Table 5-1: Base Year (2016) Planning Variable

Base Year (2016) Planning Variables	
Population 2016	1,22,013
Employment 2016	43,300
Trips Produced in Base Year	
Home Based Work	69,699
Home Based Education	66,658
Home based Others	7,761

Based on the correlation between the Planning Variables and the trips produced, the trip production and attraction equations are developed. They are shown in Table 5.2.

Table 5-2: Correlation equations

Trip Type	Productions/Attraction Model	R^2 value
Home based Work Trips		
Production	0.561*(Population) + 83	0.85
Attraction	0.543*(Employment)+28	0.75

The regression exercise showed a good correlation between planning variables and trip generated. The regression plot has been represented in Figure 5-2 to Figure 5-7.

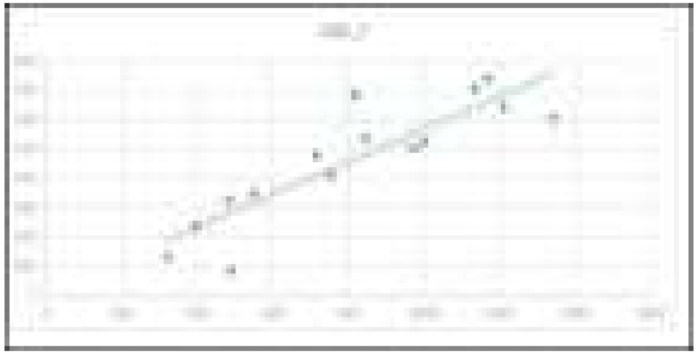


Figure 5-2: Home Based Work Production

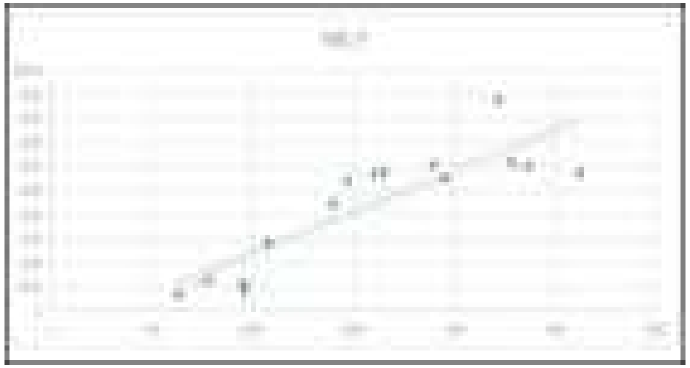


Figure 5-3: Home Based Education Production

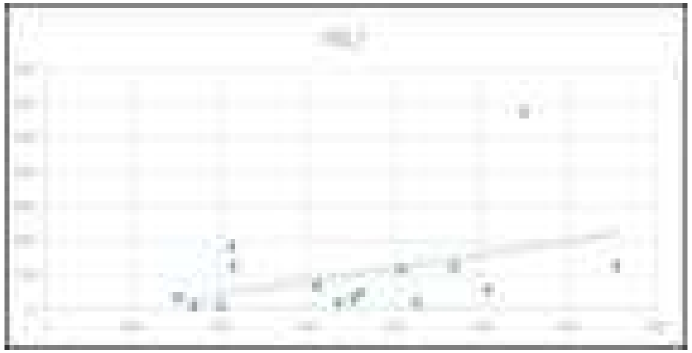


Figure 5-4: Home Based Others Production

Figure 5-5: Home Based Work Attraction

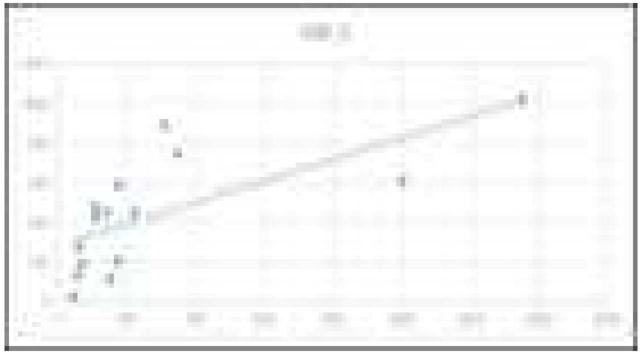


Figure 5-6: Home Based Education Attraction

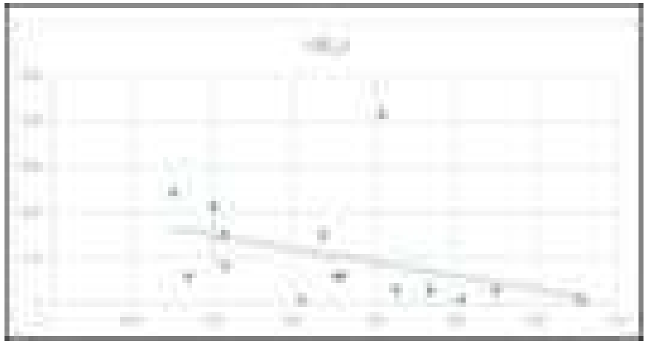


Figure 5-7: Home Based Others Attraction

5.2.2. Trip Distribution

Second stage is Trip distribution or interchange. In this stage the spatial interchange of trips is modeled (from where to where). Trip distribution modeling is done based on the observed travel pattern which was analyzed from the OD survey and passenger survey. OD matrix for the entire horizon year was developed at this stage. In this study doubly constrained gravity model has been used.

This model originally generated from an analogy with Newton's gravitational law. Newton's gravitational law says, $F = GM_1M_2/d_2$, Analogous to this $T_{ij}=C\ OD/C_{ij}$, introducing some balancing factors

$$T_{ij}=A_i\ O_i\ B_i\ D_i\ f(C_{ij}),$$

where A_i and B_i are the balancing factors,

$F(C_{ij})$ is the generalized function of the travel cost.

This function is called deterrence function because it represents the disincentive to travel as distance (time) or cost increases. For calculation of deterrence function, the 'combined function' i.e. combination of exponential and power function is used in this study. The form of the model is such that power (a=0) or exponential (β=0) functions may be used for the deterrence function. The inclusion of both a and β represents a gamma function, sometimes called a Tanner function.

The base year (2016) Productions and Attractions obtained from the corrected O-D matrices, skim matrices from network and the calibrated function parameters were used to generate synthetic matrices in Visum.

The Trip length distributions from Observed/Corrected and Synthetic O-D matrices were calculated and comparison graphs are shown in. The average trip length obtained from the model is presented in the Table 5-3.

Table 5-3: Average Trip Length (Estimated and plotted)

Trip Distribution	Avg. Motorized Trip Length (survey)	Avg. Motorized Trip Length (Plotted)
Home Based Work Trips	4.7 km	4.7 km
Home based Education Trips	4.91 km	4.9 km
Home based Others Trips	4.3 km	4.3 km

5.2.3. Modal Split

Third stage is related to modal split (which modes are used). This depends upon the observed relationship between modes used in relation to personal characteristics, trip characteristics and mode characteristics.

- For base year model, the existing Modal share (as derived in Household Survey) has been used.
- For horizon year models, the modal share as derived from 'willingness to pay and shift', PT & IPT Stated Preference Surveys etc. was used.

The Modal share of Base year (as captured in primary surveys is shown in Table 5-4.

Table 5-4: Modal Share (Base Year 2016)

Code	Mode	HBW	HBE	HBO

Code	Mode	HBW	HBE	HBO
1	Bus	0.07%	1.38%	0.07%
2	Car	7.72%	3.04%	7.72%
3	Govt car	0.21%	0.00%	0.21%
4	Mini bus	0.14%	0.00%	0.14%
5	Mini van	0.14%	0.00%	0.14%
6	Taxi	43.59%	40.39%	43.59%
7	Truck	0.21%	0.00%	0.21%
8	Two wheeler	3.79%	1.66%	3.79%
9	Walk	44.14%	53.11%	44.14%
10	School bus	0.00%	0.41%	0.00%

For horizon years modal split, Utility expression was assigned to each OD matrix for various vehicle users.

Trips with maximum score for Cable Car were then derived for each of the OD matrix to arrive at the daily travel demand for proposed Cable Car system. For mode choice, following assumptions have been considered while deriving the utility equation: -

- People being sensitive towards time saving (More than 90% samples have chosen 5-10 mins saving for shift.
- For the aforementioned travel time saving they are willing to spend same cost or 25% extra cost.
- The 'comfort' factor have been included i.e. derived from access, egress and waiting time. Provided the out of vehicle time is less than the existing scenario, there was willingness to shift in favor of cable car system.

The utility equation used for the mode choice is:-

$U(m) = constant + (b_1 * IVT) + (b_2 * Access\ time) + (b_3 * waiting\ time) + (b_4 * egress\ time) + (b_5 * Trip\ cost)$,

Where,

- IVT - In-Vehicle Time
- Access time - Total Time spent for accessing the mode
- Waiting time - Total Time spent Waiting for the vehicle
- Egress time - Total Time spent after alighting the mode
- Cost- Total Trip Cost,

Values of variables are shown in Table 5-5:

Table 5-5: Variable for Utility equation

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	In_vehicle_Tie_in	.010	.018	.311	1	.577	1.010
	Time_at_Home_to_Boarding_point_Min	-18.205	782.336	.001	1	.981	.000
	Waiting_Time_at_Boarding_Point_Min	-16.758	782.336	.000	1	.983	.000
	Time_from_alighting_point_to_Destination_Min	-18.842	782.336	.001	1	.981	.000
	Trip_Cost_for_Rs	.009	.012	.635	1	.425	1.009
	Constant	126.349	5476.349	.001	1	.982	7.46E+54
Independent variables taken are: In_vehicle_Tie_in, Time_at_Home_to_Boarding_point_Min, Waiting_Time_at_Boarding_Point_Min, Time_from_alighting_point_to_Destination_Min, Trip_Cost_for_Rs.							

5.2.4. Traffic Assignments

The test corridor was coded into the VISUM (Version 14) model with the network attributes as captured through inventory surveys and traffic and transit details from primary and secondary sources. The traffic volume originating from every zone in the network in terms of PCUs are given as per the site survey. The other properties such as free flow speed, vehicular speeds, permitted network speeds, lane capacities etc were provided.

The calibrated model is validated by comparison of field results and model output results. The ‘Multi criterion’ approach was followed for model validation. The zone to zone travel time at aggregate level were analyzed in all the trials till the error of less then 5% is achieved. The second criteria was traffic concentration at roads, quantitatively measured by flow at the mid blocks. This was validated by comparison of model outputs and field survey outputs (traffic volume survey at mid blocks) given in Table 5.6 and percentage error shown in *Figure 5-8*. The existing network was modeled, calibrated and validated based on real data from the field, including network geometry, traffic and transit operations. The final output from this process was a validated and calibrated simulation model of the existing conditions for peak hour (9 AM to 10 AM).

Table 5-6: Modeled and Field Survey Results Comparison

	Model values		**Survey values**	
	Towards N	Towards S	Towards N	Towards S
Ranipool Taxi Stand	395	288	362	295
St Paul Church	834	1119	810	1114
Sikkim Continental	1440	1094	1367	1069
Lower Sichey	240	269	225	288
Snt Bus Stand	831	744	826	727
Chandmari	368	488	383	472
NE Taxi Stand	480	931	490	928
Helipad	96	154	99	166

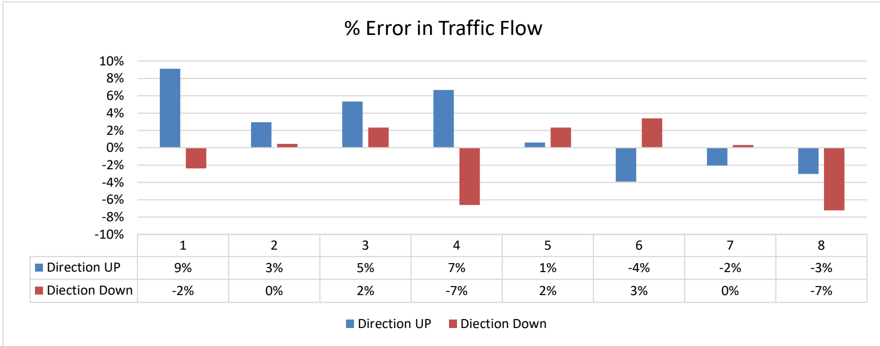


Figure 5-8: Absolute Error (%) in Traffic Flows at Various Mid-Blocks

5.3. Scenario specifications

This section describes various scenarios developed for understanding the future traffic conditions in Gangtok with and without Cable Car system. This would help in understanding the impact of Cable Car system in overall transportation system of the city. The scenarios developed are illustrated below:

1) **Base Year Scenario:** Describes the base year (2016) traffic characteristics and transit demand, the scenario is developed to understand the existing situation, which on comparison with future scenarios will help in understanding city’s development trend and how various zones are interacting with each other.

2) **Do Nothing Scenarios:** Describes the future year traffic characteristics and transit demand considering no major investments in transportation infrastructure of the city, thus helping in analyzing the efficacy of the existing network, and how it will perform under given conditions (increased demand). The problems such as congested network and increased travel time can be

identified and possible solutions/ interventions can be identified.

3) **Project Scenarios:** Describes the future year traffic characteristics with interventions such as introduction of Cable Car system as public transport mode in the city. This scenario is developed to understand how some intervention can impact the travel behavior thus bringing much relief to the people in comparison to "Do Nothing Scenario", the possible solution thus considered must be focused on relieving congestions and transit demand management.

5.4. Base Year (2016) Scenario

The base year scenario represents the present road network and current travel demand of the city. The interaction between traffic analysis zones based on the mode people choose will give fair idea about the travel behavior. This information allows transport agency / stakeholders to comprehend travel patterns and characteristics; measure trends; provide input to travel demand model development, forecasting, and planning for city-wide transportation infrastructure needs and monitor progress and changes due to implementation of transportation systems.

The network length considered is 88.22 kms and demand estimated is 1,44,117 total vehicular trips.

A. Analysis

Origin-destination (O-D) surveys (when plotted and visualized spatially) provide a comprehensive representation of the trip patterns and travel choices using all the existing modes of a city's or region's residents and floating population.

The data collected from the survey is translated into OD matrix and represented in the Figure 5-9. It can be analyzed that the city center i.e. MG Marg and adjacent areas are experiencing majority influx of traffic from southern side of the city and relatively lesser traffic from western and northern zones. Minimum traffic influx is observed from northern side of the city. The traffic distribution is analyzed through simulation modeling in Visum. The congested network and travel time are calculated for the base year. This data will be used for comparison while proposing the Cable Car system and other interventions based on the projected demand.

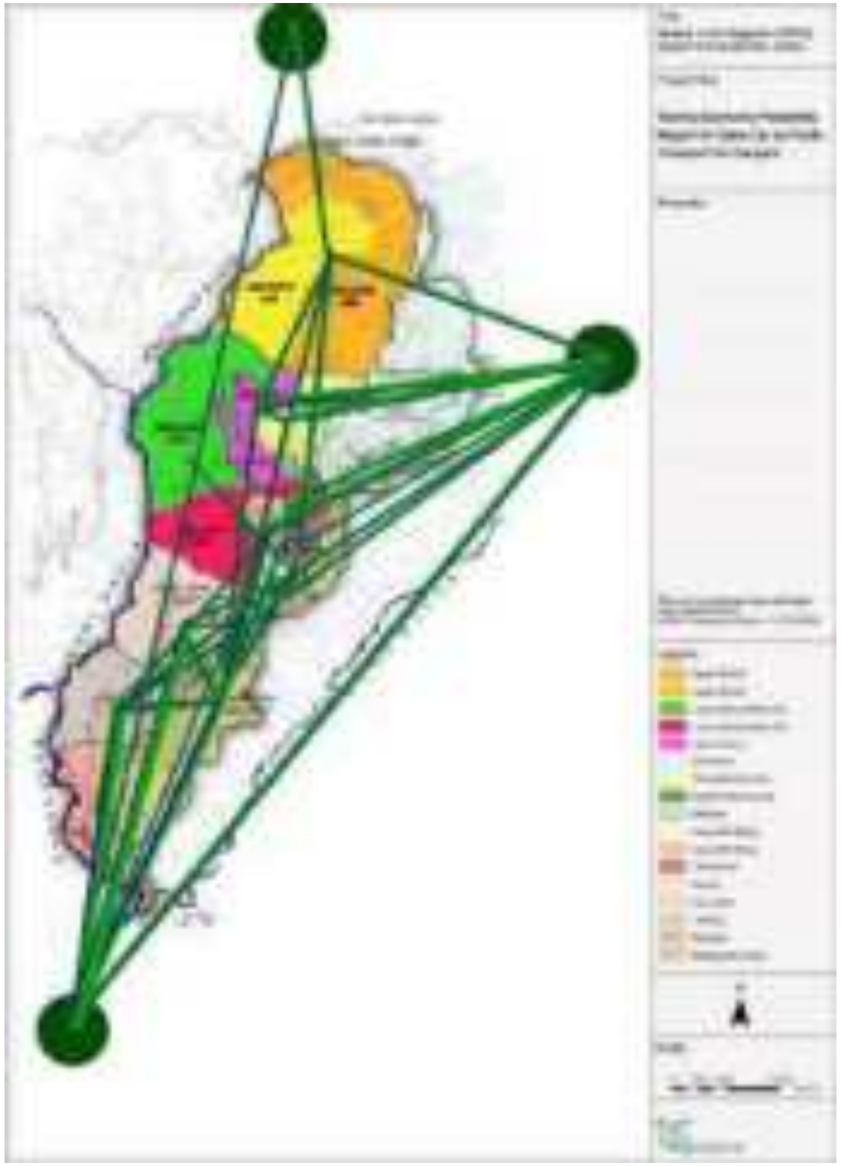


Figure 5-9: Desire Line Diagram (Do Nothing 2016)

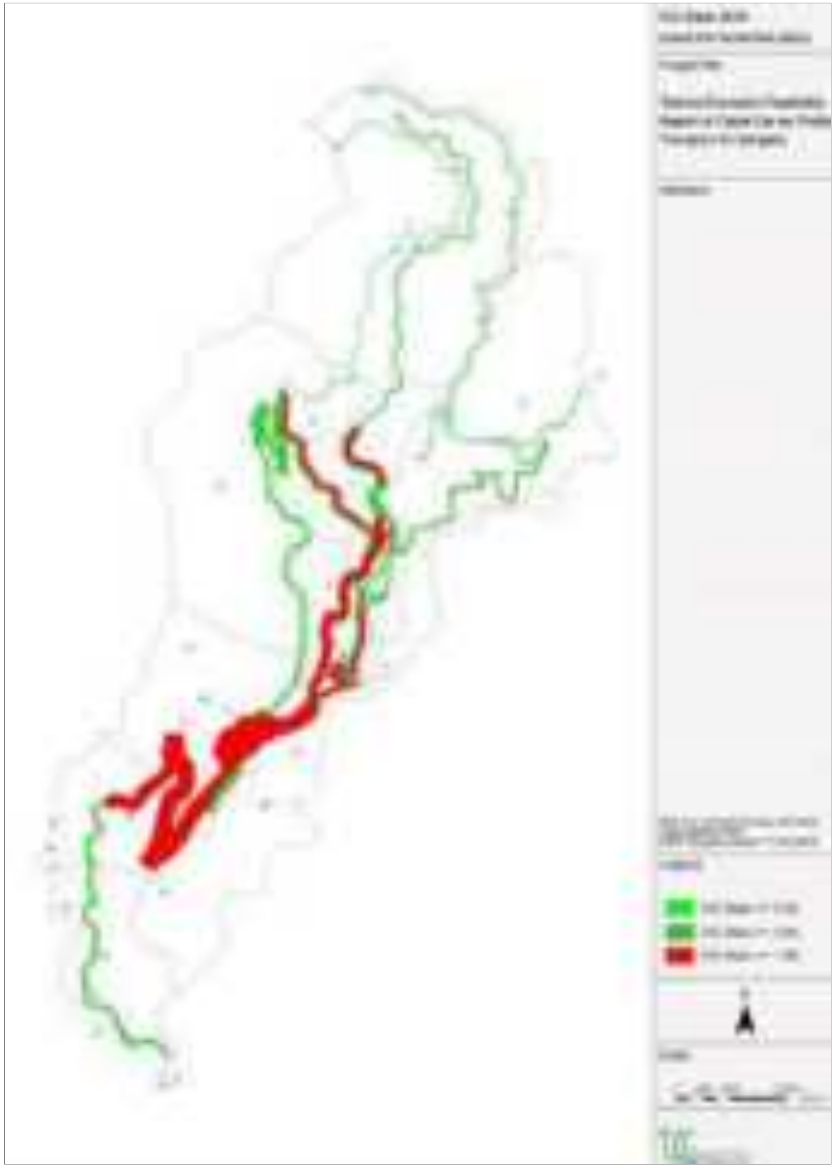


Figure 5-10: V/C Ratio Plotted on Base Year Network (2016)

The congested network (network length having volume to capacity ratio (V/C) more than 0.85) is found to be 18% as shown in Table 5-7and Figure 5-10

Table 5-7: V/C Ratios for the Road Network

V/C Ratio	% Network Length
0.00 – 0.25	21%
0.25 - 0.50	42%
0.51 - 0.85	19%
More than 0.85	18%

The average travel time for each type of modes (and purpose) are given in Table 5.8 below. The average travel time for home based work trips is found to be 18.0 – 19.5 minutes (excluding outer zones). The average travel time for Home based education trips is slightly higher than the former as the trips are made using taxi as a predominant mode.

Table 5-8: Average Travel Time During Peak Hours

Average travel time -(Peak Hour) – in minutes		
	Including outers zones	**Excluding outer zones**
Home based work trips		
Private Car	20.0	19.5
Taxi	20.0	19.7
Two Wheeler	18.5	18.3
Home based education trips		
Private Car	21.6	21.5
Taxi	22.6	22.4
Two Wheeler	19.9	18.3
Home based other trips		
Private Car	19.6	19.5
Taxi	20.6	20.0
Two Wheeler	18.38	18.25

Table 5.8 represents the Average Travel Time of the vehicles by purpose of the trip during the peak hour. Majority of home based work and education trips are made using shared taxi.

5.5. Do Nothing Scenario

The "Do Nothing Scenario" represents the present road network and projected future years travel demands of the city. The difference in interaction between zones in comparison to the base scenario can help in understanding the growing demand and whether the base network is efficient to cater to the future demands. The network length of 88 kms is same as in the base year and the projected demand for future years is derived from the regression exercise.

Origin-destination (O-D) surveys (when plotted and shown spatially) provide a comprehensive representation of the trip patterns and travel choices considering all the modes of a city's or region's residents and floating population for the future years

5.5.1. Do Nothing Scenario – Year 2021

The data collected from the trip generation exercise for 2021 (using regression modelling) and trip distribution (using doubly constrained gravity model) is translated into OD matrix and represented in Figure 5.11. It can be analyzed that the city center i.e. MG Marg and adjacent areas are experiencing most of the influx from all other zones. The incoming trips from western and southern zone (outer zones) have increased considerably. The traffic assignment is analyzed through simulation modelling in Visum. The congested network, travel time, are calculated for this model. The congested network (network length having V/C Ratio more than 0.85) is found to be 32% as shown in Table 5-9 and Figure 5-12.

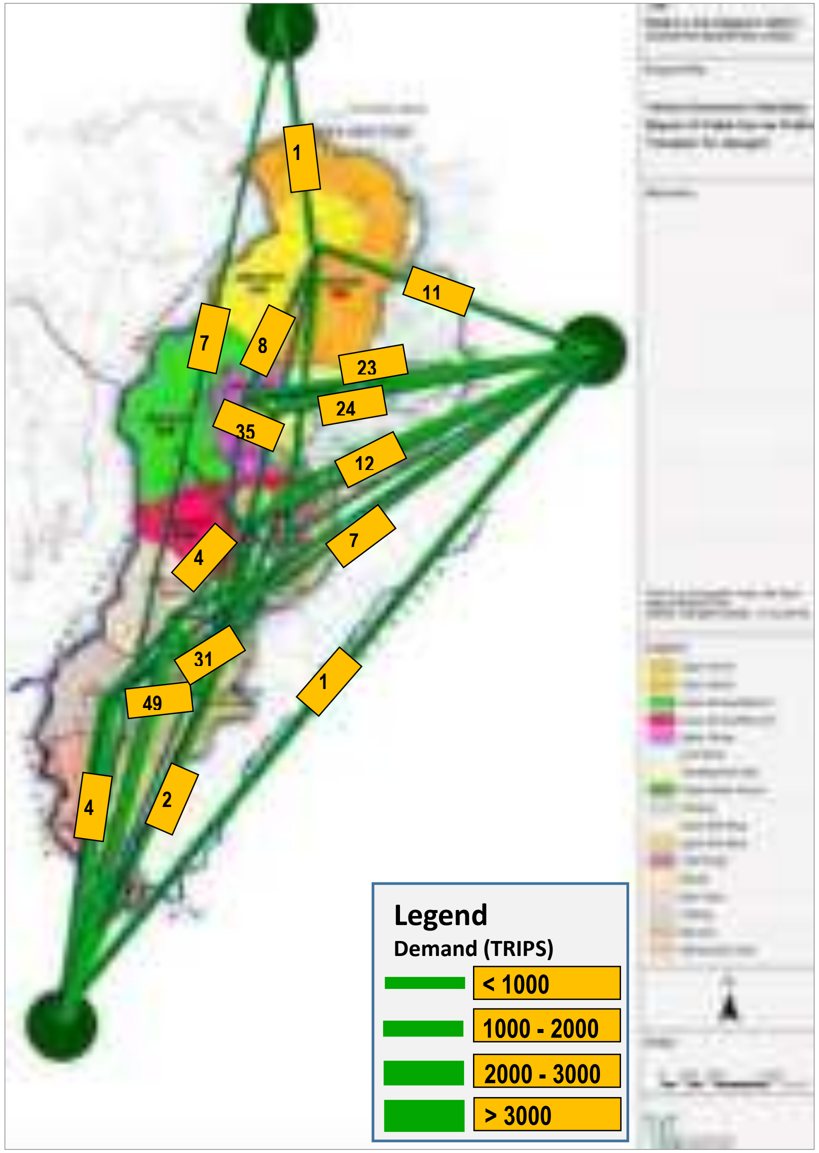


Figure 5-11: Desire Line Diagram (Do Nothing 2021)

Table 5-9: V/C Ratios for the Road Network In Do Nothing Scenario for Year 2021

V/C Ratio	% Network Length
0.00 – 0.25	21 %
0.25 - 0.50	22 %
0.51 - 0.85	26 %
More than 0.85	31 %

The average travel time for each type of modes (and purpose) are given in Table 5-10 below. The average travel time for home based work trips have increased to 23 – 25 minutes.

Table 5-10: Average Travel Time During Peak Hours in Do Nothing Scenario for Year 2021

Average travel time (Peak Hour) - mins		
	Including outers zones	**Excluding outer zones**
Home based work trips		
Private Car	32	24
Taxi	36	25
Two Wheeler	33	23
Home based education trips		
Private Car	27	22.6
Taxi	28	22
Two Wheeler	27	21
Home based other trips		
Private Car	23	22
Taxi	24.4	24
Two Wheeler	23	23

The vehicular distance travelled is shown in Table 5-11 below. Majority of home based work and Home based education trips are made using shared taxis.

Table 5-11: Total vehicle km travelled (full day) in Do Nothing Scenario for Year 2021

Total vehicle km travelled_DN_2021		
	Including outers zones	**Excluding outer zones**
Home based work trips		
Private Car	15505	14085
Taxi	76646	69917
Two Wheeler	11195	10532
Home based education trips		
Private Car	5096	5022
Taxi	63102	60200
Two Wheeler	5297	4282
Home based other trips		
Private Car	1639	1595
Taxi	8756	7920
Two Wheeler	1232	1193

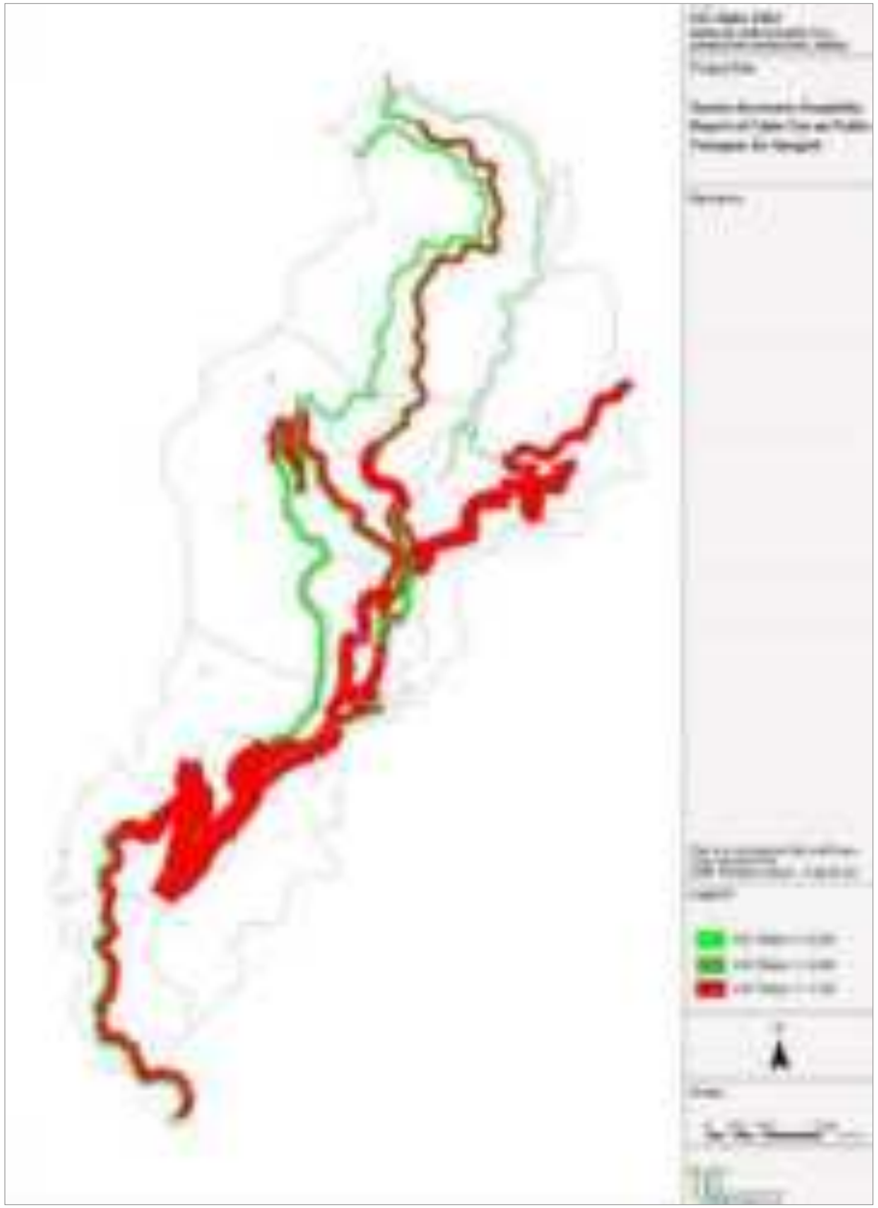


Figure 5-12: V/C Ratio in Do Nothing Scenario for Year 2021

5.5.2. Do Nothing Scenario – Year 2031

The data collected from the trip generation exercise for 2031 (using regression modelling) and trip distribution (using doubly constrained gravity model) is translated into OD matrix and represented in the Figure 5-13. It can be analyzed that the city center i.e. MG Marg and adjacent areas are experiencing most of the incomings trips from all the other zones. The incoming from western and southern zone (outer zones) have considerably increased. The traffic assignment is analyzed through simulation modeling in Visum. The congested network, travel time, are calculated for this model.

The congested network (network length having V/C Ratio more than 0.85) is 60% as shown in Table 5-12 and Figure 5-14.

Table 5-12: V/C Ratios for the Road Network In Do Nothing Scenario for Year 2031

V/C Ratio	% Network Length
0.00 – 0.25	27 %
0.25 - 0.50	3 %
0.50 - 0.85	10 %
More than 0.85	60 %

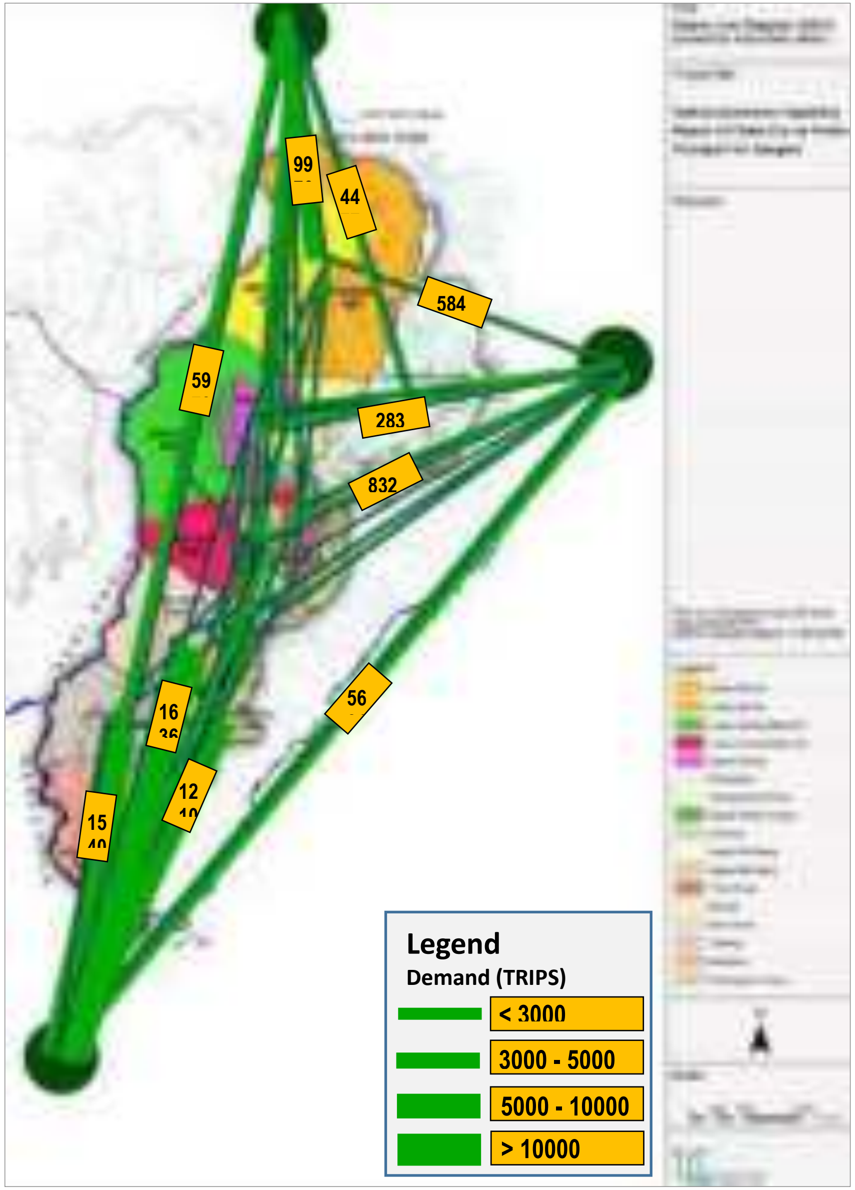


Figure 5-13: Desire Line Diagram (Do Nothing 2031)

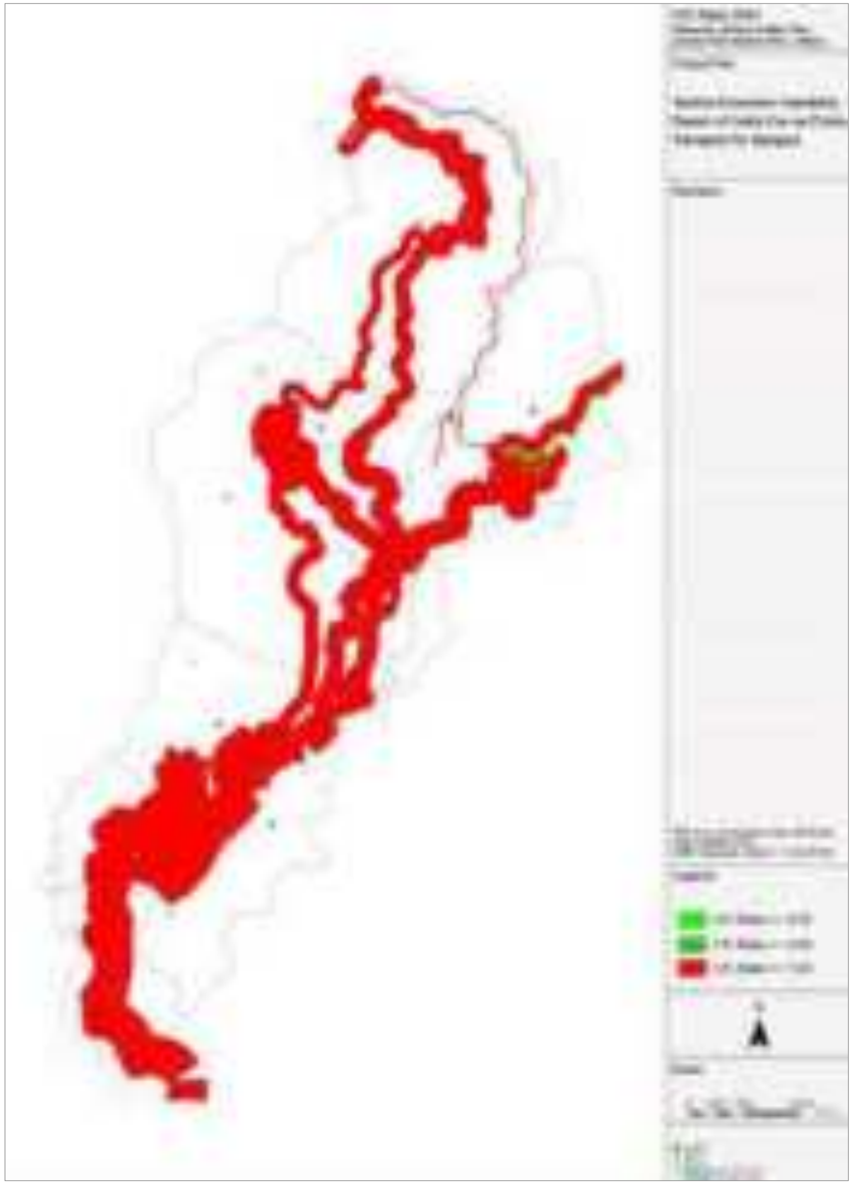


Figure 5-14: V/C Ratio in Do Nothing Scenario for Year 2031

The average travel time for each type of modes (and purpose) are given in Table 5-13 below. The average travel time for home based work trips have increased to 101-109 minutes.

Table 5-13: Average Travel Time During Peak Hours in Do Nothing Scenario for Year 2031

Average travel time (Peak Hour)_DN_2031 - mins		
	Including outers zones	**Excluding outer zones**
Home based work trips		
Private Car	117	105
Taxi	120	101
Two Wheeler	118	109
Home based education trips		
Private Car	99	99
Taxi	93	89
Two Wheeler	97	100
Home based other trips		
Private Car	27.0	24.8
Taxi	28.9	28.8
Two Wheeler	28.8	29.0

The vehicular distance travelled is shown in Table 5-14 below. Majority of home based work and Home based education based trips are made using taxi.

Table 5-14: Total vehicle km travelled (full day) in Do Nothing Scenario for Year 2031

Total vehicle km travelled_DN_2031		
	Including outers zones	**Excluding outer zones**
Home based work trips		
Private Car	22905	20808
Taxi	113227	103287
Two Wheeler	16538	15559
Home based education trips		
Private Car	7748	7635
Taxi	95943	91531
Two Wheeler	113222	91531
Home based other trips		
Private Car	3179	3094
Taxi	16982	15360
Two Wheeler	2389	2314

5.5.3. Do Nothing Scenario – Year 2041

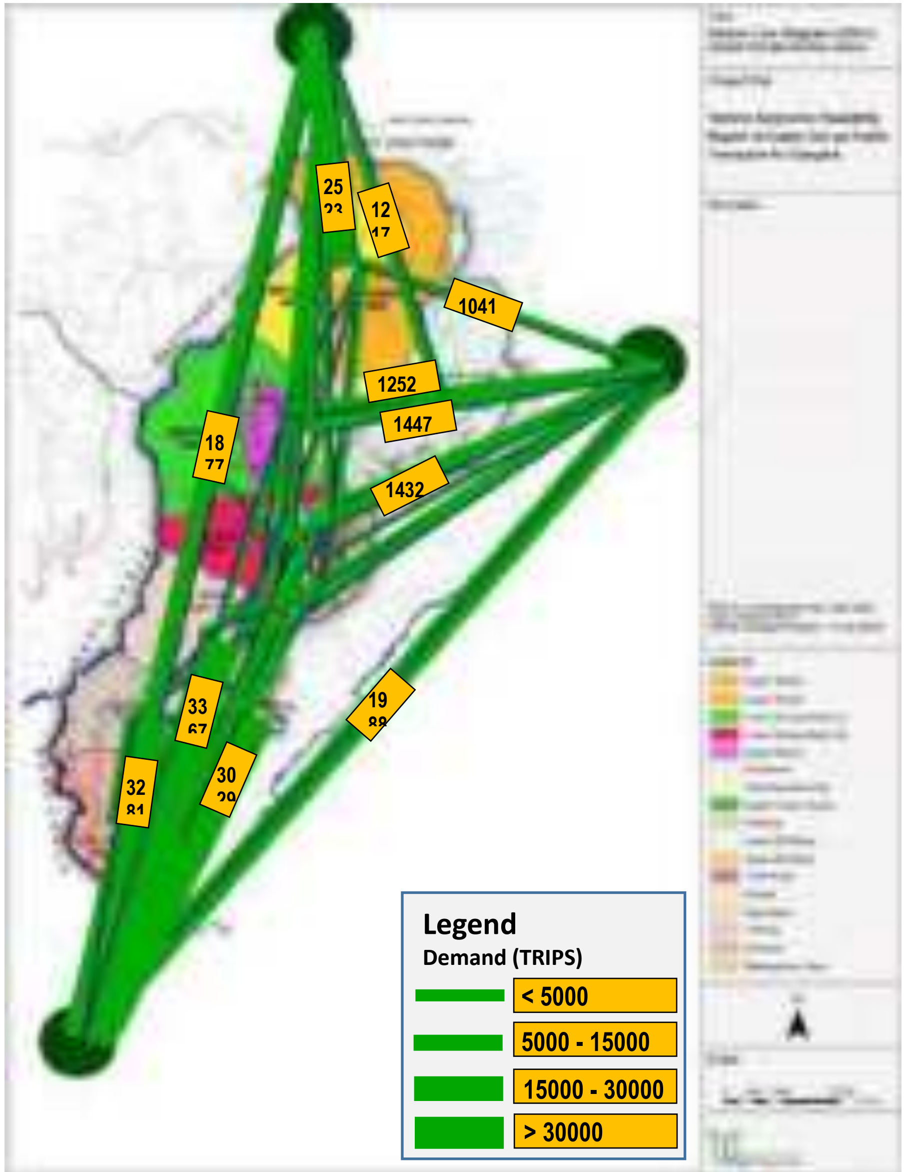
The data collected from the trip generation exercise for 2041 (using regression modelling) and trip distribution (using doubly constrained gravity model) is translated into OD matrix and represented in the Figure 5-15. It can be analyzed that the city center i.e. MG Marg and adjacent areas are experiencing most of the incomings trips from all the other zones. The incoming from western and southern zone (outer zones) have considerably increased. The traffic assignment is analyzed through simulation modeling in Visum. The congested network, travel time, are calculated for this model.

The congested network (network length having V/C Ratio more than 0.85) is 72% as shown in Table 5-15 and Figure 5-16.

Figure 5-16*Table 5-15: V/C Ratios for the Road Network In Do Nothing Scenario for Year 2041*

V/C Ratio	**% Network Length**
0.00 – 0.25	22 %
0.25 - 0.50	3 %
0.50 - 0.85	4 %

More than 0.85	71 %



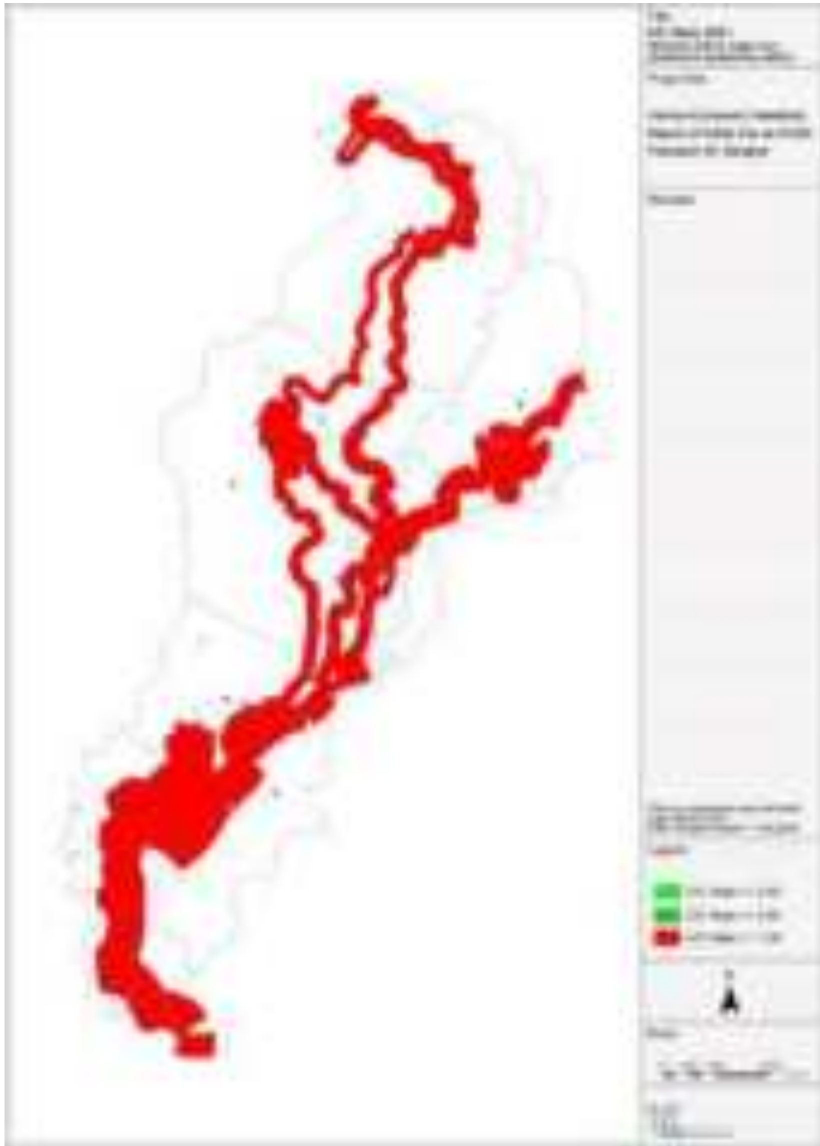


Figure 5-15: Desire Line Diagram (Do Nothing 2041)

Figure 5-16: V/C Ratio in Do Nothing Scenario for Year 2041

The average travel time for each type of modes (and purpose) are given in Table 5-16 below. The average travel time for home based work trips have increased to 101-109 minutes.

Table 5-16: Average Travel Time During Peak Hours in Do Nothing Scenario for Year 2041

Average travel time (Peak Hour) - mins		
	Including outers zones	Excluding outer zones
Home based work trips		
Private Car	231	179
Taxi	243	167
Two Wheeler	244	185
Home based education trips		
Private Car	232	139
Taxi	297	128
Two Wheeler	235	138
Home based other trips		
Private Car	162	160
Taxi	158	156
Two Wheeler	167	166

The vehicular distance travelled is shown in Table 5-17 below. Majority of home based work and Home based education based trips are made using taxi.

Table 5-17: Total Vehicle Kilometers Travelled in Do Nothing Scenario for 2041

Total vehicle km travelled_DN_2041		
	Including outers zones	Excluding outer zones
Home based work trips		
Private Car	36158	32847
Taxi	178738	163048
Two Wheeler	26107	24562
Home based education trips		
Private Car	12231	12053
Taxi	151455	144490
Two Wheeler	12714	10279
Home based other trips		
Private Car	5937	5779
Taxi	31714	28684
Two Wheeler	4462	4321

5.5.4. Do Nothing Scenario – Year 2051

The data collected from the trip generation exercise for 2051 (using regression modelling) and trip distribution (using doubly constrained gravity model) is translated into OD matrix and represented in the Figure 5.17. It can be analyzed that the city center i.e. MG Marg and adjacent areas are experiencing most of the incomings trips from all the other zones. The incoming from western and southern zone (outer zones) have considerably increased. The traffic assignment is analyzed through simulation modeling in Visum. The congested network, travel time, are calculated for this model.

The congested network (network length having V/C Ratio more than 0.85) is 80% as shown in Table 5-18.

Table 5-18: V/C Ratios for the Road Network In Do Nothing Scenario for Year 2041

V/C Ratio	**% Network Length**
0.00 – 0.25	13 %
0.25 - 0.50	8 %

V/C Ratio	% Network Length
0.50 - 0.85	7 %
More than 0.85	72 %

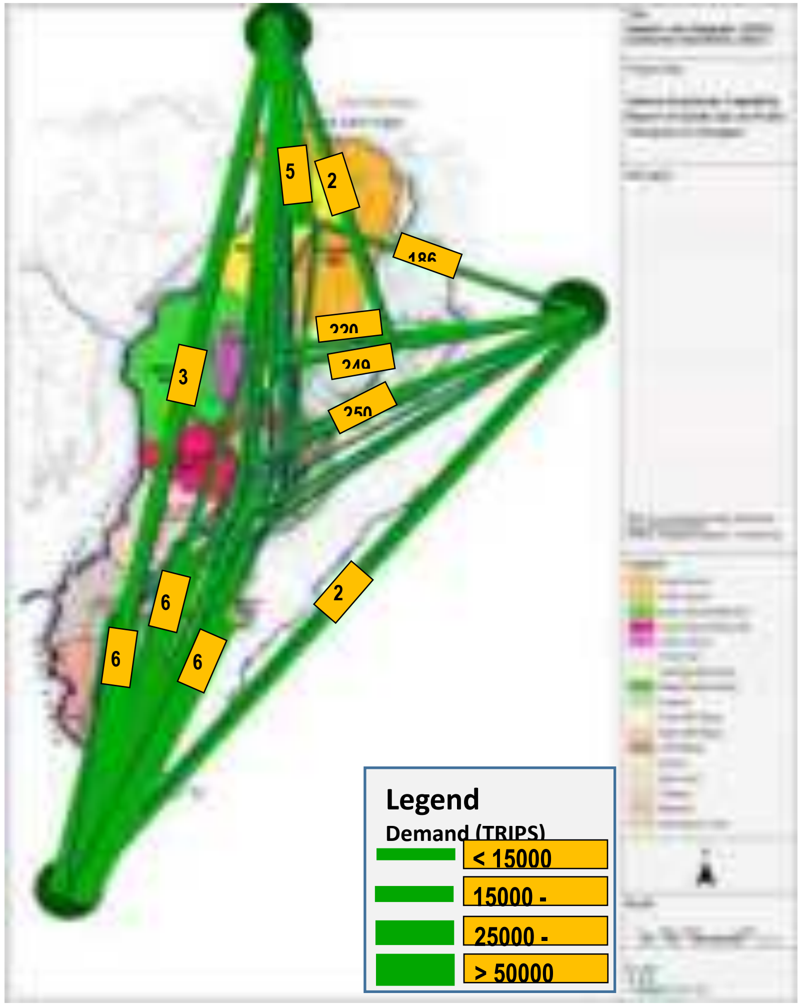


Figure 5-17: Desire Line Diagram (Do Nothing 2051)

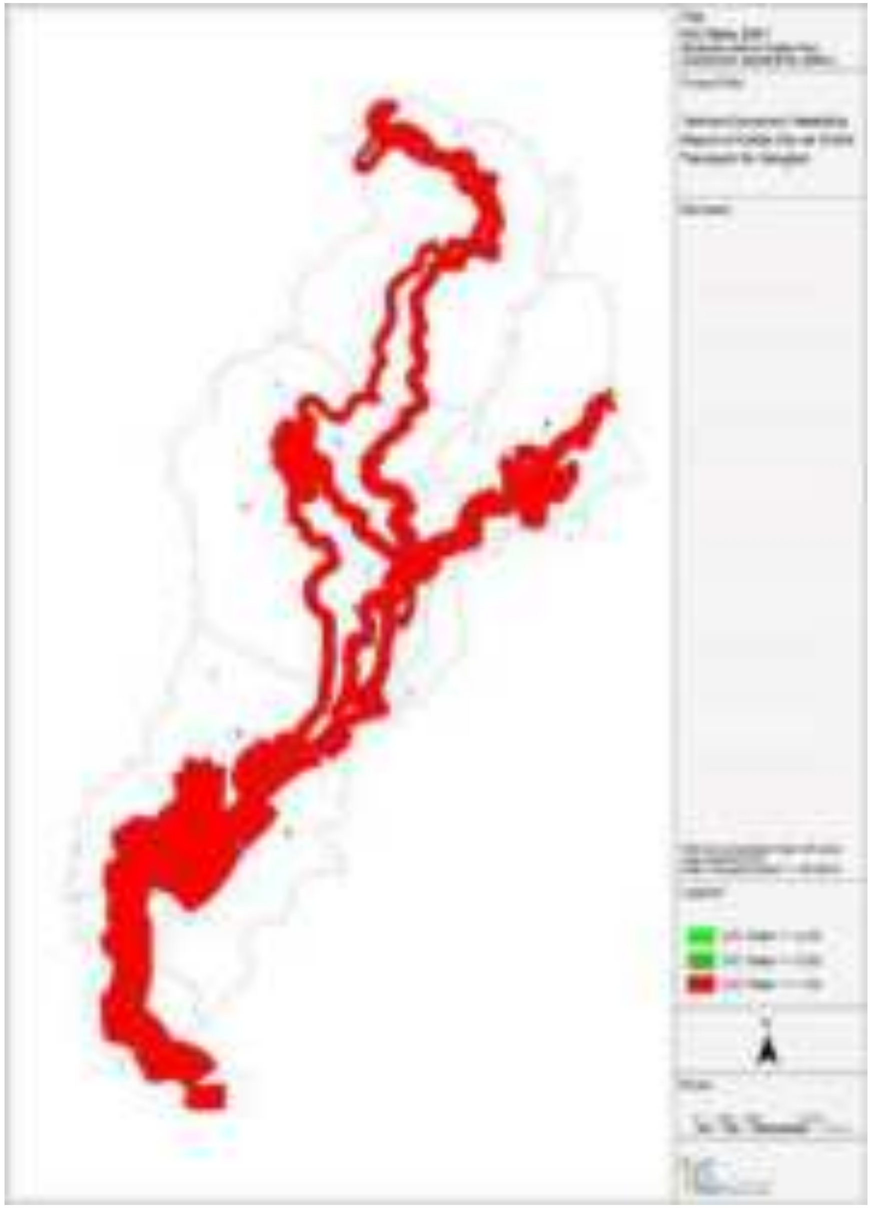


Figure 5-18: V/C Ratio in Do Nothing Scenario for Year 2051

The average travel time for each type of modes (and purpose) are given in Table 5.19 below. The average travel time for home based work trips have increased to 101-109 minutes.

Table 5-19: Average Travel Time During Peak Hours in Do Nothing Scenario for Year 2051

Average travel time (Peak Hour)_DN_2051		
	Including outers zones	Excluding outer zones
Home based work trips		
Private Car	394	305
Taxi	402	276
Two Wheeler	414	314
Home based education trips		
Private Car	332	287
Taxi	313	243
Two Wheeler	339	287
Home based other trips		
Private Car	183	181
Taxi	190	187
Two Wheeler	210	209

The vehicular distance travelled is shown in Table 5.20 below. Majority of home based work and Home based education based trips are made using taxi.

Table 5-20: Total Vehicle Kilometers Travelled in DO Nothing Scenario for 2051

Total vehicle km travelled_DN_2051		
	Including outers zones	Excluding outer zones
Home based work trips		
Private Car	59891	54408
Taxi	296059	270070
Two Wheeler	43242	40683
Home based education trips		
Private Car	20259	19964
Taxi	250867	239330
Two Wheeler	21060	17025
Home based other trips		
Private Car	10876	10586
Taxi	58096	52546
Two Wheeler	8173	7916

5.6. Alternative Analysis of Public Transit Modes

The previous sections clearly suggest that Gangtok is in dire need of an alternate public transportation system which is capable of catering to its present and future year demands.

Table 5-21 and Figure 5-19 shows comparison of critical parameters of various public transit options short listed for Gangtok considering the estimated future demands and topographical constraints.

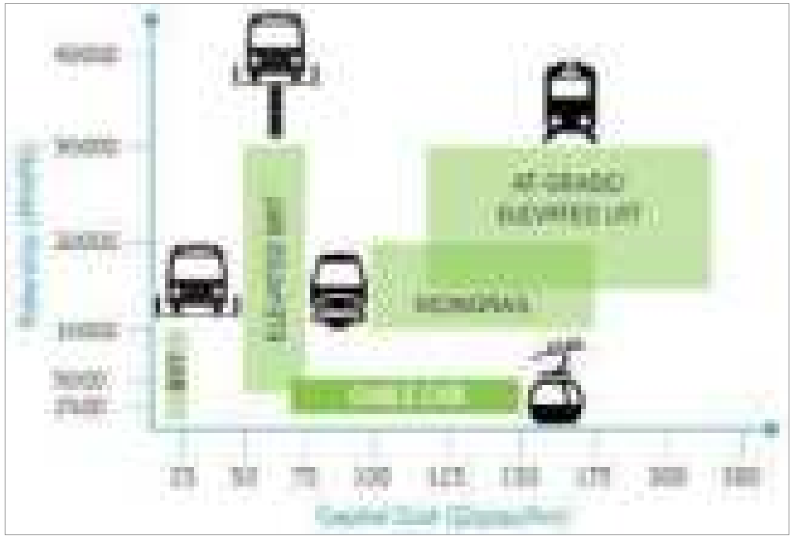


Figure 5-19: Comparison of Mass Transit Options Considered for Gangtok

It is evident that considering high gradients and sharp turns across Gangtok's road network and other topographical constrains common among hill cities, any road or rail based transit system would either not be feasible to construct or would require major engineering interventions leading to exorbitantly high construction cost and time. Thus a Cable Car system would be best suited owing to its minimal footprints.

Table 5-21: Comparison of Mass Transit Options Considered for Gangtok

Parameters	**LRT**	**Monorail**	**BRT**	**City Bus**	**Cable Car**
Physical Segregation	At-grade/Elevated	Elevated	At-grade/Elevated	At-grade	Elevated
Propulsion Fuel	Electric	Electric	Diesel/CNG/Electric	Diesel/CNG/Electric	Electric
Transit Track	Road/Viaduct	RCC Beam	Road/Viaduct	Road	Steel Cable
Station Spacing (m)	350-1600	600-1200	500-800	400-700	1000-1500
Operational Units	1-3	1-5	1-3	1	No Limit
Floor Height	Low/High	Low/High	Low//Medium/	Low/Medium/ High	Low

Parameters	LRT	Monorail	BRT	City Bus	Cable Car
			High		
Average Vehicle Capacity	110-250	90-180	60-120	60-120	8-15
Average Operating Speed (km//hr)	30-50	25-40	20-40	15-35	15-20
Ridership (PPHPD)	15000-30000	10000-20000	2000-30000	2000-7000	2000-5000
Capital Cost (Rs in Crore/Km)	120-250	100-175	10-25 (At-Grade) 50-75 (Elevated)	Minimum Cost	70-150

5.7. Cable Car Network Planning

According to the technical definition of the Indian Bureau of Technical Standards, an "Aerial Ropeway or Cable Car System" is a special form of transportation system where passengers are carried above the ground. A ropeway uses a tensioned wire ropes supported above the ground. Aerial Ropeways are particularly useful in hilly regions where the facility in surmounting natural barriers gives them a great advantage over rail/road based transit systems, both of which may need heavy civil engineering work and large footprint to secure easy gradient. Some of the salient features of ropeways includes they are easy to maintain; pollution free; environment friendly (small footprint therefore requires minimum tree and land cutting); adds to city aesthetics; their power demand is clean and modest; and, their operations are not seriously affected by adverse climatic and or heavy traffic conditions.

Gangtok has a linear road network which means that fundamentally the requirement is of a mass transit system along the trunk line (NH-10) and feeder systems to traverse the inner areas. For station area location and planning, high population density areas and employment centers are considered. Considering the increasing travel demand in future years it is proposed that a Cable Car system be provided as mass transit mode along the trunk network and shared taxies which are currently plying along trunk network shall be reorganized to serve as a feeder system.

5.7.1. Conceptual Alignment

Based on the primary data analysis done for demand feasibility the conceptual alignment of Cable Car System along trunk network is identified and shown in Figure 5-20. NH-10 is identified as the truck line and the proposed cable car system network is envisaged primary along it.

The total network length is 13 km (Approx.), with North-South Line from Ranipool Taxi Stand to Burtuk Ward. The west alignment connects Taxi stand north district to District administrative centre and Hospital at Sichey. The east alignment connects the 2nd Mile HFC Chruch to the Old STNM Hospital station. The stations are placed within dense built-up areas thus ensuring that maximum potential users lie within walkable distance.

Station at Taxi Stand North District, Sikkim National Transport, Gangtok Municipal Corporation and Ranipool Taxi stand can be developed as multimodal interchange hub (cable car to taxi/bus).

Table 5-22 lists identified cable car station locations along the conceptual alignment;

Table 5-22: Cable car station locations

SN	Station Location
North South alignment	
1	Ranipool Taxi Stand
2	Tourism Office Complex
3	Sikkim Manipal Hospital
4	Gangtok Municipal Corporation
5	Denzong Cinema/Supermarket
6	Old STNM Hospital
7	Taxi Stand North District
8	Station near Helipad
9	Station in Upper Burtuk
West alignment	
10	District Administrative center
11	Hospital at Sichey
East alignment	
12	Chandmari Taxi stand
13	2nd Mile HFC Church

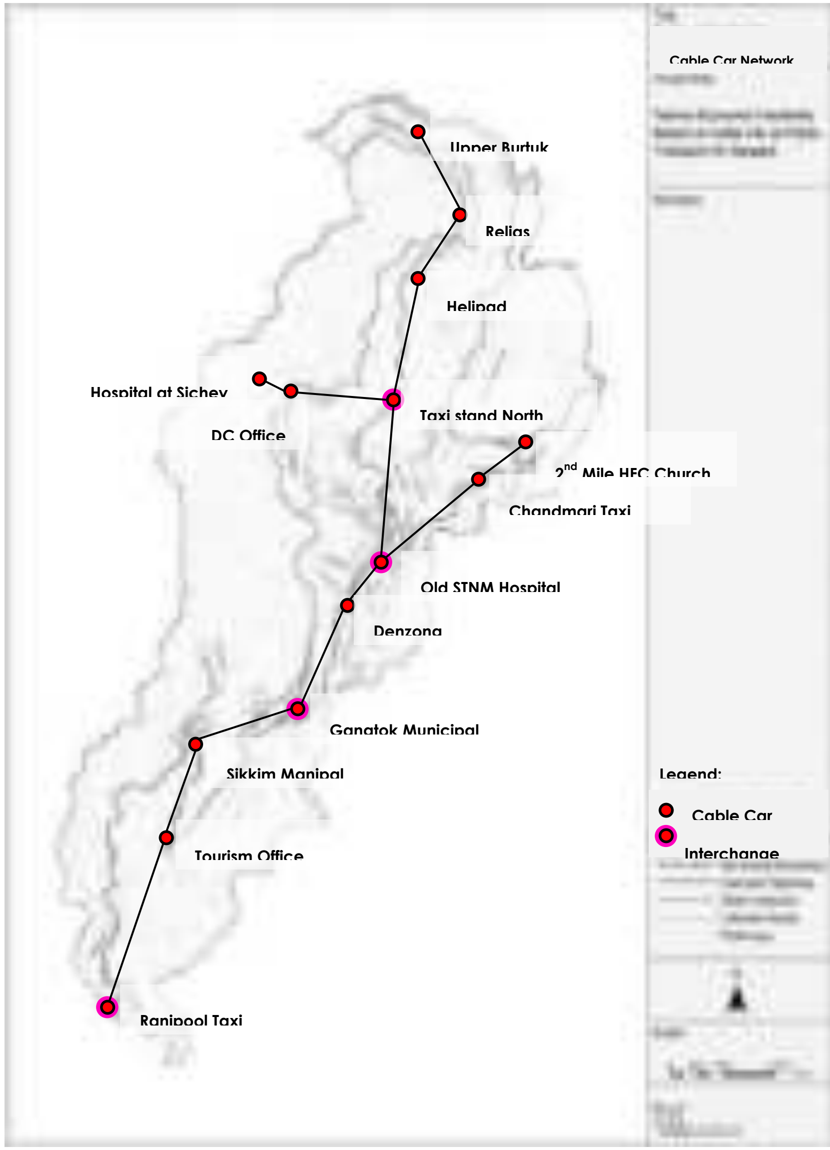


Figure 5-20: Conceptual Cable Car Alignment for Gangtok

5.7.2. Rationale Behind Concept Alignment

The conceptual Cable Car system alignment discussion in the previous sub-section is based on some essential planning concepts, these a presented as under;

Maximum Network Coverage: Considering the city structure the Cable Car alignment is envisaged with a view to make the service available to as many potential users as possible. More than 75% of the area is covered under walkable-transit accessible zone. The catchment of the proposed alignment is shown in Figure 5.21.

Multimodal Integration: Cable Car Stations are planned to maximized walkability and also to integrate with the existing modes of transport such as NMT, IPT and Public Transport modes. All major taxi stands (i.e. Ranipool Taxi Stand, Taxi Stand near Gangtok Municipal Corporation, Ranka Taxi Stand, Taxi Stand of North District etc.) and Bus Stand (SNT Bus Stand) are in close proximity to the identified stations locations. Considering this several Cable Car stations are suggested to be developed as Mulitmodal Interchanges and shown in Figure 5-20.

Transit Accessible Station planning: The station spacing is done considering the 'walkability concept', the trunk network is planned to cover maximum built up under walkable distance. Because majority of trips start and end with a walk, integration efforts to improve all modes (NMT, IPT, PT and Cable Car) simultaneously leads to safe and convenient access to transit and discourage people for using private vehicles.

Figure 5-21: Walkability Concept

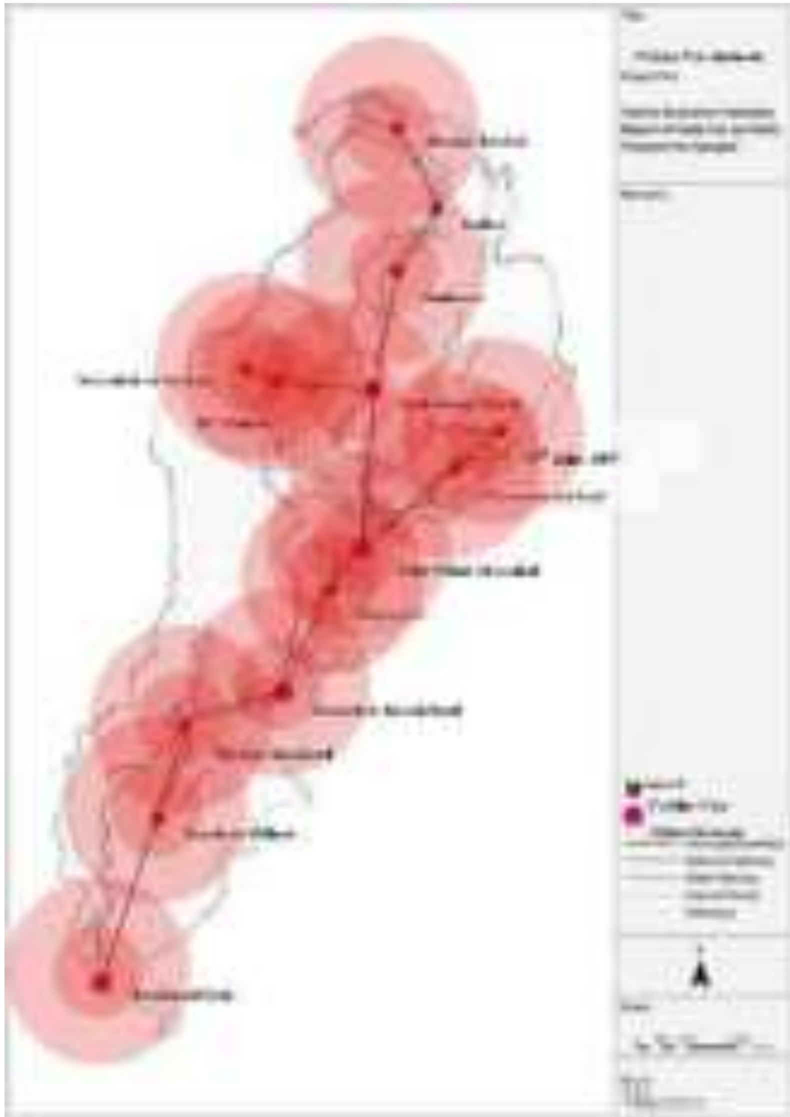


Figure 5-22: Conceptual Cable Car Alignment Catchment Area

5.8. Cable Car Ridership Estimation

For the given set of data (vehicular time, access time, wait time, egress time) the utilities are calculated as using the constant and coefficient as found in binomial regression. The equation is $y = C + a(x) + b(y) + c(z)$, where C is constant, a, b and c are respective coefficients for the independent variables. The exponential of the utility value is calculated and that is used for the calculation of the probability for the shift to proposed mode over existing and vice versa.

$$\textbf{Probability} = \frac{\textbf{Exp (proposed)}}{\textbf{(exp(proposed)+exp(existing)}}$$

For future projections, the growth rate of 6.0% (as per Comprehensive Mobility Plan for Gangtok - 2009) has been assumed. The projected population for future years 2021, 2031, 2041 and 2051 presented in Table 5-23 were used for estimating trip generation (travel demand estimation).

Table 5-23: Future Years Projected Population (as per CMP Gangtok)

SN	Year	Population
1	2021	2,00,805
2	2031	3,59,610
3	2041	6,44,007
4	2051	11,53,318

Table 5-24 presents estimated ridership of proposed Cable Car system in peak hours (as derived from four stage modelling in VISUM network modelling). Table 5-25 presents estimated directional traffic of proposed Cable Car system in peak hours (as derived from four stage modelling in VISUM network modelling).

Table 5-24: Estimated Horizon Year Peak Hour Station Loadings for Cable Car in Gangtok – 2021, 2031, 2041 & 2051

Sl. No.	Name	Corridor	Peak Hour							
			2021		2031		2041		2051	
			Boardings	Alightings	Boardings	Alightings	Boardings	Alightings	Boardings	Alightings
1	Ranipool	North – South	310	46	486	89	736	104	1186	126
2	Tourism Office Complex	North – South	315	264	504	531	794	870	1313	1467
3	Sikkim Manipal Hospital	North – South	491	443	738	649	1147	876	1885	1214
4	Gangtok Municipal Corporation	North – South	231	266	558	421	829	564	1293	773
5	Denzong Cinema/Supermarket	North – South	663	1039	945	1738	1262	2764	1717	4572
6	Old STNM Hospital	North – South	107	241	150	367	200	500	280	692
7	Taxi Stand North District	North – South	609	686	992	1068	1384	1435	1987	1998
8	Helipad	North – South	0	0	0	0	0	0	0	0
9	Burtuk	North – South	572	245	866	352	1250	499	1862	746
10	Hospital at Sichey	West	32	16	81	43	125	63	199	95
11	District Center	West	36	110	105	165	153	213	222	280
12	Chandmari Taxi Stand	East	82	61	115	95	151	135	211	193

Sl. No.	Name	Corridor	Peak Hour							
			2021		2031		2041		2051	
			Boardings	Alightings	Boardings	Alightings	Boardings	Alightings	Boardings	Alightings
13	2nd Mile HPC Chruch	East	84	94	129	132	182	174	258	242

Table 5-25: Estimated Horizon Year Peak Hour Sectional Loadings for Cable Car in Gangtok – 2021, 2031, 2041, 2051

Sl. No	Line Section	Corridor	Maximum Sectional Loading- Peak Hour			
			2021	2031	2041	2051
Section 1	Ranipool -Tourism Office Complex	North South	498	759	1144	1833
Section 2	Tourism Office Complex-Sikkim Manipal Hospital		896	1368	2113	3456
Section 3	Sikkim Manipal Hospital -Gangtok Municipal Corporation		1007	1660	2547	4125
Section 4	Gangtok Municipal Corporation-Denzong Cinema/Supermarket		647	958	1285	1877
Section 5	Denzong Cinema/Supermarket-Old STNMHospital		679	1062	1454	2026
Section 6	Old STNM Hospital-Taxi Stand North District		695	1153	1676	2509
Section 7	Taxi Stand North District-Helipad		809	1316	1903	2818
Section 8	Helipad-Burtuk		572	866	1250	1862
Section 9	Hospital at Sichey-District Center	West	60	81	232	355
Section 10	District Center-Taxi Stand North District		14	183	232	321
Section 11	Old STNM Hospital-Chandmari Taxi Stand	East	34	759	174	242
Section 12	Chandmari Taxi Stand-2nd Mile HPC Chruch		82	125	182	258

5.9. Project Scenario

The "Project Scenario" represents the existing road network, proposed cable car network and travel demand of the city for future year (i.e. 2021, 2031, 2041 and 2051). The Project Scenario can be compared with Do Nothing Scenario to ascertain benefits of cable car as main public transport in Gangtok. The road network length is 88 km and two line of cable car have been considered.

5.9.1. Project Scenario – Year 2021

This scenario represents impact on city's transportation system in 2021 post implementation of Cable Car system.

The congested network (network length having v/c ratio more than 0.85) had reduced to 25% in comparison to do nothing scenario as shown in Table 5-26. Thus 7% reduction in the congested road network is achieved by implementing cable car system as public transport.

Table 5-26: V/C Ratios for the Road Network In Project Scenario for Year 2021

V/C Ratio	% Network Length	Comparison with do nothing
0.00 – 0.25	22 %	
0.25 - 0.50	23 %	
0.51 - 0.85	30 %	
More than 0.85	25 %	-7 %

The average travel time for each type of mode w.r.t. the trip purpose and its comparison with the do nothing scenario are shown in Table 5-27.

The vehicular distance travelled by each mode w.r.t the trip purpose and its comparison with the do nothing scenario is shown in

Table 5-28.

Table 5-27: Average Travel Time During Peak Hours in Project Scenario for Year 2021

Average travel time (Peak Hour) - mins				
	Including outers zones	Excluding outer zones	Travel time saving in comparison to do nothing scenario	
Home based work trips				
Private Car	31	23.4	1	0.6
Taxi	36	22	0	3
Two Wheeler	32	22	1	1
Home based education trips				
Private Car	25	21.6	2	1
Taxi	26	20	2	2
Two Wheeler	25	20	2	1
Home based other trips				
Private Car	22	22	1	0
Taxi	22	22	2.4	2
Two Wheeler	21	22	2	1

Table 5-28: Total Vehicle Kilometers Travelled in Project Scenario for 2021

Total vehicle km travelled				
	Including outers zones	**Excluding outer zones**	**Vehicular Km saving in comparison to do nothing scenario**	
Home based work trips				
Private Car	14730	13381	775	704
Taxi	50586	46146	26060	23772
Two Wheeler	10635	10006	560	527
Home based education trips				
Private Car	4841	4770	255	251
Taxi	41647	39732	21455	20468
Two Wheeler	5032	4068	265	214
Home based other trips				
Private Car	1557	1516	82	80
Taxi	5779	5227	2977	2693
Two Wheeler	1170	1133	62	60

Figure 5-23 shows the ridership (peak hour passengers) along the proposed Cable Car system in year 2021. Figure 5-24 shows V/C ratios across the road network for project scenario in 2021, the sections marked in red are congested (V/C Ratio > 0.85). Significant changes can be observed in comparison to do nothing scenario of the same year.

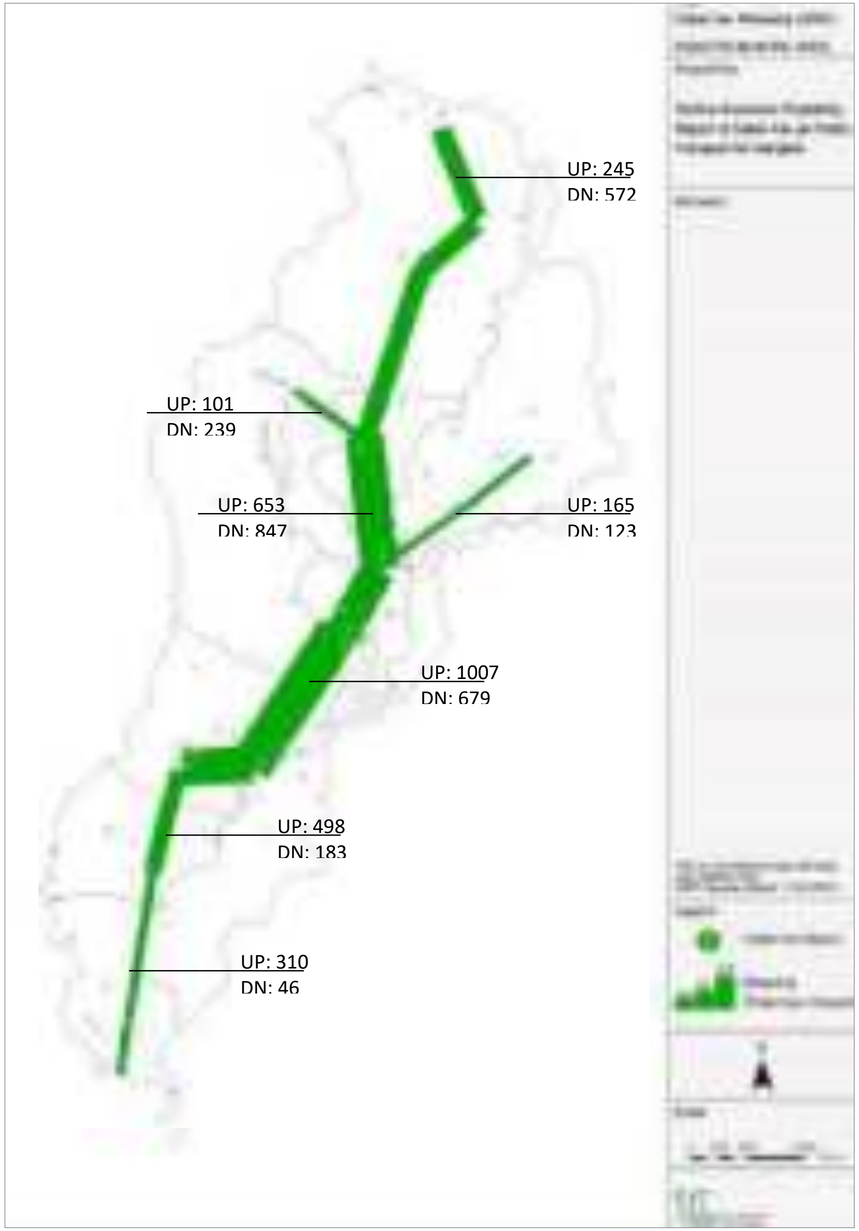


Figure 5-23: Cable Car System Ridership in the Year 2021

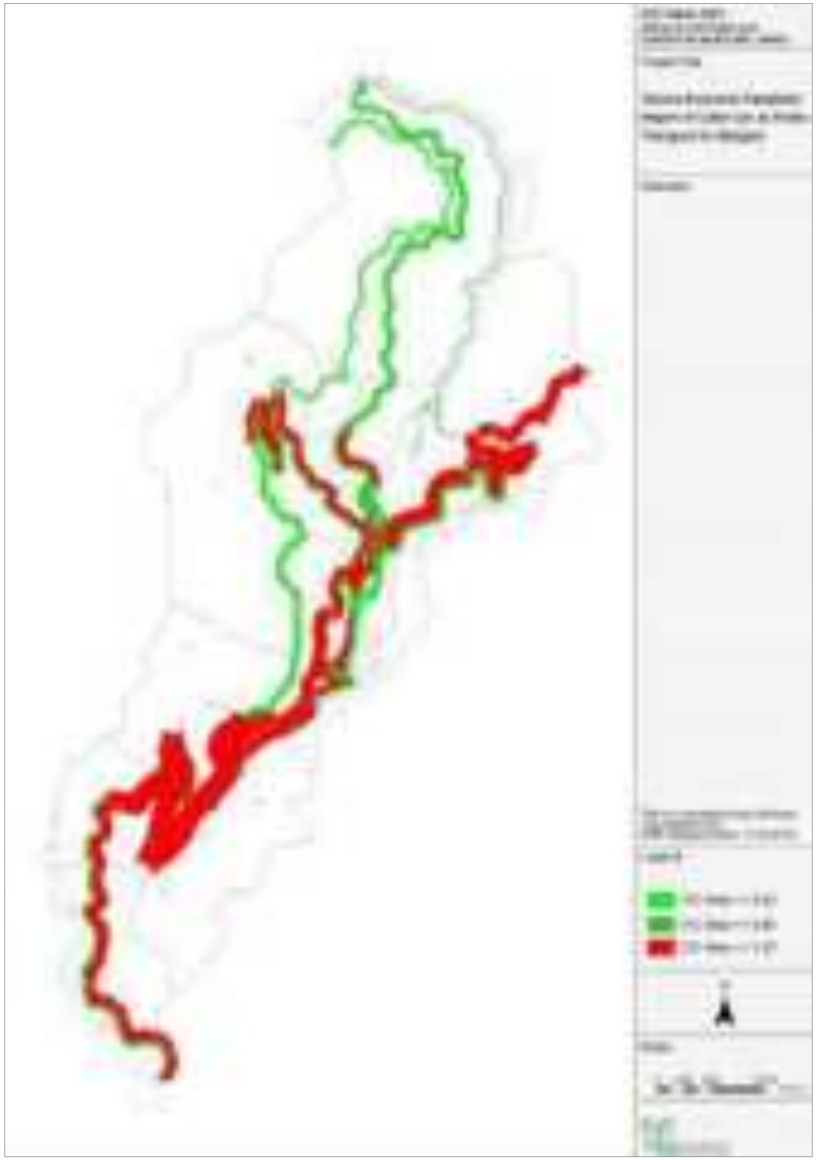


Figure 5-24: V/C Ratio in Project Scenario for the Year 2021

5.9.2. Project Scenario – Year 2031

This scenario represents impact on city's transportation system in 2031 post implementation of Cable Car system.

The congested network (network length having v/c ratio more than 0.85) had reduced to 51% in comparison to do nothing scenario as shown in Table 5-29. Thus 9% reduction in the congested road network is achieved by implementing cable car system as public transport

Table 5-29: V/C Ratios for the Road Network In Project Scenario for Year 2031

V/C Ratio	% Network Length	Comparison with do nothing
0.00 – 0.25	24 %	
0.25 - 0.50	12 %	
0.51 - 0.85	13 %	
More than 0.85	51 %	-9 %

The average travel time for each type of mode w.r.t. the trip purpose and its comparison with the do nothing scenario are shown in Table 5-30

The vehicular distance travelled by each mode w.r.t the trip purpose and its comparison with the do nothing scenario is shown in Table 5-31

Figure 5-25 shows the ridership (peak hour passengers) along the proposed Cable Car system in year 2031.

Table 5-30: Average Travel Time During Peak Hours in Project Scenario for Year 2031

Average travel time (Peak Hour)				
	Including outers zones	Excluding outer zones	Travel time saving in comparison to do nothing scenario	
Home based work trips				
Private Car	60	41	57	64
Taxi	69	39	51	62
Two Wheeler	64	42	54	67
Home based education trips				
Private Car	28	22	71	77
Taxi	29	22	64	67
Two Wheeler	28	22.7	69	77
Home based other trips				
Private Car	23	23	4.0	1.8
Taxi	24	23	4.9	5.8
Two Wheeler	22	22.8	6.8	6.2

Table 5-31: Total Vehicle Kilometers Travelled in Project Scenario for 2031

Total vehicle km travelled			
	Including outers zones	Excluding outer zones	Vehicular Km saving in comparison to do nothing scenario
Home based work trips			

Total vehicle km travelled				
Private Car	21691	19705	1214	1103
Taxi	72420	66063	40807	37225
Two Wheeler	15661	14735	877	825
Home based education trips				
Private Car	7337	7230	411	405
Taxi	61365	58543	34578	32988
Two Wheeler	7627	6166	105594	85365
Home based other trips				
Private Car	3011	2930	168	164
Taxi	10862	9824	6120	5536
Two Wheeler	2262	2191	127	123

Figure 5-26 shows V/C ratios across the road network for project scenario in 2031, the sections marked in red are congested (V/C Ratio > 0.85). Significant changes can be observed in comparison to do nothing scenario of the same year.

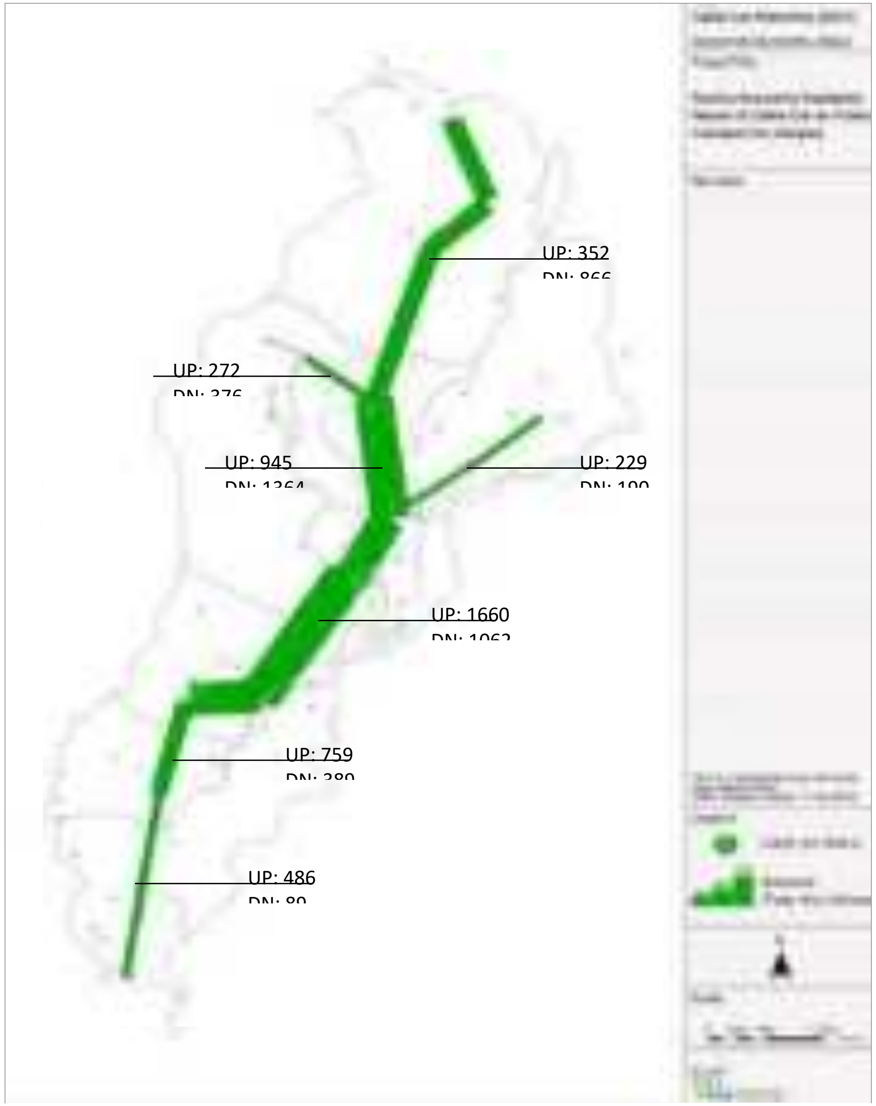


Figure 5-25: Cable Car System Ridership in the Year 2031

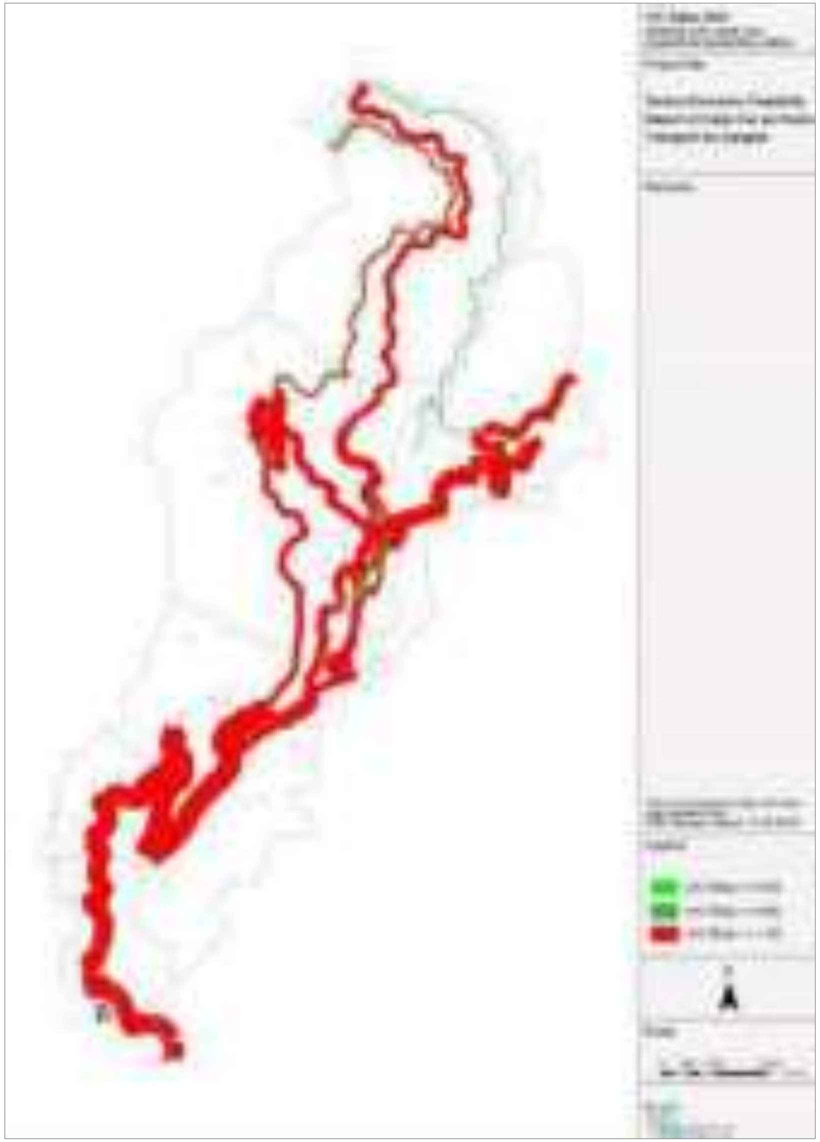


Figure 5-26: V/C Ratio in Project Scenario for the Year 2031

5.9.3. Project Scenario – Year 2041

This scenario represents impact on city's transportation system in 2041 post implementation of Cable Car system.

The congested network (network length having v/c ratio more than 0.85) had reduced to 51% in comparison to do nothing scenario as shown in Table 5-32. Thus 4% reduction in the congested road network is achieved by implementing cable car system as public transport.

Table 5-32: V/C Ratios for the Road Network In Project Scenario for Year 2041

V/C Ratio	% Network Length	Comparison with do nothing
0.00 – 0.25	22%	
0.25 - 0.50	3%	
0.51 - 0.85	8%	
More than 0.85	68%	-4 %

The average travel time for each type of mode w.r.t. the trip purpose and its comparison with the do nothing scenario are shown in Table 5-33.

The vehicular distance travelled by each mode w.r.t the trip purpose and its comparison with the do nothing scenario is shown in Table 5-34.

Figure 5-27 shows the ridership (peak hour passengers) along the proposed Cable Car system in year 2031.

Table 5-33: Average Travel Time During Peak Hours in Project Scenario for Year 2041

Average travel time (Peak Hour)				
	Including outers zones	Excluding outer zones	Travel time saving in comparison to do nothing scenario	
Home based work trips				
Private Car	179	131	52	48
Taxi	202	125	41	42
Two Wheeler	193	138	51	47
Home based education trips				
Private Car	117	101	78	67
Taxi	113	88	76	59
Two Wheeler	120	101	80	68
Home based other trips				
Private Car	97	96	65	64
Taxi	95	94	63	62
Two Wheeler	100	100	67	66

Table 5-34: Total Vehicle Kilometers Travelled in Project Scenario for 2041

Total vehicle km travelled				
	Including outers zones	Excluding outer zones	Vehicular Km saving in comparison to do nothing scenario	
Home based work trips				
Private Car	34350	31205	1808	1642
Taxi	117967	107612	60771	55436
Two Wheeler	24801	23333	1305	1228
Home based education trips				
Private Car	11619	11450	612	603
Taxi	99960	95363	51495	49126
Two Wheeler	12079	9765	636	514
Home based other trips				
Private Car	5640	5490	297	289
Taxi	20931	18932	10783	9753
Two Wheeler	4239	4105	223	216

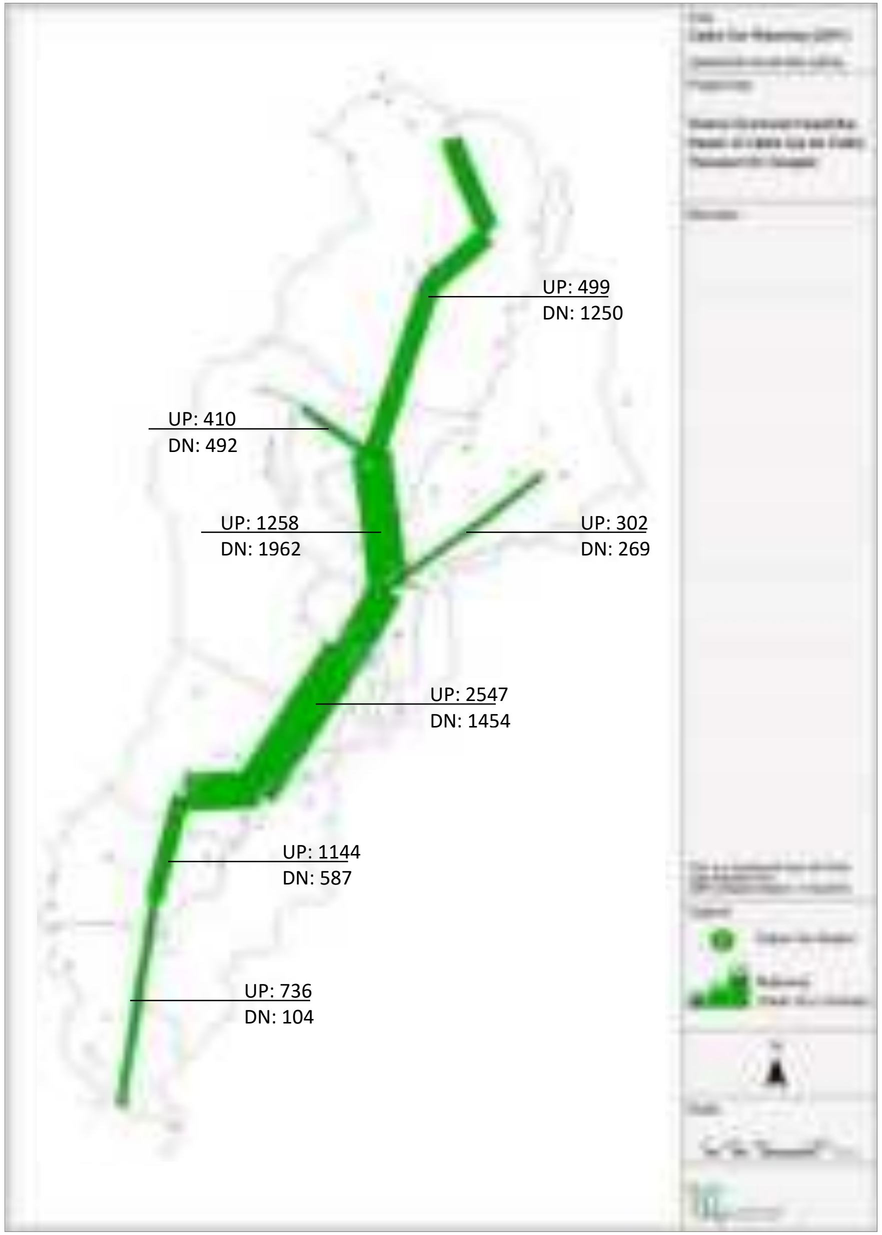


Figure 5-27: Cable Car System Ridership in the Year 2041

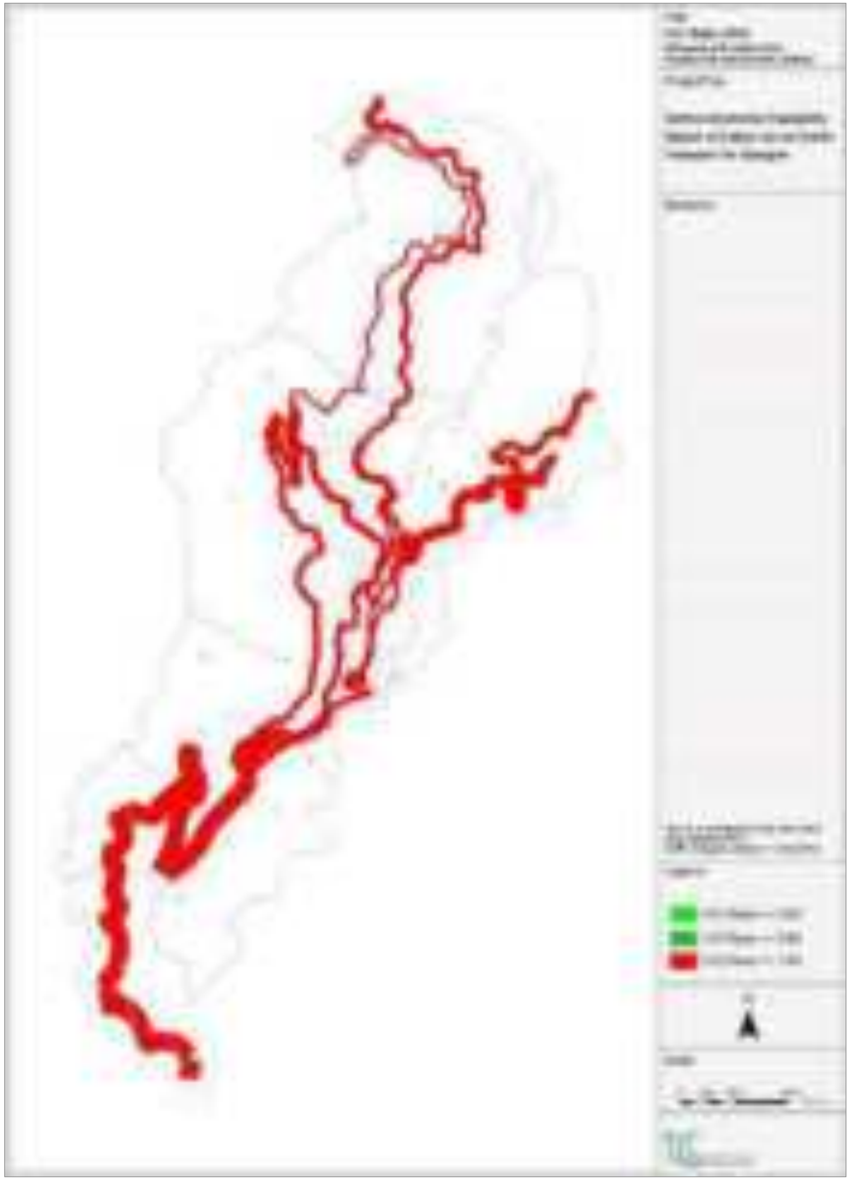


Figure 5-28: V/C Ratio in Project Scenario for the Year 2041

5.9.4. Project Scenario – Year 2051

This scenario represents impact on city's transportation system in 2051 post implementation of Cable Car system.

The congested network (network length having v/c ratio more than 0.85) had reduced to 51% in comparison to do nothing scenario as shown in Table 5-35. Thus 6 % reduction in the congested road network is achieved by implementing cable car system as public transport

Table 5-35: V/C Ratios for the Road Network In Project Scenario for Year 2051

V/C Ratio	% Network Length	Comparison with do nothing
0.00 – 0.25	23%	
0.25 - 0.50	3%	
0.51 - 0.85	0%	
More than 0.85	74%	-6 %

The average travel time for each type of mode w.r.t. the trip purpose and its comparison with the do nothing scenario are shown in

Table 5-36.

The vehicular distance travelled by each mode w.r.t the trip purpose and its comparison with the do nothing scenario is shown in Table 5-37

Figure 5-29 shows the ridership (peak hour passengers) along the proposed Cable Car system in year 2031.

Table 5-36: Average Travel Time During Peak Hours in Project Scenario for Year 2051

Average travel time (Peak Hour)				
	Including outers zones	Excluding outer zones	Travel time saving in comparison to do nothing scenario	
Home based work trips				
Private Car	236	183	158	122
Taxi	241	166	161	110
Two Wheeler	248	188	166	126
Home based education trips				
Private Car	199	172	133	115
Taxi	188	146	125	97
Two Wheeler	203	172	136	115
Home based other trips				
Private Car	110	108	73	72
Taxi	114	112	76	75
Two Wheeler	126	126	84	84

Table 5-37: Total Vehicle Kilometers Travelled in Project Scenario for 2051

Total vehicle km travelled			
	Including outers zones	Excluding outer zones	Vehicular Km saving in comparison to do nothing scenario
Home based work trips			

Total vehicle km travelled				
Private Car	56897	51687	2995	2720
Taxi	195399	178246	100660	91824
Two Wheeler	41080	38649	2162	2034
Home based education trips				
Private Car	19246	18966	1013	998
Taxi	165572	157958	85295	81372
Two Wheeler	20007	16174	1053	851
Home based other trips				
Private Car	10332	10057	544	529
Taxi	38343	34680	19753	17866
Two Wheeler	7764	7520	409	396

Figure 5-30 shows V/C ratios across the road network for project scenario in 2031, the sections marked in red are congested (V/C Ratio > 0.85). Significant changes can be observed in comparison to do nothing scenario of the same year.

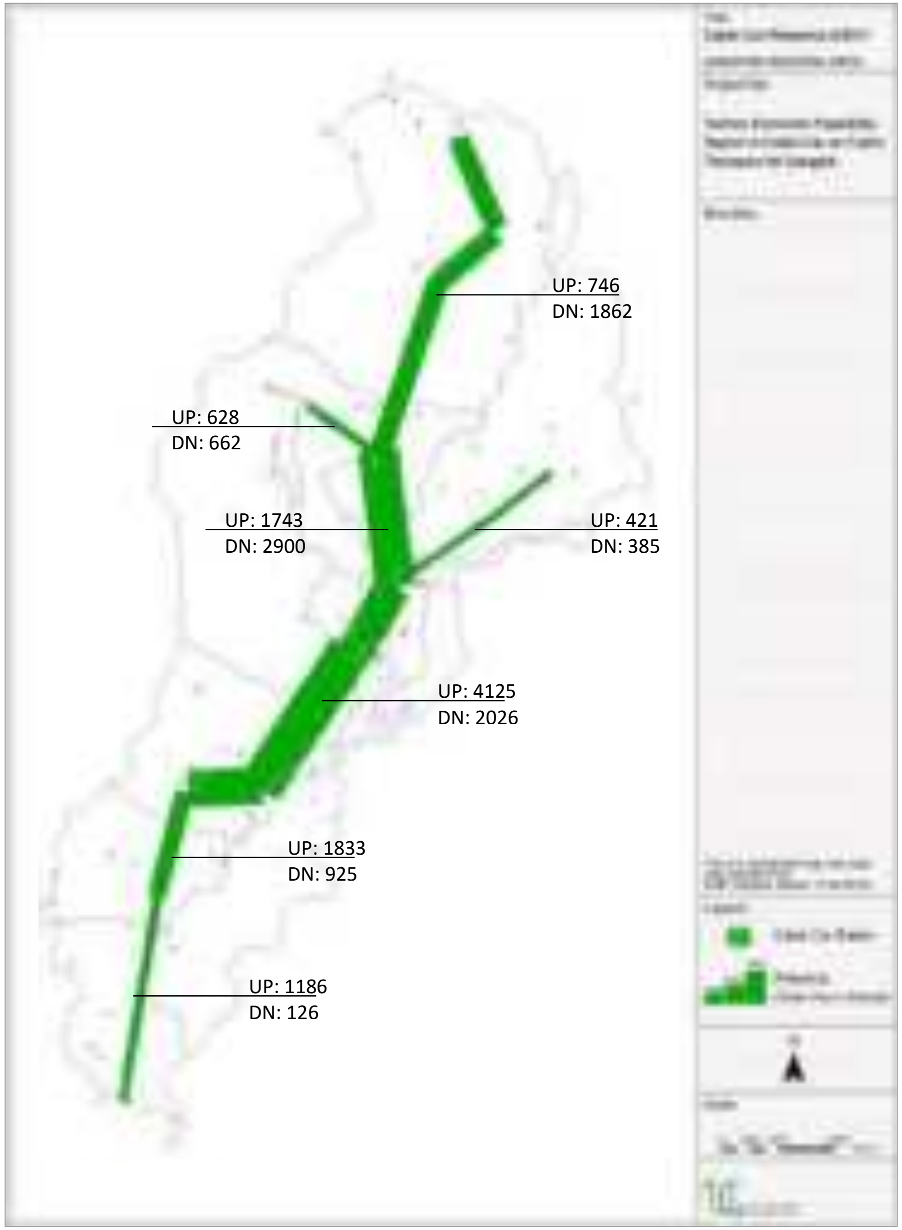


Figure 5-29: Cable Car System Ridership in the Year 2051

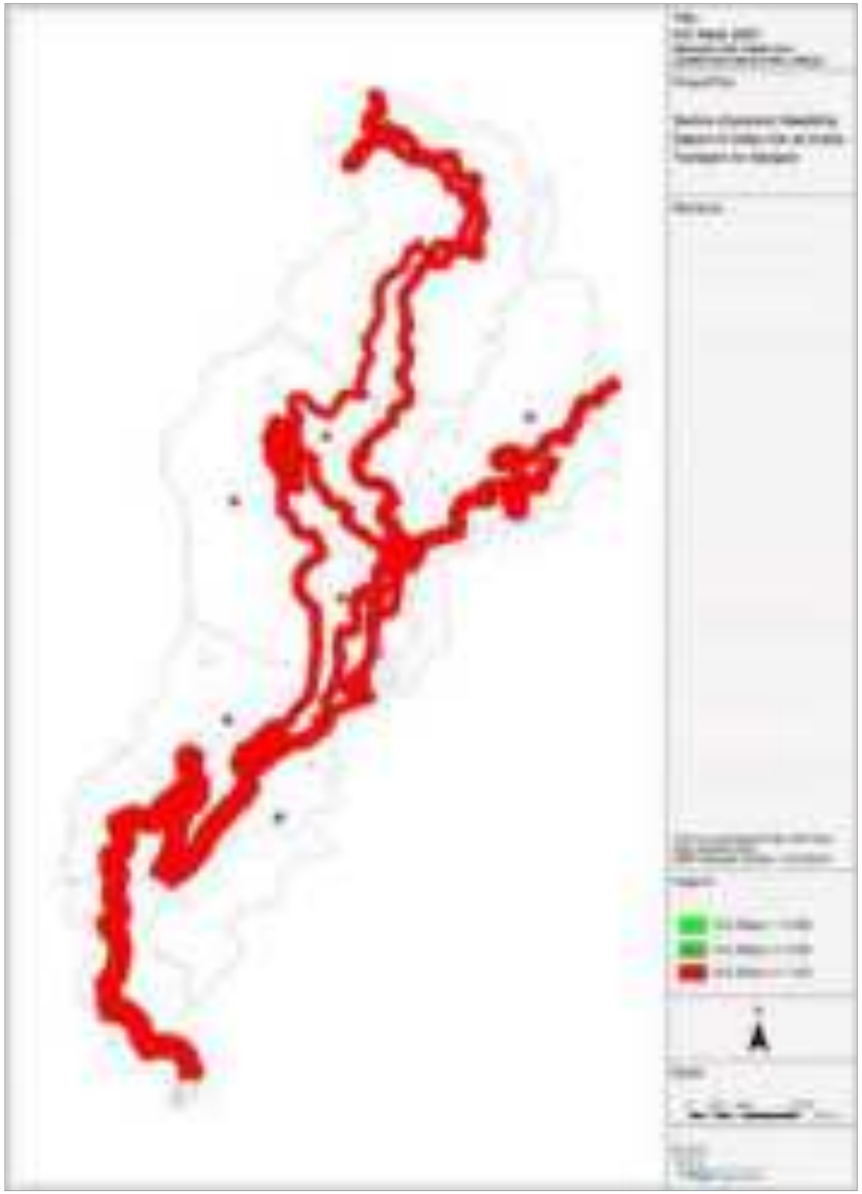


Figure 5-30: V/C Ratio in Project Scenario for the Year 2051

Chapter 6 CABLE CAR TRANSIT TECHNOLOGY

6.1. Introduction to Cable Car Transit Systems

This chapter has been crafted to provide fairly detailed insight of the various Cable Car transit technology options available to choose from while planning a Cable Car system for a city.

The information in this chapter is inspired by the 1st Edition of "Cable Car Confidential" – an essential guide to Cable Cars, Urban Gondolas & Cable Propelled Transit, authored by Steven Dale, Tino Imhauser and Nicholas Chu.

6.1.1. What is a Cable Car Transit (CCT) System?

Also known as Cable Propelled Transit (CPT), it is a transportation technology that moves people in motor-less, engine-less vehicles that a propelled by steel cable.

The two main CCT configurations include Top-Supported systems (vehicles/cabins supported from above) and Bottom-Supported systems (vehicles/cabins supported from below via tracks). Since this study is for Gangtok city which is primarily a hilly city, Bottom-Supported systems are unsuitable for such terrains thus the technology description in the following sections will be limited to Top-Supported CCT systems only.

6.1.2. Cable Car Transit System Components

While there are innumerable components involved in comfortable, safe and efficient CCT systems, the most important to understand CCT systems are described in following sub-sections.

A) Cabins/Carriers/Gondolas

Carriers are defined as the structural and mechanical assemblage in, or on which the passengers of a ropeway system are transported. The carrier includes the carriage or grip, hanger, and the passenger cabin or Gondolas. A typical Gondola is shown in Figure 6-1

Figure 6-1: Typical Gondola Type in CCT Systems

B) Grips

Grips are used to attach cabins with the cable in a CCT system. There are two types of grips in use viz. detachable and non-detachable (fixed). A detachable grip enables a cabin to separate itself from the cable when it enters a station whereas a non-detachable grip remains fixed to the cable at all times. In a detachable grip CCT system the speed of the cabin is reduced when entering a station via a conveyor system. Cabins can then move slowly through the station thereby enabling passengers to board and alight without disrupting the flow of the entire system. As a result, this feature dramatically increases cable line's capacity and speed. Detachable grips also enable intermediary and angle stations. Two types of detachable grips used in CCT system are shown in Figure 6-2.

Figure 6-2: Detachable Grips and Cables in CCT System

C) Cables/Ropes

The cable/rope is the heart of any CCT system. Cables are generally used as a haulage rope or a track rope (Aerial Tramways) or one rope may support both functions. A haulage rope propels and supports cabins while a track rope doesn't move and merely provides additional support. Ropes are generally described by their outside diameter in inches. Common usage is a 1 1/8 inch haul rope and a 1 7/8 inch track rope for a Bi-cable system, or a 1 3/8 inch rope for a Mono-cable system. Typical types of cables used in CCT systems can be seen in Figure 6-2

D) Towers

Towers are intermediate structures that support the track and haulage ropes between terminals. They are often steel framed, and are sometimes pylon shaped. The tower's primary function is to hold and allow the haulage rope movement through wheels. Towers must also have guides to keep carriages from hitting them for safety. Towers might not always be necessary depending on the length of the system. Figure 6-3 shows some type of towers constructed in CCT systems

Figure 6-3: Some Types of Towers Constructed in CCT Systems

E) Stations/Terminals

Stations are for passengers to board and alight and can be built in almost any shape and size. Typically, CCT system stations are classified into four types viz. a) Drive Station: station where motors and other major system components are located providing power to drive a cable line, (b) Intermediate Stations: stations located in between drive and return stations, (c) Angle Station: these stations allow for a CCT line to change direction en-route to a destination, and (d) Return Station: station where the haulage cable is circulated around a bull-wheel in order to return to the drive station. Some types of stations constructed in CCT systems are shown in Figure 6-4.

F) Bull-wheel

A bull-wheel is a large metal wheel on which the haulage cable turns. It transfers kinetic energy from a motor to the haulage cable thereby moving the cabins forward. A bull wheel is shown in Figure 6-5

Figure 6-4: Some Types of Stations Constructed in CCT Systems

Figure 6-5: Bull-wheel in a CCT Systems

G) Sheaves

Sheaves assemblies are grouping of rubber lined wheels which support or depress the haulage cable. Sheaves are typically installed on towers as shown in Figure 6-6.

Figure 6-6: Sheaves in a CCT Systems

H) Loops

A cable "loop" is one separate section of cable connected to itself in a loop as shown in Figure 6-7. Complex CCT Systems with dual haul configurations and turns often have multiple loops.

Figure 6-7: Cable Loops in a CCT Systems

6.2. Top Supported Cable Car Transit Technologies

There are six major top-supported CCT Systems available at present, these are listed as under and described in the following sub-sections;

1) Mono-cable Detachable Gondola
2) Bi-cable Detachable Gondola
3) Tri-cable Detachable Gondola or 3S
4) Funitel
5) Aerial Tram
6) Pulsed Gondola

6.2.1. Mono-Cable Detachable Gondola (MDG)

It is a type of aerial lift in which the cabin is suspended from a moving loop of steel cable that is strung between two terminals, sometimes over intermediate supporting towers. The cable is driven by a bull wheel in the terminal, which is connected to an engine or electric motor. Gondolas have small cabins, set at regularly spaced close intervals. The systems are continuously circulating with cabins passing around the terminal bull wheels. Cabins detach from the hauling rope at terminals, are decelerated and carried through the unloading and reloading areas at a very slow speed, then accelerated for reattaching to the haulage rope for high speed travel "on the line" between terminals. Cabin capacity of MDG systems varies from 4 to 15 persons per cabin and system capacity can go up to 4,000 PPHPD. A MDG system and schematic diagram of its functioning is shown in Figure 6-8 and *Figure 6-9* respectively.

Figure 6-8: A Mono-Cable Detachable Gondola System

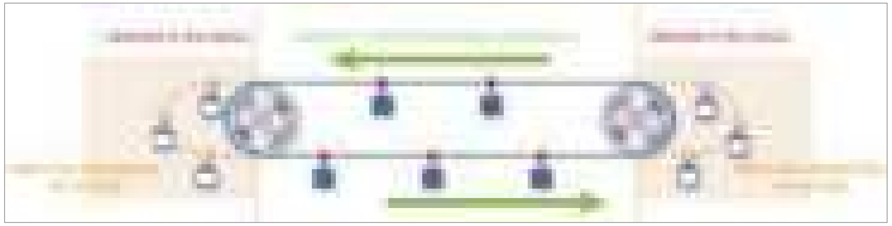


Figure 6-9: Schematic Diagram on Functioning of Mono-Cable Detachable Gondola System

6.2.2. Bi-Cable Detachable Gondola (BDG)

BDG systems combine features of both Gondola and Reversible Ropeway systems. On the one hand, they use the reversible ropeway technology in their operation (i.e. separate ropes serve the two functions: static support ropes or "track cables" and a moving "haul rope"), which allow the system to have long spans, and therefore overcome difficult terrain conditions. On the other hand, the system is detachable, which allows the system to have a high capacity similar to the capacity of detachable circulating systems. The difference between a BDG and an MDG system is that unlike MDG systems, which are both propelled and suspended by the same cable, BDG systems have two separate cables for the two functions. Cabin capacities ranging from 5 to 17 persons per cabin and transport capacity of up to 4,000 PPHPD. A BDG system and schematic diagram of its functioning is shown in Figure 6-10 and Figure 6-11 respectively.

Figure 6-10: A Bi-Cable Detachable Gondola System

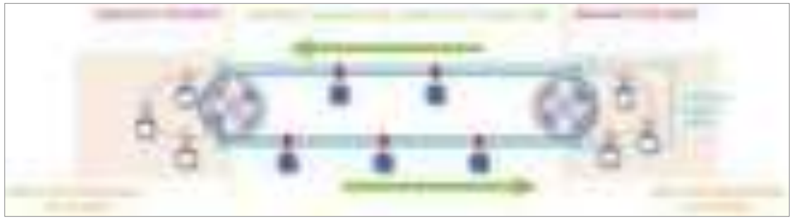


Figure 6-11: Schematic Diagram on Functioning of Bi-Cable Detachable Gondola System

6.2.3. Tri-Cable Detachable Gondola (TDG/3S)

Similar to BDG systems, TDG systems (sometimes referred to as 3S technology) combine features of both Gondola and Reversible Ropeway systems (i.e. separate ropes serve the two functions). However, unlike BDG systems, TDG systems have two stationary cables that support the cabins instead of one in BDG systems. Although TDG systems are more expensive than both MDG and BDG systems, this added cost is more than offset by their advantages, as these detachable circulating ropeways can carry more passengers with higher speeds i.e. up to 38 passengers and system capacity of more than 6,000 PPHPD. Other advantages of TDG systems include their outstanding wind stability, low power consumption and the use of very long spans of up to 3 Kms. A TDG system and schematic diagram of its functioning is shown in Figure 6-12 and Figure 6-13 respectively.

Figure 6-12: A Tri-Cable Detachable Gondola System

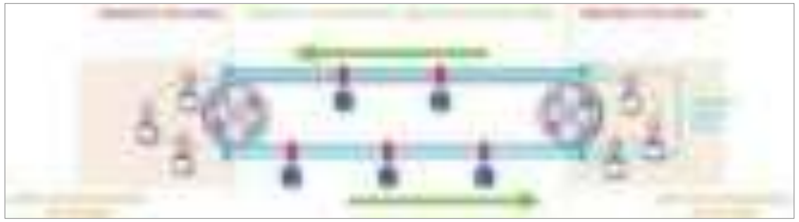


Figure 6-13: Schematic Diagram on Functioning of Tri-Cable Detachable Gondola System

6.2.4. Funitel

Funitel is a detachable grip system that utilizes dual grips with a single, dual loop cable providing both support and propulsion. Given this system configuration, it is sometimes referred to as a dual loop mono-cable. Like MDGs, BDGs and TDGs, funitel system are characterized as continuously circulating systems with cabins that circulate around two end terminals. It offers line speed and wind stability similar to 3S systems but with shorter tower spans and smaller cabin capacities. A Funitel system and schematic diagram of its functioning is shown in Figure 6-14 and Figure 6-15 respectively

Figure 6-14: A Funitel System

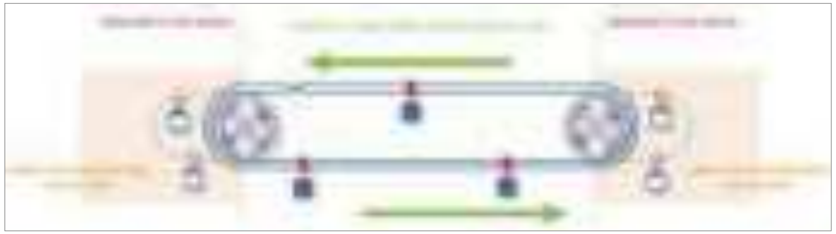


Figure 6-15: Schematic Diagram on Functioning of Funitel System

6.2.5. Aerial Tram

Aerial Tram utilizes fixed grips. Their lack of detachability reduces their capacity in comparison to detachable system like the TDG and MDG but they offer the highest maximum speeds among all cable technologies. These systems operate with two cabins that shuttle back and forth in tandem between two end terminals. However, Aerial Trams can also be built in a 'dual haul' configuration where the cabins operate independently from each other on two separate cable loops. Dual haul systems presents two clear advantages viz. (a) if one line is stopped for maintenance, the second line can continue to provide service; (b) the system allows for greater scheduling flexibility and is more demand responsive. With this technology, mid stations are rare and turning is impossible. Schematic diagram of single loop and dual haul aerial tram systems are shown in Figure 6-16 and Figure 6-17 respectively and the system is shown in Figure 6-18.

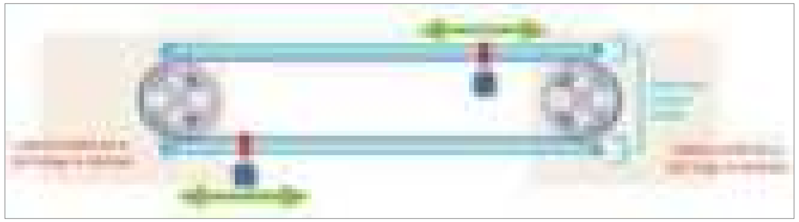


Figure 6-16: Schematic Diagram on Functioning of Single Loop Aerial Tram

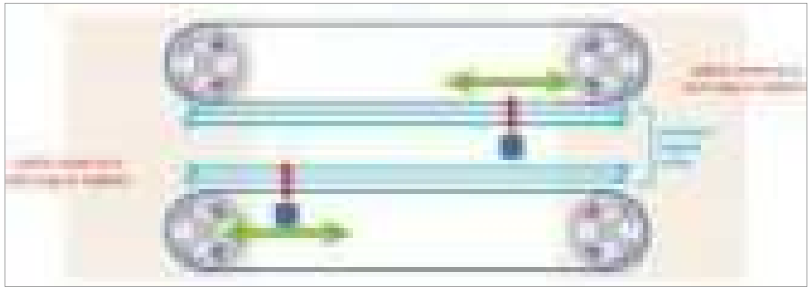


Figure 6-17: Schematic Diagram on Functioning of Dual Haul Aerial Tram

Figure 6-18: An Aerial Tramway System

Figure 6-19: A Pulsed Gondola System

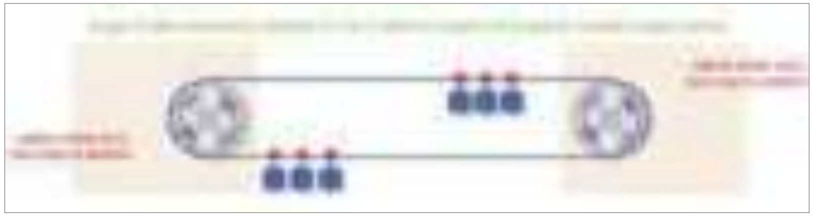


Figure 6-20: Schematic Diagram on Functioning of Pulsed Gondola System

6.3. Comparison of Cable Car Transit Technologies

Table 6-1 presents comparison of critical parameters of various top supported cable car transit technology options essential for selection of suitable technology w.r.t city's climate, topography, built-up and demography and estimated future transit demands. These parameters include tower spacing requirements, maximum wind speed tolerance, maximum system capacity, maximum operating speed etc.

Table 6-1: Comparison of Critical Parameters of Various Top Supported Cable Car Transit Technologies

Parameters	MDG	BDG	TDG/3S	Funitel	Aerial Tram	Pulsed Gondola
No. of Cables	1	2	3	1 (Dual Loop)	3	1
Maximum Speed (Kmph)	22	25	27+	27	45	22
Maximum Capacity PHPDT	Up to 4000	Up to 4000	Above 6000	4000-5000	Up to 2000	Up to 2000
Maximum Wind Speed Tolerance (Kmph)	Up to 70	Up to 70	100+	100+	80+	Up to 70
Grip	Detachable	Detachable	Detachable	Detachable	Fixed	Fixed
Cabin capacity	Up to 15	Up to 17	Up to 38	Up to 24	Up to 200	Up to 10
Tower Spacing (m)	100-300	Upto 1500	Upto 3000	500-1000	NA	NA
Relative Capital Cost	Low	Low-Medium	High	Medium-High	Medium-High	Low

6.4. Benefits of Cable Car Transit System

Cable cars are the best option where there is a need to move people across a significant barrier, such as difficult terrain which is too steep for road or rail networks, existing transport infrastructure such as motorways and in areas of traffic congestion where there is limited space for on-ground transport. They require small physical and environmental footprint and have lower capital and operational costs in comparison to other modes of transit. They are also an iconic addition to a city's skyline. The major benefits include:

- Drastic reduction in emissions
- Average speed comparable to other mass transit modes
- Highly safe mode of transport
- Minimal footprints

A) Emission Reduction

Most CCT systems are electrically driven and are incredibly energy efficient. Cable car systems run continuously and are not subject to the energy-eating stop-and-go traffic waves that affects land-borne vehicles. Since travel by cable generates less rolling resistance than terrestrial transit systems, this results in lower energy consumption.

Unlike cars and buses, cable cars produce no point source emissions. Depending on the elevation, passenger flow and system alignment, CCT systems can utilize gravity as and energy source

Figure 6-21 shows comparison of emissions per passenger kilometer by CCT systems, Buses and LRT systems. It is evident that the emissions by CCT systems are considerably low in comparison to other two modes.

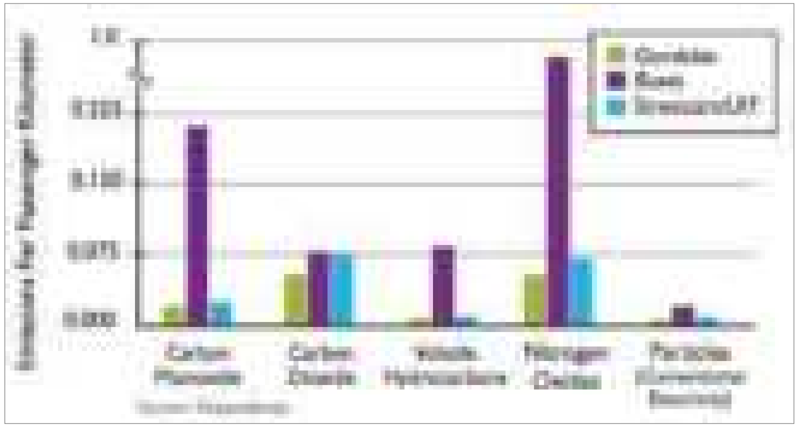


Figure 6-21: Comparison of Emissions by Various Modes of Public Transit

B) High Average Operating Speed

The average operating speed of CCT systems are comparable to other mass rapid transit modes as shown in Figure 6-22. This is by virtue of its exclusive right-of-way operations which enables CCT systems to operate closer to its maximum operating speed. Other bus or rail based system, however designed for higher maximum operating speed, achieves much lower average operating speed due to increased vehicular resistance and frequent stoppages.

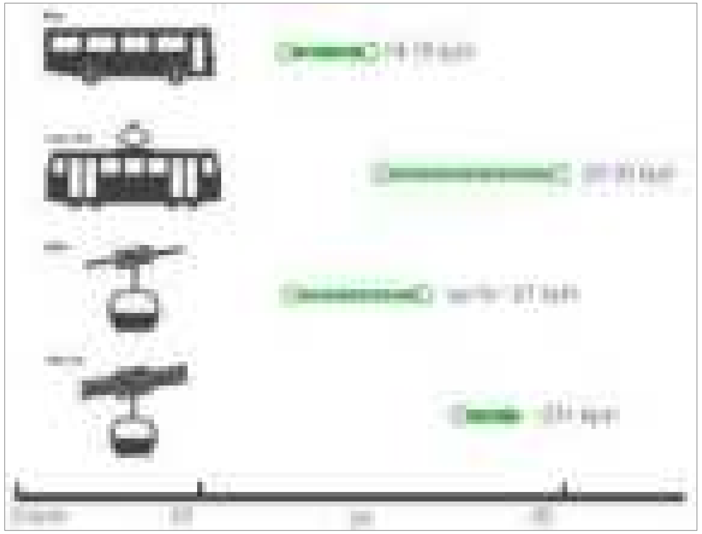


Figure 6-22: Operating Speed Comparison of Various Transit Modes

C) Safe Mode of Transit

Historically, CCT systems have been found to be highly safe public transit mode globally. This is ensured by adherence to strict regulation developed in Europe, stringent daily inspections and strict maintenance schedule.

Statistics from Switzerland which is home to the world's highest per capita use of Cable Cars reveals that CCT riders are

- 3 X less likely to be injured than in Tram, Bus, Train
- 50 X less likely to be injured than in Car

Statistics from North America reveals that CCT systems have 1 death per 900 million passengers whereas other transit systems have 1 death per 31 million passengers.

6.5. Safety Features

Modern cable car systems have evolved several safety features to avoid any inconvenience to the users, thus ensuring high level of safety. Some of these essential features are described in the following sub-sections;

A) Back-up Motors

A minimum of one back-up motor is built into all CCT systems. This feature ensures that passengers are never stranded in emergency situations where, in rare instances, the system experience engine failure or power outage

B) Cabin Recovery

Cabin recovery systems are a safety feature which enables riders to remain in a cabin during a breakdown. These systems allow a CCT system to retrieve cabins back into terminals without need for on-line evacuations.

C) Rope Position Detection

Rope position detection technologies recognize when a cable deviates from a sheave assembly at an early stage. This feature reduces the risk of de-ropement and prevents operational failures.

D) Protection from Wind & Lightning

Due to advances made in cable technology and cabin stabilization, new CCT systems can operate under wind conditions greater than 100 Kmph. Advance CCT systems can be equipped with electrical grounding system thereby protecting the systems and passengers from lightning strikes.

E) Factor of Safety

CCT systems are built to European ropeway standards which mandate a factor of safety of 4. This means that all system components are built to handle four times the expected maximum load.

F) Communication

Cabins can be equipped with cameras and intercom systems. These electronic devices enable passengers to reach the operators at any time. Cameras are connected to central control which allows operators to monitor any suspicious behaviors.

G) Rescue Planning

All CCT system operators are required to prepare emergency evacuation plans. In the rare event that a CCT system is inoperable, there are many different ways to safely evacuate passengers. These includes;

- Ropeway Techniques
- Evacuation Platforms
- Fire truck ladders
- Helicopter
- Cabin Recover (discussed in point-B, this is the preferred method of rescue as passengers remains in Cabin)

In case of prolonged emergency, cabins can be equipped with survival gear such as water, blankets and food.

H) System & Cabin Management

There are many opportunities to ensure that riders are safe during all hours of operation. These include;

- Placing attendants on duty at all stations is financially viable as ticketing can be automated and the need for drivers is eliminated.
- Female-only, single passenger or group cabins can be utilized during late of non-peak hours.
- Lighting cabin interiors at night help to increase visibility and safety.

Chapter 7 CASE STUDIES

7.1. San Agustin Metro Cable, Caracas, Venezuela

7.1.1. Design Concept

Fully integrated with the Urban Rail Metro System of Caracas, the public transit system provided in the "formal" part of the city, San Agustin Metro Cable (Figure 7-1) is 1.8 km in length and uses gondolas that hold eight passengers each. The total capacity of the system allows for moving 1,200 PPHPD. Of its five stations, two are in the valley and connect directly with the existing public transit system; three additional stations are located along the mountain ridge on sites that meet the demands of community access (*Figure 7-2*), established pedestrian circulation routes, and suitability for construction with minimal demolition of existing housing. The entire system is designed on modular principles, effectively a kit-of-parts, using pre-fabricated components. The stations, essentially shed buildings, are inexpensive to manufacture and erect, producing economies of scale and meeting the functional and aesthetic objectives. Critically, the structural and architectural design enables simple, low-cost, and rapid alteration and expansion of each station, to adapt to future needs and objectives.

In addition to minimizing the impact on the built environment, elevating stations above ground serves significant climatic and geographic purposes. Airflow at pedestrian level is preserved, and adjacent homes continue to benefit from the cleansing and cooling effects of the prevailing winds. Erosion from the typically heavy annual rains is minimized, protecting the station structures themselves as well as the surroundings. And the stilt-like legs greatly simplify compliance with seismic requirements. Additionally, the structural support for the platforms and cable car system is independent of that for the station shell, which is thus unaffected by the inevitable vibrations from system operations and pedestrian movement.

Figure 7-1: Metro Cable San Agustin, Caracas, Venezuela

Figure 7-2: Metro Cable Alignment & Intermodal Integration

7.1.2. Alignment & Intermodal Integration

MetroCable line with 4 sections. At both valley terminals, San Augustin and Parque Central, the cable car is interconnected with the urban rail system (Metro) and/or the BRT (MetroBus, Bus Rapid Transit) as shown in Figure 7-2. This interconnection is one of the strongest and most important enablers of accessibility for the areas served.

7.1.3. Layout

Though the five stations share a common set of components and designs – platform levels, access ramps, materials, structural design elements and circulation patterns – they differ in configuration and in the possibility to add functionalities that address other community needs beyond transportation.

The primary materials used in the construction of Caracas Metro Cable are steel and concrete – highly durable, appropriate to the hot, humid climatic conditions, and requiring little if any maintenance and repair.

The elevation profile of Metro Cable alignment is shown in *Figure 7-3*.

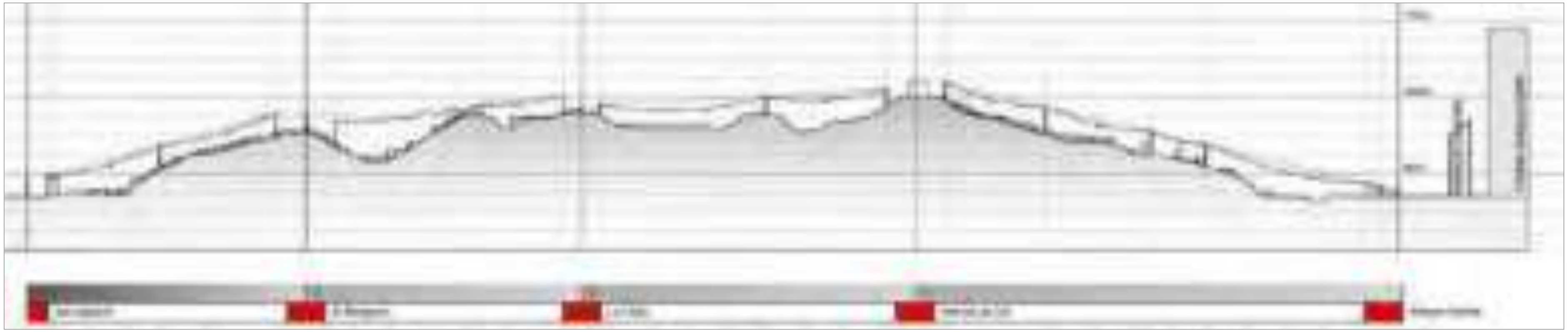


Figure 7-3: Elevation Profile of Metro Cable

The stations are skinned with corrugated steel sheets, glass cladding, and a factory-applied gel coat that resists delamination. The platforms and footings are concrete and connected with steel columns. The woven wire screening ramps and pedestrian bridges will, in time, support indigenous vines, providing shade and softening the hardscape.

7.1.4. General System Features

The detachable grip technology allows for high passenger comfort, including safe loading and unloading at creep speed in the stations. Speeds of up to 6 m/s on the line enable transport capacities of up to 3600 PPHPD, depending on the cabin size.

All equipment is extremely maintenance friendly, thanks to easy access to all mechanical parts. It is available fitted with an overhead or underground vault drive.

Symbolic disposition of 3S Gondola System is shown in Figure 7-4. Every sub-section has its own traction cable and can operate independently from neighboring segments. Vehicles in normal operation transfer from one section to the next automatically and at slow motion, while passengers can board or disembark. Passengers wanting to continue their journey to further stops remain on the vehicle. The transfer process from one segment to the next, fully automated, takes between 30-60 seconds, depending on the exact system layout.

7.1.5. System Characteristics

Major salient characteristic of San Agustine Metrocable are listed in Table 7-1. The system cost of 21 Million USD is for the electromechanical system provided by the manufacturer but the entire project, including the system's large community center stations, has been reported to have cost 318 Million USD.

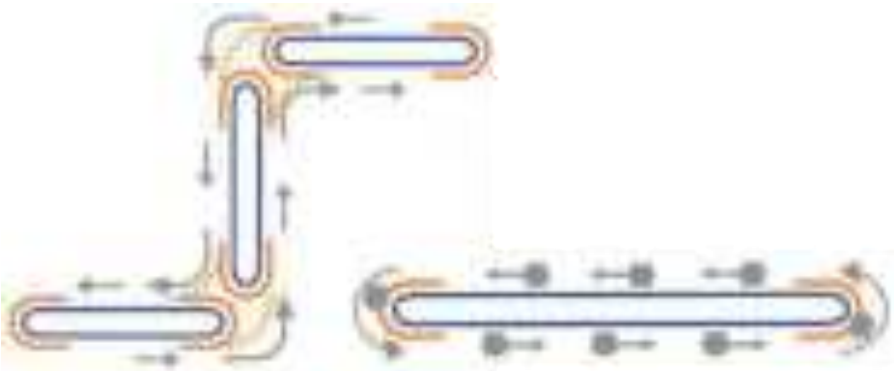


Figure 7-4: Schematic Representation of Operations

Table 7-1: System Characteristics of San Agustine Metro Cable

SN	System Characteristics	Values
1	Technology	MDG
2	Length (Km)	1.8
3	Commencement Year	2010
4	No. of Stations	5
5	No. of Cabins in Operation	52+1 (Rescue Cabin)
6	Cabin Capacity	8-10
7	Max Speed (Km/Hr)	18
8	Avg. Speed (Km/Hr)	12
9	Trip Time (Min)	9
10	System Capacity (PPHPD)	Up to 1500
11	Annual Ridership (Lakhs)	28
12	System Cost (USD-Million)	21
13	Cost Per Km (USD-Million)	9
14	Fare Cost (USD)	0.25

Figure 7-5: Components of Metro Cable

7.1.6. Gondolas

The cabins are built from aluminum and use a solar electrical power supply for lighting and security. They are suspended with a special steel rope supported by towers of steel and concrete base. Each cabin has interior lighting, a communications system and a maximum capacity of 8 to 15 persons, depending on the exact layout.

Level access to the cabins for boarding and disembarking is a feature which makes the cable car 100% accessible, making use easy for senior citizens, wheelchairs and pushchairs. In addition, urban cargo (goods) and equipment can be carried in times of lower demand.

The smooth, calm circulation of the cabins provides for a stress-free and safe ride. Panoramic windows allow for an all-round view and for personal security, movement provides natural ventilation without requiring air conditioning – for a real nature experience.

Figure 7-6: Metro Cable Gondolas

7.1.7. Stations

Each section of the cable car can technically operate independently from the others, having its own vault drive. Parking and maintenance of the gondolas is centralized in one of the base stations for better efficiency. Different types of Cable Car Stations in Caracas Metro Cable are shown in Figure 7-7, Figure 7-8 & Figure 7-9.

Figure 7-7: San Agustin Metro Cable Station

Figure 7-8: Terminal and Drive Station

Figure 7-9: Parking and Service Area in Metro Cable

A. **Intermediate Station**

La Ceiba station illustrates well the rigid, simple, yet aesthetic design of the cable car stations, aligning good functionality with a compact structure minimizing surface consumption. The station is fully accessible. New footpaths and stairs connect the station to the informal settlement area nearby. Schematic representation of La Ceiba station (intermediate station) is shown in Figure 7-10.

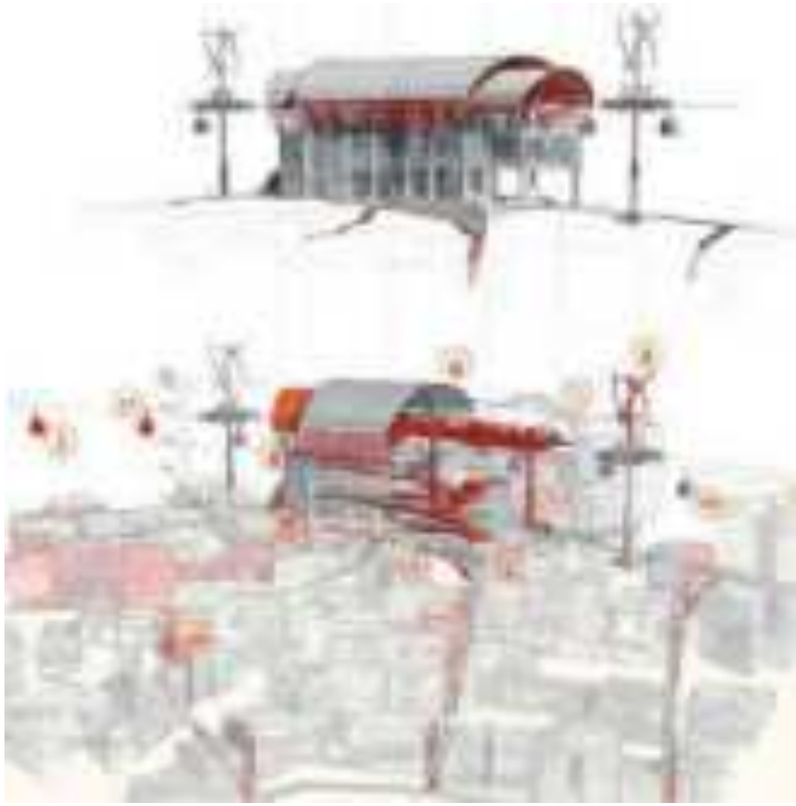


Figure 7-10: Schematic Design of La Ceiba Metro Cable Station

B. **Multimodal Interchange Station (Metro Cable – Metro Rail)**

Schematic design of the rail-cable interchange at Parque Central is given in Figure 7-11. To maximize user comfort, accessibility and usability, the MetroCable sits on top of the Metro rail station. Both modes are linked by escalators and elevators for speedy connections. The transferring customer remains within the paid area without need to cross faregates and tap out and in. Besides comfort, the latter is also important to maximize the capacity of the station at peak times.

Figure 7-11: Schematic Design of Parque Central Metro Cable Station

7.1.8. Multi-utility Stations

Transportation infrastructure as standalone does not fulfil the holistic approach towards catalyzing sustainable transformation in a neighborhood: A "Transportation Plus" solution is adopted, where the area surrounding stations is not only considered from a pure transportation perspective - as a catchment area - but also loaded with multiple activities. Following sub-sections illustrates multi-utility stations of Caracas Metro Cable.

A. Vertical Gym

The vertical gym at La Ceiba Station (Figure 7-12, Figure 7-13, Figure 7-15) allows for recreational activities and sports classes, giving the neighborhood a new center that also functions as a transportation hub.

Figure 7-12: Schematic Design of La Ceiba Station with A Vertical Gym

Figure 7-13: Image of Vertical Gym Constructed at La Ceiba Station

Figure 7-14: Interior of Vertical Gym

B. Housing

Innovative housing (*Figure 7-15*) that replicate the functionalities of vibrant neighborhood communities instead of destroying them: While providing for a safe, healthy environment with basic infrastructure such as water, electricity and sewage properly delivered, all building floors have a direct footpath linking them to the Metro Cable station, providing the comfort of safe, direct access by means that are simple, efficient and comparably affordable to build and maintain.

Figure 7-15: Schematic Design of Housing Complex Integrated with Metro Cable Station

C. Music School

A music school including a multi-use performance stage, elevating the value of the new hub that the Metro Cable creates to a cultural level. A schematic design is shown in Figure 7-16.

Figure 7-16: Schematic Design of Music School Integrated with Metro Cable Station

7.2. Metrocable Line K, Medellin, Colombia

7.2.1. About the System

The Medellin Line K is located in Medellin, Colombia – the second largest city in the country. It is considered the world's first modern example of a Cable Car Transit System. It opened in 2004 at 2.0 Kms long and it is fully integrated into the city's transit network. It was built to connect hillside barrio residents to the city center as shown in Figure 7-17 and Figure 7-18. Since the cable lift was introduced, resident commute times dropped from over an hour to ass little as 10 minutes.

This system is also one of the world's most successful CCT system to date as it transports over 12 million passengers a year and carries up to 40,000 passenger trips per day. Its success largely led to the construction of Medellin's second and third CCT line, Line J and Line L.

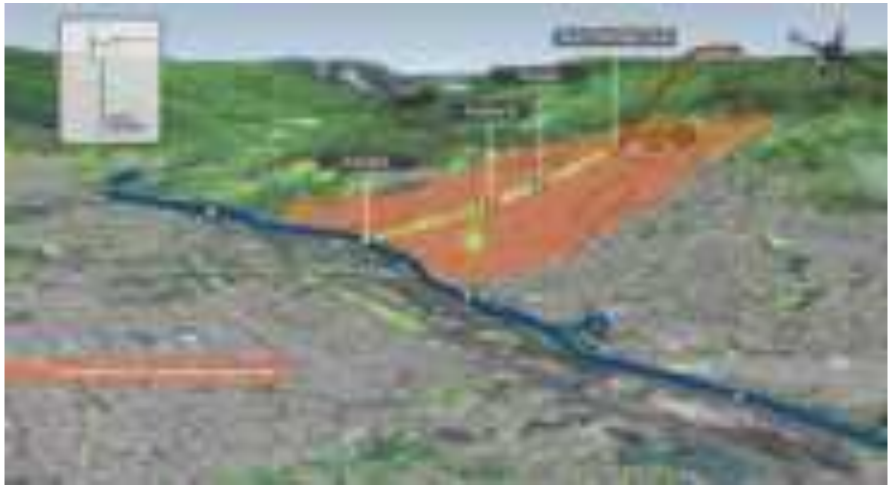


Figure 7-17: Medellin Metro Cable Line K Alignment

Figure 7-18: Medellin Metro Cable Line K, Colombia

7.2.2. Design Concept

The stations in Medellin's Metrocable Systems are designed with both function and form in mind. They are seamlessly integrated with the pedestrian realm which improves passenger flow and circulation. Some stations function not only as a way to access rapid transit, but double ass a community facility. For example, Acevedo station contains libraries and computer labs which are available for user of all ages.

To ensure that the surrounding area is used during all times of day and to promote continual system ridership, an abundance of public space around stations is available.

One of the of the Line K's most unique feature is that it is entirely integrated, both fare-wise and physically, with the city's transit system. Transferring from Cable to Rail is convenient, quick, and straightforward since the Gondola station is located immediately above the rail station. The lne also connects to Metrocable Line L, allowing residents to reach Parque Arvi – a popular nature reserve outside the city

7.2.3. System Characteristics

Major salient characteristic of Line K of Medellin Metrocable are listed in Table 7-2

Table 7-2: System Characteristics of Line K of Metrocable

SN	System Characteristics	Values
1	Technology	MDG
2	Length (Km)	2.0
3	Commencement Year	2004
4	No. of Stations	4
5	No. of Cabins in Operation	90
6	Cabin Capacity	10
7	Max Speed (Km/Hr)	18
8	Avg. Speed (Km/Hr)	17
9	Trip Time (Min)	7
10	System Capacity (PPHPD)	3000
11	Annual Ridership (Lakhs)	120
12	System Cost (USD-Million)	26
13	Cost Per Km (USD-Million)	13
14	Fare Cost (USD)	1

7.3. Metrocable Line J, Medellin, Colombia

7.3.1. About the System

After the successful implementation of Line K, the city quickly began construction of Medellin's second cable lift i.e. Line J. This 2.6 km line replaced the untimely and unreliable private bus system and was built as part of a larger social development program.

By providing a quick and direct connection to the Metro network as shown in *Figure 7-19*, its primary purpose was to improve living standards in one of the city's most disadvantaged neighborhoods. Since its opening, the cable lift effectively integrated several terrain-constrained communities back into the city proper.

This CPT line operates in the San Javier district, which include the rapidly expanding and growing barrio neighborhoods of Vallejuelos and La Aurora.

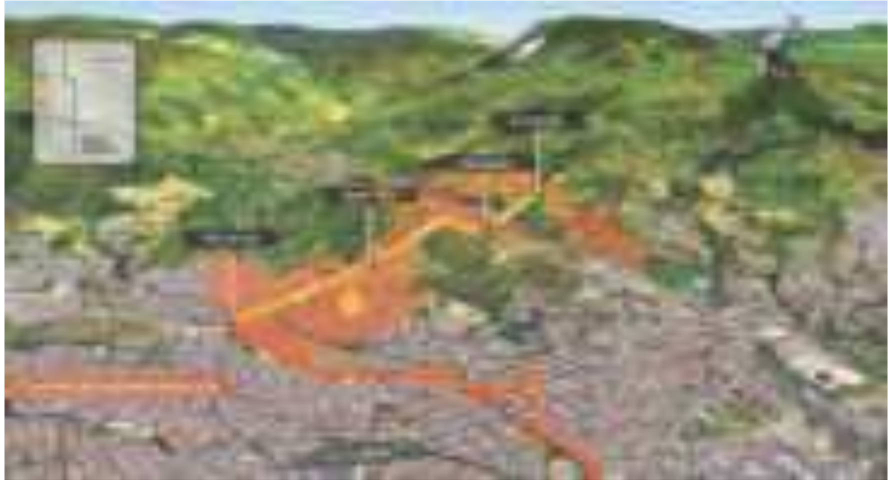


Figure 7-19: Medellin Metro Cable Line J Alignment

7.3.2. Design Concept

As discussed in the Medellin Metrocable Line K section, the station architecture of the city's Metrocable lines are well designed, visually attractive, and practical. They are surrounded by public spaces and promote pride in their communities. The stations are easily accessed and are well connected to the Medellin Metro system.

Line J is fully integrated, both fare-wise and physically, with the city's above-ground metro system. Transferring between the two is fast, simple and convenient since the gondola system is located immediately above the rail station.

Figure 7-20: Medellin Metro Cable Line J, Colombia

7.3.3. System Characteristics

Major salient characteristic of Line J of Medellin Metrocable are listed in Table 7-3

Table 7-3: System Characteristics of Line J of Metrocable

SN	System Characteristics	Values
1	Technology	MDG

SN	System Characteristics	Values
2	Length (Km)	2.6
3	Commencement Year	2008
4	No. of Stations	4
5	No. of Cabins in Operation	119
6	Cabin Capacity	10
7	Max Speed (Km/Hr)	18
8	Avg. Speed (Km/Hr)	16
9	Trip Time (Min)	10
10	System Capacity (PPHPD)	3000
11	Annual Ridership (Lakhs)	50
12	System Cost (USD-Million)	50
13	Cost Per Km (USD-Million)	19.2
14	Fare Cost (USD)	1

7.4. Teleferico do Alemao, Brazil

7.4.1. About the System

The Teleferico do Alemao, also know as Supervia – Teleferico A, is Brazil's first cable car system used purely for mass transit purposes, Shown in Figure 7-21 and Figure 7-22, at 3.5 Km long with six stations, it opened in 2011 as one of the world's longest and most sophisticated CPT line. Similar to the other systems constructed in Medellin and Caracas, this line was developed as part of a social development plan to help integrate residents back into the city proper.

CPT technology was considered ideal in this case since traditional transit types cannot easily navigate steep terrain like cable. This cable car system is built to serve the 85,000 residents of Complexo do Alemao – largely considered one of the Rio de Janeiro's largest favela neighborhoods. To achieve strategies related to social inclusion, residents of this community are entitled to two free tickets daily. It is also becoming a popular tourist destination ass it offers visitors a glimpse into favela life.

Figure 7-21: Alignment of Teleferico do Alemao

Figure 7-22: Teleferico do ALemao, Brazil

7.4.2. Design Concept

In terms of size, Rio's gondola stations are similar to those found in Caracas. The stations are large and include spaces for a variety of community services related to job training, medical services and legal aid. Like Caracas, the atypical size and scale of the stations explain the high system cost. The electromechanical cost of the gondola system itself has been estimated to be only 26.5 Million USD which is less than 20% o the total project price.

Before the introduction of the CPT line, the only form of transportation for many residents, outside of walking, were various informal transit modes such as motorcycle taxis. The cable lift now provides a direct connection to the city's suburban rail line – Saracuruna Supervia Line, and has significantly cut travel times down for many residents.

7.4.3. System Characteristics

Salient characteristic of Teleferico do Alemao are listed in Table 7-4.

Table 7-4: System Characteristics of Teleferico do Alemao

SN	System Characteristics	Values
1	Technology	MDG
2	Length (Km)	3.5
3	Commencement Year	2011
4	No. of Stations	6
5	No. of Cabins in Operation	152
6	Cabin Capacity	10
7	Max Speed (Km/Hr)	18
8	Avg. Speed (Km/Hr)	13
9	Trip Time (Min)	16
10	System Capacity (PPHPD)	3000
11	Annual Ridership (Lakhs)	40
12	System Cost (USD-Million)	133
13	Cost Per Km (USD-Million)	38
14	Fare Cost (USD)	1

Figure 7-23: Station of Teleferico do Alemao

7.5. Constantine Telecabine, Algeria

7.5.1. About the System

Constantine, a city with nearly half a million residents, is one of the country's largest cities and is considered the capital of eastern Algeria. The urban area is spread throughout steep terrain while the Rhumel River carves through the city.

Constantine has been experiencing traffic growth since the end of the civil war and as a result, the city's road and bridge network is heavily congested during peak times. To improve mobility for its resident and to reduce grid lock, the Constantine Telecabine was proposed and immediately built in 2008. Today it functions as a three station system, as shown in Figure 7-24, which provides a cost effective and efficient transport alternative for the 1 Lakhs residents living in northern Constantine. Instead of a 45-minute car journey through existing transport channels, the cable car reduces travel time to just 7 minutes. It connects Ben Badis University Hospital, one of the city's largest job generators while linking two neighborhoods.

Figure 7-24: Alignment of Constantine Telecabine, Algeria

7.5.2. Design Concept

The station architecture in Constantine Telecabine is a mixture of modernist styles and utilitarian design. For example, the Hospital Station is built with glass-roofed domes whereas the Tatache Belkacem Station is designed with whitewashed stones and bricks. All the stations are modest in size and are built to accommodate the projected ridership numbers. Unlike the South American Systems which provide a wide-range of social services within stations, the stations simply function as transport facilities.

Figure 7-25: Constantine Telecabine, Algeria

7.5.3. System Characteristics

Salient characteristic of Constantine Telecabine are listed in Table 7-5.

Table 7-5: System Characteristics of Line J of Metrocable

SN	System Characteristics	Values
1	Technology	MDG
2	Length (Km)	1.5
3	Commencement Year	2008
4	No. of Stations	3
5	No. of Cabins in Operation	33
6	Cabin Capacity	15
7	Max Speed (Km/Hr)	22
8	Avg. Speed (Km/Hr)	12
9	Trip Time (Min)	7
10	System Capacity (PPHPD)	2000
11	Annual Ridership (Lakhs)	25
12	System Cost (USD-Million)	14
13	Cost Per Km (USD-Million)	9.3
14	Fare Cost (USD)	0.25

7.6. Key Take-Away for Proposed CCT System

The extensive review of existing cable car transit systems operating successfully as public transport globally has given some very important learnings to the study team for consideration while finalizing CCT system proposal for Gangtok. The important inferences are as under:

- Design Concept: As illustrated in San Augustine, the cable car was proposed along the congested areas to provide access to public transport; Similarly, if the cable car system is provided as a formal mode of public transport along the congested central spine i.e. National Highway; the cable car system would be successful. Also this alignment will provide alternate mode to reach the employment establishments.
- General System Features and Capacity: as observed in case studies, the detachable grip technology (MDG/BDG/TDG) can be provided for high passenger comfort, safe loading and unloading at creep speed in the stations. Speeds of up to 8.5 m/s on the line enable transport capacities of up to 6000 PPHPD, depending

on the cabin size. Since the peak demand in horizon year is 4000 PHPDT, the MDG system can be designed.

- Multi Modal Integration: as seen in Teleferico do Alemao, Brazil, Metrocable Line J, Medellin and San Agustin Metro Cable, Caracas; Cable Car can be integrated with existing public transport modes i.e. mass transit system or Bus (Local / Regional) as well as Intermediate para transit i.e. local and regional taxis. In Gangtok, it is proposed that the cable car is integrated with bus system and Taxis
- Transit oriented development/ Property development at Stations: As observed in San Agustin Metro Cable, Caracas; the cable car stations can be provided with additional activities: recreational/ social. Since the topography in Gangtok demands high rise construction. Similar activities can be provided in stations. This will lead to increase in revenue (Non fare box).

Chapter 8 CABLE CAR TRANSIT SYSTEM DESIGN

8.1. Introduction

This chapter will provide preliminary designs of the CCT system selected in previous chapter for the city of Gangtok i.e. a MDG system. The chapter comprises of Gangtok CCT system's stations routing and site proposals

The chapter is based on the site visit and analysis and preliminary designs prepared by Urban Think Tank (UTT), our CCT system experts based at Switzerland. A detailed report titled "Gangtok Metro Cable – As Core Infrastructure for a Gangtok Sustainable Urban Mobility Strategy" was prepared by UTT as part of this study which is represented here in this report.

This chapter presents the schematic designs of stations as part of a transportation system that is adequate, safe, comfortable, equitable, efficient and sustainable. The designs will be further detailed in the succeeding phases, once the sites are verified and approved. The goal is for the system to enhance the exiting social fabric and touristic opportunities through the incorporation of integrated programs into and around stations. Additionally, it should act as a catalyst encouraging a more sustained urban development along it routes, helping decongest the vulnerable central axis of Gangtok.

The chapter compiles methodologies of analysis, observations and conclusions, leading to specific layout and design suggestions. The core idea is not to obtain a ropeway system as a singular piece of transportation infrastructure, but have it be a cornerstone of a fully redesigned urban mobility plan for Gangtok, ready for the 21st century.

A. Joint Site Visit

A joint site visit of proposed Gangtok CCT system alignment was conducted between 9th to 13th September, 2017 to advance the preliminary design process.

Figure 8-1: Identified Site for CCT Station at Ranka Taxi Stand

The participants of the visit include representatives from UD&HD, UTT, LEAP and UMTC. The main objectives of this visit was to identify land for placement of CCT stations within the proposed locations, provide site exposure to the CCT system experts and to interact with the major stakeholder's in the city.

Extensive site inspection was conducted at all 14 station locations identified in the previous chapters and tentative land Pockets/Buildings were identified for CCT stations (Figure 8.1). Consultant's team was accompanied by representatives from UD&HD (client) to help identify potential Land Pockets/buildings for CCT stations. The details of all 14 CCT station placements at identified sites will be provided in subsequent sections.

UTT experts also had an extensive exposure of the city to understand the topography, existing transportation system and travel pattern of the city inhabitants and visitors. They also met the major stakeholder to understand their vision for the city and expectations with regard to the proposed CCT system.

Meetings with the Principal Chief Engineer Cum Secretary, Urban Development and Housing Department (UD&HD) Mr. G. T. Bhutia and his team (Figure 8-2) as well as the Minister of Urban Development, Housing, Food, Civil Supplies & Consumer Affairs Department, Govt. of Sikkim, Shri Narendra Kumar Subba, among others helped in understanding the stage and prospects of planning, current issues and opportunities.

Figure 8-2: Meeting with PCE Cum Secretary and other officials of UD&HD, Govt. of Sikkim

8.2. Proposed Station Sites

As identified in the previous chapters, Figure 8-3 shows proposed CCT station locations in Gangtok. The proposed CCT system is made of total 14 stations with 10 stations in North South line, 2 stations in East line and 2 stations in West line. The proposed alignment follows the natural structure of the valley and Gangtok's residential topography. It also provides an incentive to extend settlements along its line, thus defining an axis for future urbanization.

Figure 8-3: Proposed Station Sites of Gangtok CCT System

8.3. Site Analysis

A detailed site analysis was carried out with respect to the proposed CCT system alignment and provided in the following sub-sections;

8.3.1. Population Density

Gangtok is home to an estimated around 1 Lakh inhabitants mainly living in hilly terrain, mainly in buildings flanking steep mountain roads. An analysis of population density shown in Figure 8-4 shows that while settlement patterns basically follow the geography of the valley, lateral extensions to mountain flanks require performant first and last mile connection offers fully integrated with the cable car.

The CCT system defines an axis along the valley along which future urbanization is projected to happen. This takes pressure off the highly dense core, while raising the quality and value of other areas along the cable car: Currently remote from Gangtok's economic center due to cumbersome road transportation, the cable car reduces travel time by factors of up to 1:12. More equitable and more inclusive settlement structures result as a consequence.

8.3.2. Settlement Structure & Physical Expansion

The remote settlements of Penlong Pang Than (10 Kms from Gangtok City Centre), Bhusuk (9 Kms), Rumtek (25 Kms), Ranks Luing (25 Kms), shown in Figure 8-5, also benefits from the cable car on multiple levels;

- Road access gets faster since congestion in Gangtok is resolved
- Regional Jeep Taxi service now connect the nearest suitable CCT station instead of central taxi stands in Gangtok, allowing for much faster, efficient connection.

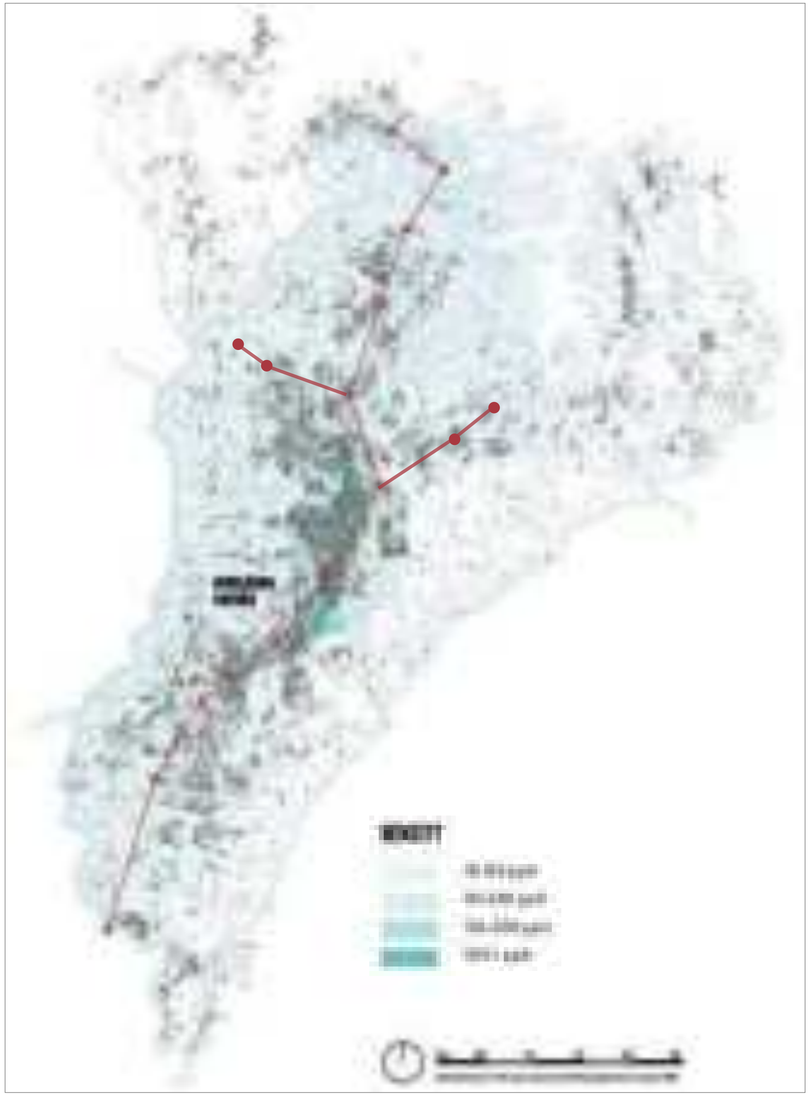


Figure 8-4: Population Density along Proposed CCT System Alignment :

- Average speed of regional taxis rises, allowing for a more efficient use of vehicles translating into better, more reliable service and lower fares.

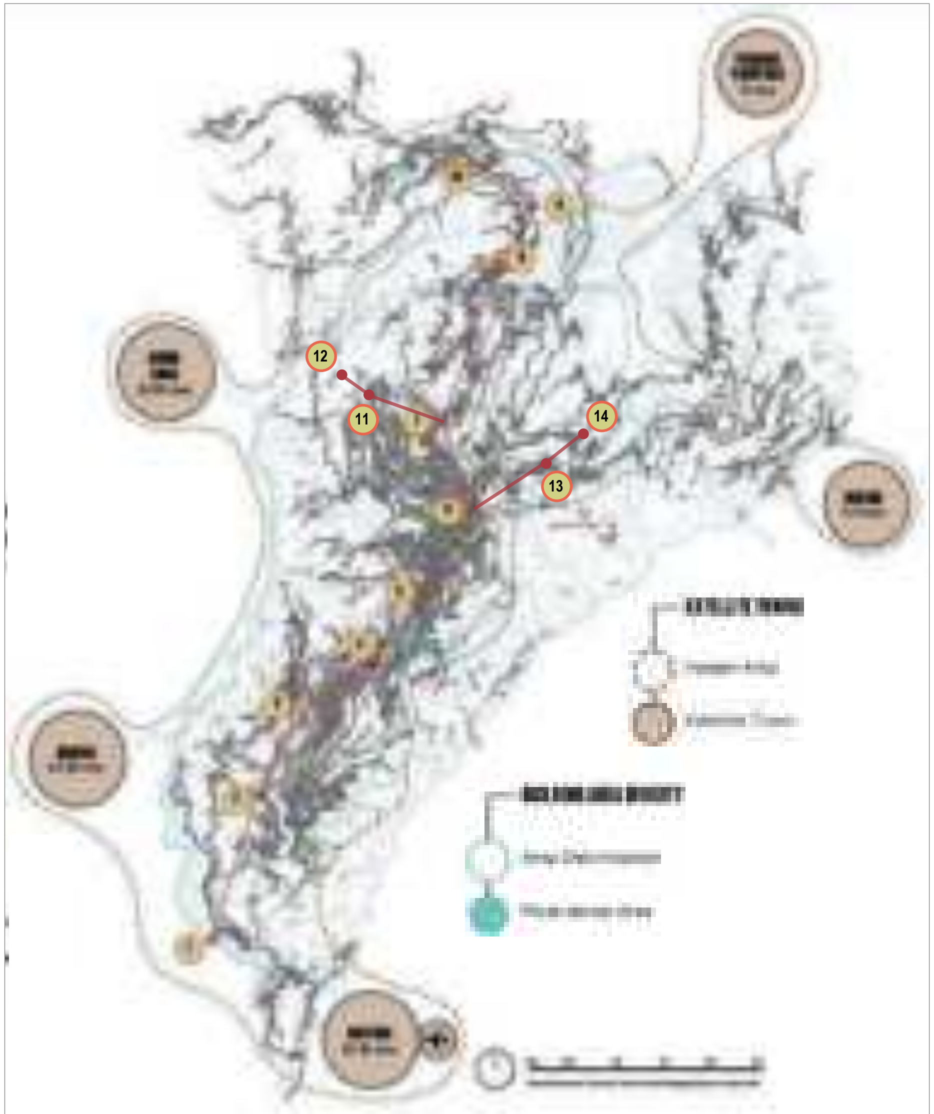


Figure 8-5: Building Density and Satellite Towns

Also, the potential of the new Pakyong Airport, expected to be opened for commercial aviation by mid of 2018, is leveraged by Gangtok CCT system: With the base station Ranipool Taxi Stand including a bus terminal, an efficient bus connection to and from Pakyong Airport can be set up, since the need for the buses to use NH-10 into Gangtok city center is eliminated. As a result, larger vehicles can be used, making travel more efficient to operators and more economical to passengers.

8.3.3. Vegetation

Gangtok is located in mountainous terrain surrounded by dense forests, consisting of robust oak, poplar, birch and elm. Coniferous trees and evergreens partly stabilize hilly grounds. The rich biodiversity supported the strong growth in eco-tourism over the past decade. Hiking, trekking, climbing, river-rafting and mountain biking are leisure activities on the rise.

On the East and on the West the city is flanked by two streams. They divide natural drainage. Due to Gangtok's subtropical, wet highland climate with a monsoon season, vegetation such as orchid variations and bamboo are abundant. Snowfall is rare but can occur. vegetation across Gangtok is shown in Figure 8-6.

8.3.4. Building Footprints

The Figure 8-7 illustrates present and future impacts of CCT on settlement areas: while precisely following the areas of existing settlements, currently remote areas receive a quality of access to the social and economic hotspots of Gangtok of a quality never seen before. With regard to the current and forecasted population growth superior to 8%, incentives are set to extend settlement along the cable car line, reducing sprawl while simultaneously relieving Gangtok's urban core that currently already shows high-density settlement patterns.

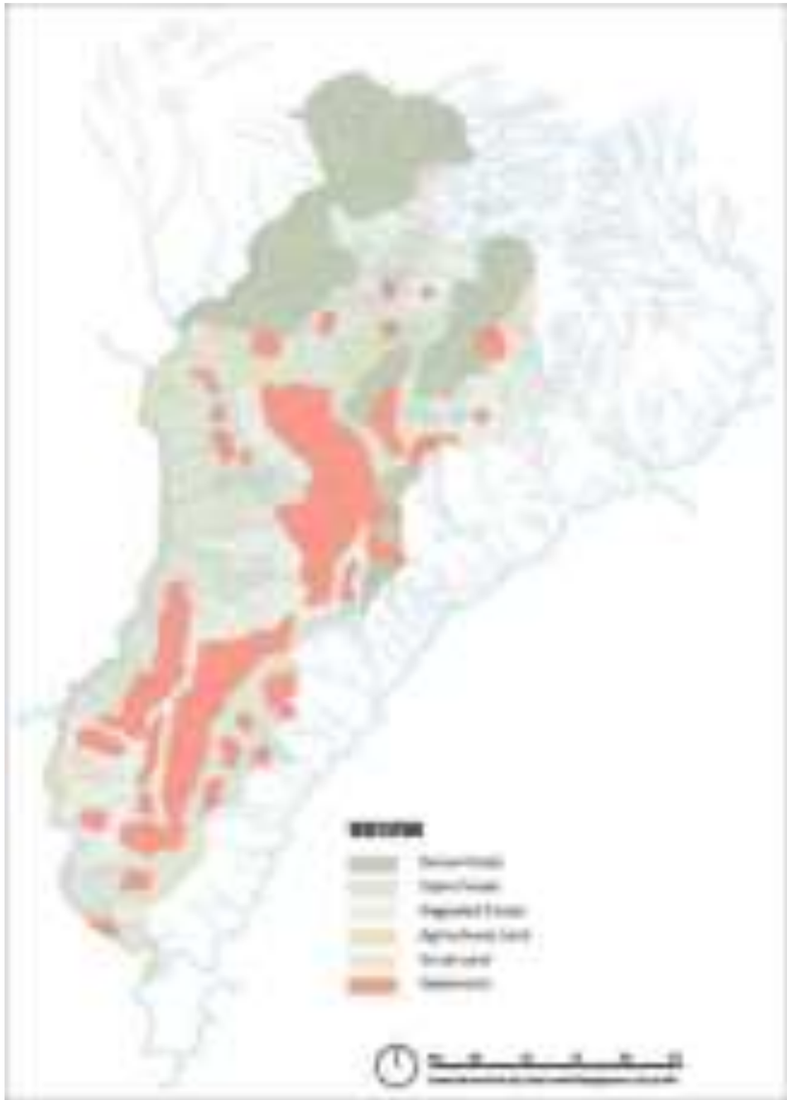


Figure 8-6: Schematic Representation of Vegetation Across Gangtok

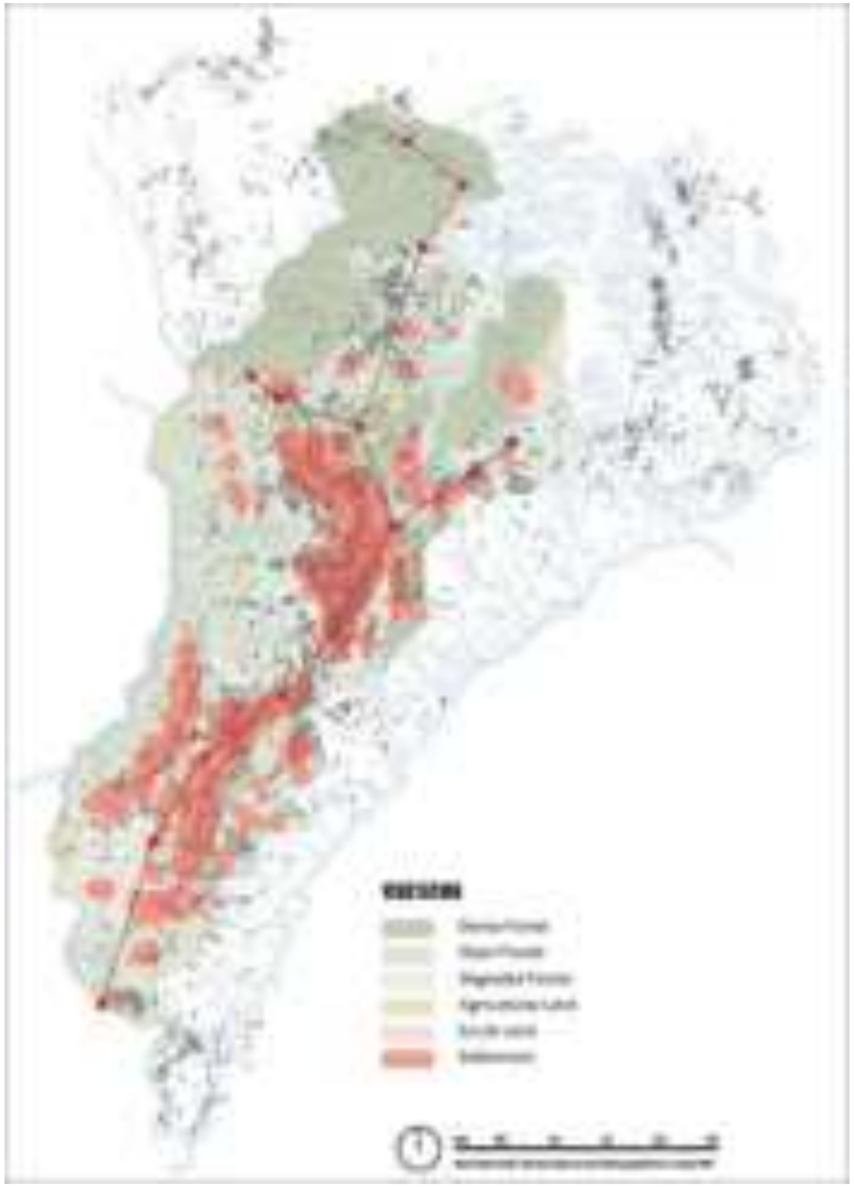


Figure 8-7: Schematic Representation of Vegetation, Settlements and CCT Line

8.3.5. Risk Zones

As shown in Figure 8-8, Large parts of the State of Sikkim are made up of fairly instable rocks. Despite the dense vegetation and forest cover the prevailing, steep slopes are therefore prone to frequent landslides. Intense surface water runoff especially during monsoon season and man-made drains have further enhanced this risk.

Gangtok is located near the convergent zone of the Eurasian tectonic plate and the Indian tectonic plate. The Indian Bureau of Standards has classified Gangtok as seismic zone IV on a scale ranging from I to V, in order of increasing seismic activity.

It is crucial for the proposed cable car to have stations and towers located outside or in low risk zones, with foundations in stable rock. Also, positioning of stations and the layout of the line are to be chosen as to make it resilient as much as possible. One measure is to make towers partly redundant by increasing their number and spacing them closer, helping avoid disaster if a single supporting tower were to be hit despite all precautions. Also, the cable car then offers alternative transportation in case of major road slides.

8.3.6. Open Spaces for Recreation

Gangtok largely lacks open and recreational space. This is increasingly seen as an inhibitor not only to well-being for locals, but also to rising tourism - Gangtok welcomes around 3.6 Lakhs tourists per year, over three times its resident population. Negative economic consequences make it specially desirable to offer green and open spaces away from the intense emissions from congested NH-10, traversing Gangtok.

Major cities like New York have adapted their zoning laws as to ensure most of their population live no more than a given time, e.g. 10 minutes., of walking from a park.

Figure 8-8: Schematic Representation of Land Stability Across Gangtok

Along with the cable car, we propose to create, in the vicinity of stations, recreational areas with a focus on community playgrounds, gardens and sitting areas. It is important to activate these areas as the cable car is neither designed for nor intended to be a standalone project. As planned for the San Agustin MetroCable in Caracas/Venezuela (see section 7), a network of recreational facilities including pocket parks and gardens can be included as part of the proposal.

8.3.7. Land Use and Building Typology

The overview of building types is based on 2011 census data. The settlements shown in the previous Figures are based on the aerial photography flown in the year 1998 and have extended considerably along the axis currently defined by NH10.

The cable car line as suggested has been designed to not only follow these latest developments in land use, but is seen as incubator providing an axis for future, controlled and more sustainable expansion of the city (see section 8.3.2), reflecting the richness of its environment and helping protect the nature that is increasingly becoming part of its economic capital. An adaptation of zoning laws to support this is envisioned.

Given the steepness of the slopes and the scarcity of flat land, many houses are of a multi-story typology on very compact ground. Built close to steep valley hillsides, building access in this case is generally through one of the intermediate floors, which is equivalent to street level. This typology, given the number of floors, remains comparably low in overall height. For the construction of the cable car, this is a key advantage, since it helps limit the height of towers and allows for the cable car to equally follow the mountain.

8.3.8. Public Transportation Modes – Local Transport

Local transportation is operated by a fleet of small, compact cars seating a maximum of 4 passengers. Fares are subject to negotiation. Virtually no scheduled buses or other larger vehicles are available. While this taxi-like operation is well regulated in terms of pick-up points (shown in Figure 8.9), and the regulation largely respected by drivers, it has the huge inconvenience of keeping a large number of small vehicles on the road, each of them occupying valuable slots on the highway, further tightening congestion.

This is a classic case of mis-assignment of transportation infrastructure: While on routes in heavy demand, the most efficient way to organize transit is the operation of large, scheduled vehicles, smaller vehicles are very suitable for trunk routes or even on-demand, first- and last mile operation. In this scenario, small vehicles carry passengers to the connection points with mass transit.

It is a key functionality of the projected cable car to take over this role of mass transit. The small 4-seaters would then be re-assigned to last-mile distribution to/from the cable car stations: Especially with regard to the rising importance of tourism, there is significant business opportunity arising from this reassignment.

8.3.9. Public Transportation Modes – Regional Transport

Mainly worked by Four-Wheel-Drive Vehicles seating a maximum of 8-10 passengers, regional transport is operating in and out of the official taxi stands shown in Figure 8-10. As with local transport, full integration and excellent connectivity with the cable car are crucial to avoid redundancies in operation, to lower trip times for passengers, and to reduce and ultimately eliminate road congestion.

Figure 8-9: Location of Local Taxi Stops/Stands Across Gangtok

Figure 8-10: Location of Regional Taxi Stands Across Gangtok

8.3.10. Public Transportation Modes – Intercity Transport

Especially towards the mountainous regions of the Himalayas further up NH-10 (and 31 resp. 31A), it is operated by Four-Wheel-Drive Vehicles seating a maximum of 8-10 passengers. Full-size buses at the time of writing play an inferior, almost negligible role.

It is noteworthy though that according to Ministry of Railways, a broad gauge rail line from Shiliguri to Gangtok is formally part of the Sikkim infrastructure planning. Also, regular bus services along NH-10 have repeatedly emerged on the Sikkim government development agenda. While the latter are likely to come into reality than a train up the valley, they need to be planned for: For better integration, it is suggested to re-locate the existing Gangtok bus terminal (shown in Figure 8-11) to the bottom station of the cable car, making it unnecessary for buses from Shiliguri and Kalimpong to make a full run to/from the current bus terminal, saving time, fuel, emissions including noise, and avoiding operations parallel to the cable car.

With a relocated bus terminal, passengers would then leave the bus at the lowest most station of the cable car, shortcut traffic by literally flying above Gangtok, and be driven by small car to their final destination from the closest cable car station, in a model of true inter-modality.

Intercity trips are often performed with a size-able luggage, provision for which can be easily made in the CCT cabins design.

Figure 8-11: Location of Regional Bus Stands Across Gangtok

8.3.11. Transportation Infrastructure – Main Roads

Gangtok is served by NH-10, and its extensions Highways 31 and 31A. While 92 per cent of roads in Gangtok have two lanes, roadways suffer from severe congestion. Today on key roads of Gangtok cars form around 90% of total traffic by movement, which is extremely high both by Indian as by international standards.

Data from the Indian Center for Science and the Environment shows that in mountainous towns like Gangtok the share of car trips in the total number of daily trips is as much as 40% - much higher than many lowland cities. A key reason is the underdevelopment of public transportation - Gangtok originally was a walking city and did not properly adapt to growing motorization, resulting in severe levels of congestion, poor walkability and unacceptable levels of active and passive road safety.

Major regional settlements at 5-30 kms distance are served by 4x4 taxis operating on mountain roads. The NH-10 to Shiliguri will also provide, via connecting roads, access to the new Pakyong airport that is to open to commercial service in the mid of 2018.

Major road network within Gangtok and connections to satellite cities are shown in Figure 8-12.

Figure 8-12: Major Roads in Gangtok

8.3.12. Transportation Infrastructure – Road Traffic Volume

Today, despite increase in the number of vehicular trips by 14 times over the past two decades, the average daily trip length in Gangtok is still around 3 km. 30% of roadways in Gangtok encounter problems with parking saturation - which is a clear indicator of too many private vehicles in operation.

Beyond the strongly impacted quality of life of citizens, the possible negative repercussions on the fast growing tourism ecosystem have already briefly been mentioned in section 2. Data shows Gangtok urgently needs a return to low-carbon mobility, or better even zero-carbon mobility, as brought by the cable car.

The pedestrianization of one of the core commercial streets, M. G. Road, shows that traffic mitigation measures can be implemented and will be accepted and even welcomed. For sustainable, scalable success, it is important not to be restricted to isolated interventions but to actively promote the cable car as an incubator for a whole series of well-connected and balanced measures, relying on each other and planned in a single approach. As mentioned in sections 5 and 6, demand responsive transit for the first and last miles, complementing the cable car, is one key to a low-carbon mobility, reducing dependence on personal vehicles.

Traffic volumes at critical locations along the road network in Gangtok are shown in Figure 8-13.

Figure 8-13: Traffic Volumes an Major Roads in Gangtok

8.4. Gangtok Cable Car Transit System Elements

8.4.1. Overview

A critical component to evaluate within the CCT system feasibility study is the potential terminal and routing options for the proposed system. This section presents a diagram of the proposed CCT system route connecting Gangtok from Ranipool Taxi Stand in the south to Upper Burtuk in the North and New Hospital at sichey in the West and Chandmari in the East, along a 13 km route with 13 sections and 14 stations, 13 of which are open for passenger service.

The stations site proposal responds to the main landmarks and points of activity to connect within the city of Gangtok. Neuralgic points like Tourism Office Complex, Sikkim Manipal Hospital, New Hospital at Sichey and the Denzon Cinema/Supermarket Complex are considered as strategic because they are significant trip generators: Serving them has positive impact in the city mass transport system. The implementation of proposed cable car network shall be taken up in two construction phases:

Phase I: Consists of the 6 lowermost sections, from Ranipool Taxi Stand to Old STNM Hospital in the North South Line. As per the site analysis, this segment is the most critical area in terms of traffic congestion, existing and forecasted transit demands and activity density, and has the most potential to certify the success of the cable car project. It is crucial that together with its realization, a complete redesign of the road transport system come into effect, and smaller vehicles are assigned to first and last mile services instead of "working" along the main artery.

Phase II: Consists of the following sections;

4. North Link - 4 uppermost sections of Old STNM Hospital to Upper Burtuk and
5. East Link - 2 sections connecting STNM Hospital to Chandmari Area.
6. West Link – 2 Sections connecting Taxi Stand North District to Hospital at Sichey.

This phase will consolidate the connection, serving all major Gangtok residential areas in their current layout.

Technically and economically, the benefits of dealing with a segmented system of ropeways are numerous: easy maintenance and strategic independence of the segments, which translates in less operational costs and higher flexibility in construction, operations and maintenance.

This section calculates the potential plot of land required and the probable affectation of existing structures that need to be demolished: The "plot" indicates the space on which the station will be placed. The "affectation area" is the space required for construction machinery and security perimeter. Both areas have to be cleared from trees and land prepared for accessibility and construction.

It is crucial that all stations be erected on Government land. Besides the sites for the stations, additional plots of land need to be available during construction for stocking of material, pre-assembling of towers, loading and unloading pieces of the system, and for helicopter landing. These areas must be secured and accessible for heavy trucks.

8.4.2. Choice of Cable Car Technology

Based on the site and framework analysis, alternative technology analysis (refer chapter 6, sub section 6.3) and San

Agustin Metro Cable case study, Monocable Detachable Gondola (abbreviated as 10-MGD) has been suggested as best suitable technology:

For reasons of better and more intuitive understanding, the project's core characteristics are developed as much as possible in analogy to the highly successful San Agustin system (Chapter 7, subsection 7.1).

Furthermore, the choice of San Agustin as reference case serves as a proof of feasibility under difficult conditions that are, at the base, comparable to a possible Gangtok implementation.

Section 9.2. lists a detailed breakdown of an MGD's performance, including the presentation and functionality analysis of its major components.

The description of the vehicles (gondolas) in section 9.2.3. refers capacities of 10 to 12 pax per vehicle: At a maximum occupancy of 10, all pax are seated, whereas 12 pax is based on standees which shall be allowed only if unavoidable. Also, mixed operations (with lowering benches) are possible. In all these cases, the general system properties and the size category of vehicles remain the same, the only notable modification are the exact vehicle typology itself and the specific design of some structural elements.

Only detailed capacity calculations based on the exact integration into the urban fabric and the integration with other modes in an entirely redesigned local transport system - including the re-assignment of on-demand modes to new, better suited tasks as previously emphasized in section 6.3 - have to reveal which capacity choice, cabin layout and detailed solution works best within the span given in this report. This choice mainly reflects vehicle configuration and has no major impacts on the other elements.

The insertion of the proposed cable car into urban fabric, as derived from the analysis documented in the report and explained in detail in chapter 5 and Sub section 5.6, is based on MGD technology. Also, the station footprint used as a base for the detailed description of the individual stations, and the characteristics of the line are all 10-MDG based (Section 10.4).

The detailed insertion of the proposed cable car line into the landscape (Section 8.5) is based on structural assumptions for 10-MGD.

The detailed, specific presentation of the station elements and system components of the Gangtok cable car (section 9.2), is based on 10-MGD and shows the dimension of the static elements, moving elements and vehicles accordingly, with the highest degree of precision possible and reasonable at this stage of planning.

8.4.3. Use-Incentivizing Measures for Passengers

Strong emphasis is put on the necessity to never consider the cable car - as per the design approach developed in the report - as a standalone system, but as a "spinal axe" connected to other modes. This is of critical importance:

The only way to maximize the positive externalities of the cable car is to consider it as an integrator fostering the emergence of a multi-modal public transport network (section 5.6.2), with a very special focus on walkability. A core element is station catchment area extension, (Section 5.6.1 and section 8.5). Another important measure we suggest is the deployment of an electric bike-sharing system with the cable car stations as home pods. Mainstream research on shared mobility of the past 3 years has clearly shown that self-drive modes, in a simple-to-use, affordable way, provide one of the cheapest and most efficient ways of leveraging fixed-route mass-transit modes, in this case the cable car, with on-demand door-to-door mobility at the users' request.

The importance of boosting walkability in an urban environment is mentioned on section 5.6.2. Furthermore, as described in section 8.5, the importance of a good linkage of the stations with the local pedestrian grid is emphasized, using the successful application in San Agustin as a model. Breaking these approaches down to local level is part of architectural design process of every station and will happen in the further development of the Design.

A key result from the detailed analysis of the status quo is that Gangtok's current transportation problems are largely based on an inefficient deployment and task assignment of existing transport modes. As developed in the report, a core problem originates in a large amount of small vehicles being used as a backbone of what should be a mass transportation approach (case studies in chapter 7). Thus, from a combination of system efficiency, economic and social considerations, we suggest to re-assign the small vehicles to last-mile transportation, where they are used according to their systemic advantages and can fully unfold their potential: In an entirely reshuffled assignment, they provide services to and from the cable car stations, while the cable car takes the role of transportation along the valley axis, freeing NH-10 from local transport.

The expected combined outcome of these measures is an economic boost for both local residents, businesses, environmental quality (air, noise etc.) and tourism.

Additional Elements

Beyond a redevelopment of the passenger transport case which is the "standard" element of any feasibility analysis of an urban cable car, the specific situation in Gangtok, as per the analysis especially, from chapters 4,5 and 7, lets us suggest to also plan the cable car for use as small cargo transportation mode.

The main reason for this is the local economy in Gangtok, the rising importance of tourism as a distribution channel, and the fact that the very same road space is shared between passenger and cargo transportation. The system we suggest - with platform elevators in the cable car stations and a last-mile cargo distribution system from the stations to businesses and homes - complements the efforts proposed for passenger transportation in the Gangtok municipality

8.4.4. General System Features

(A) Working principle of a Monocable Detachable Gondola (MGD) cable car system: Vehicles (gondolas) grip to an overhead moving cable moving at constant speed (navy blue), carried by towers. In stations, gondolas uncouple from the cable on a decelerator (thick orange) and move slowly along suspended rails (thin orange), giving passengers the chance to board and alight. Gondolas change direction while moving in the station, before accelerating and gripping the cable (navy blue) in the opposite direction.

(B) Schematic illustration (not to scale) of all sections of the Gangtok Metro Cable aligned: While every section can operate by itself, in normal operation gondolas transfer from one section to another in stations (light blue), bypassing the turnaround on overhead rails (orange dotted). A gondola then travels seamlessly from station 1 to station 10 providing a continuous system transport experience, giving passenger the option to board, stay on board or alight at every single station on the line. In the event of an operational disruption or to add extra capacity to a part of the line at a certain time, a subset or all of the gondolas can also be made to turn around at any given station.

Figure 8-14: Schematic Illustration of Proposed MDG System for Gangtok

8.5. Station Routing & Site Proposals

Vector Maps are based on aerial photography taken in 1998, Satellite Images are based on Google Maps, 2017

All recommendations are preliminary, final decisions have to be made on site after negotiations with the client, all relevant stakeholders and all technical details. No ownership information (plot lines) which could be matched with maps of 1998 was provided. It has to be taken into consideration to use when possible government owned land, otherwise land which is owned by as few different owners as possible. Whenever possible higher ground should be used in order to decrease station costs. Each station has to be integrated with additional modes of transport (Taxi, pedestrian...).

Figure 8-15: Gangtok Cable Car System Alignment and Phasing

8.5.1. Station-1 "Taxi Stand Ranipool"

The Gangtok Metro Cable can only function efficiently with regard to solving Gangtok's current transportation gridlock in a sustainable way if the cable car becomes the backbone of local transport and parallel circulation of taxis and other for-revenue passenger operation within Gangtok can be avoided. As previously explained, those vehicles get re-affected to last-mile service instead, complementing the cable car providing added value instead of competing with it.

"Taxi Stand Ranipool", in its role as base station, serves several technical and commercial functions going beyond those of the other stations on the line. In the map, only the core station building with essential cable car functionality is shown. All components as described below are to be added on surfaces adjacent to the station:

(1) Welcome Center: The station becomes a new entry point to Gangtok for both residents and tourists. All infrastructure for welcoming guests, e.g. a tourist office information point, are included in the station premises.

(2) An SNT bus terminal is included in the station complex. Bus services e.g. from Siliguri now end at this cable car station, transferring passengers and their luggage to the cable car. This reduces current and further heavy bus operations along the narrow highway 10, saving on vehicular movements as well as on fuel burned for parallel runs. Only exception are bus services going beyond Gangtok: Those call both at the "Taxi Stand Ranipool" station and at the "SNT bus terminal" station (sections 8.5.1 and 8.5.6).

(3) On a flat surface in immediate vicinity of the station, surface for a car and truck parking lot is to be reserved, providing storage for an expected rise of private vehicles of visitors to Gangtok, in line with rising car ownership rates in India.

An electronic toll system is to prevent unauthorized vehicles from accessing Gangtok. Modeled on the regulation in operation in the Swiss municipality of Zermatt, it is to efficiently prevent road access to Gangtok for vehicles that have not previously been granted permission

A cargo ramp for the efficient transfer of small cargo between trucks and the cable car is to be provided, with elevators accessing the cable car platform from there.

Finally, a garage system for gondola parking is to be built next to the station, allowing for gondolas of the whole system to be stored during operational shutdowns and for extra gondola storage outside peak hours, as well as for service and repair interventions on the gondolas.

A smaller number of gondolas will also be stored on side tracks in intermediate stations, allowing for efficient service phase-in and phase-out on all sections of the line.

The schematic site proposals for "Taxi Stand Ranipool" Station are shown in Figure 8-16, Figure 8-17 & Figure 8-18".

8.5.2. Station-2 "Tourism Office Complex"

Named after the Sikkim Tourist Organization headquarters, this station serves the local neighborhood. With the forecasted growth in population, it's role can further be expanded.

The schematic site proposals for "Tourism Office Complex" Station are shown in Figure 8-19, Figure 8-20& Figure 8-21".

Figure 8-16: Schematic Placement of Proposed MDG System at Identified Site at Taxi Stand Ranipool Station Location

Figure 8-17: Aerial View of Proposed Taxi Stand Ranipool MDG Station and Surrounding Areas

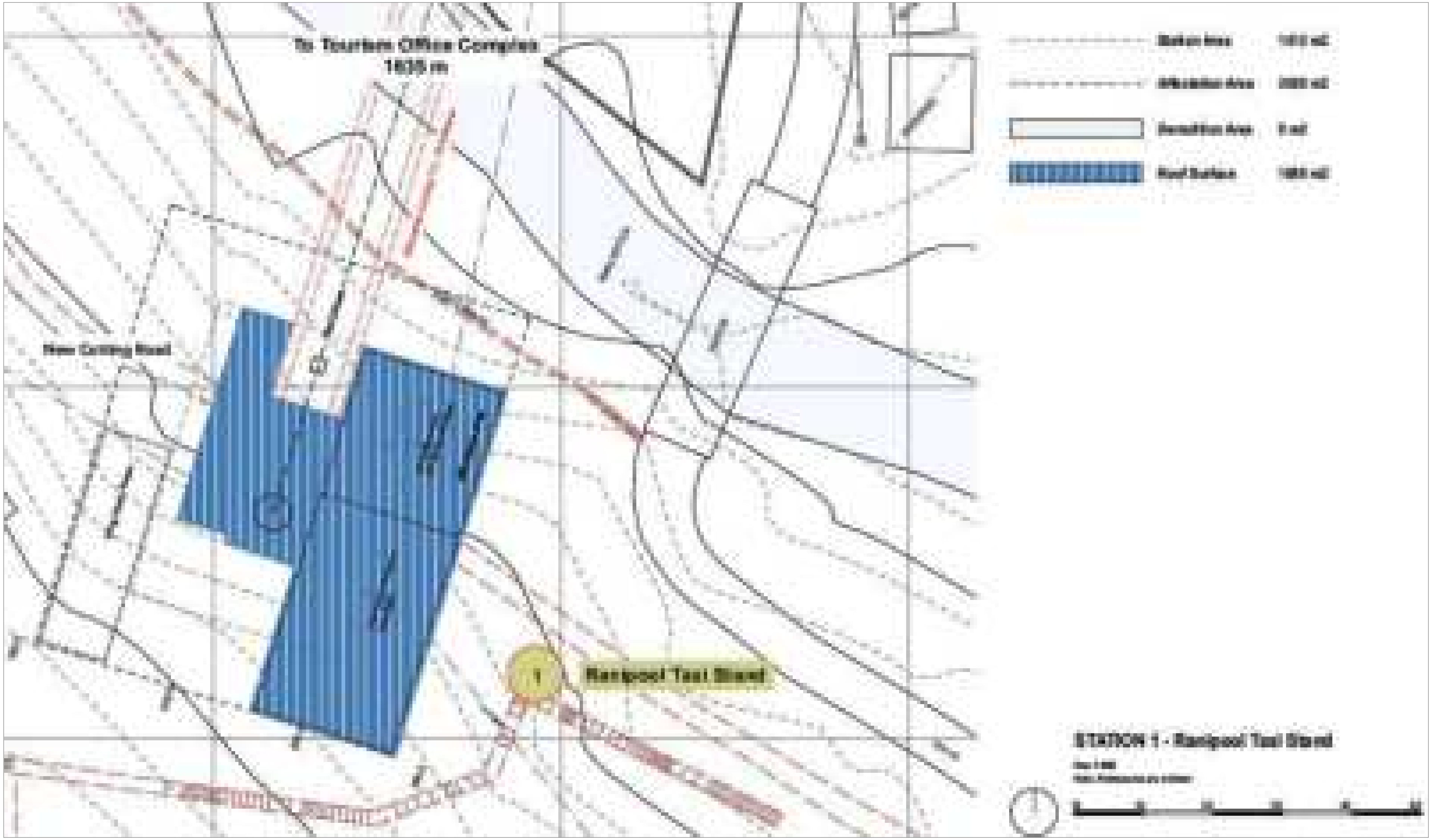


Figure 8-18: Schematic Placement of Proposed Taxi Stand Ranipool MDG Station on Topographical Survey Map of 2017

Figure 8-19: Schematic Placement of Proposed MDG System at Identified Site at Tourism Office Complex Station Location

Figure 8-20: Aerial View of Proposed Tourism Office Complex MDG Station and Surrounding Areas

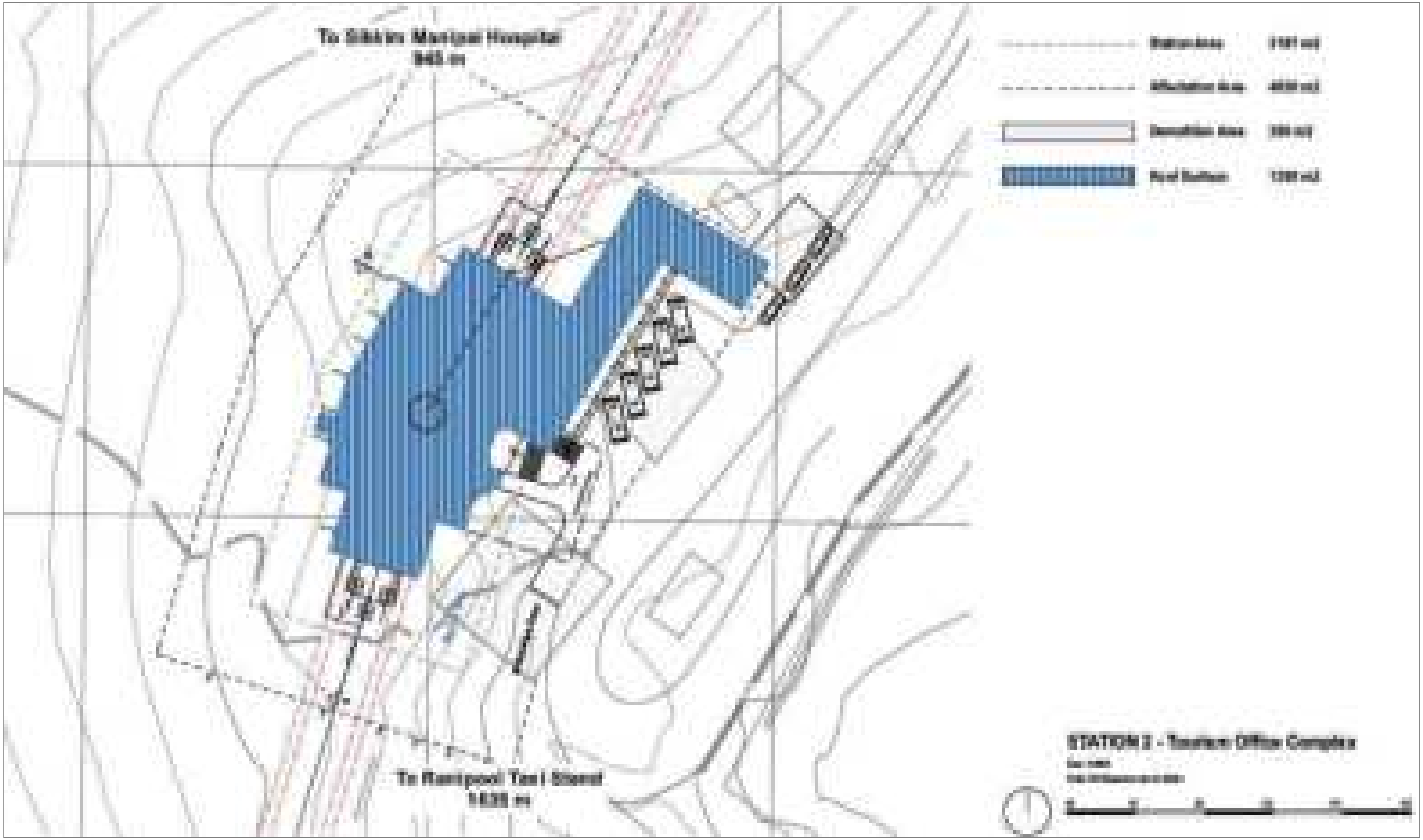


Figure 8-21: Schematic Placement of Proposed Tourism Office Complex MDG Station on Topographical Survey Map of 2017

8.5.3. Station-3 "Sikkim Manipal Hospital"

The station serves the hospital and the local neighborhood. The station is located on a slope. It is to allow level access to National Highway 10 from below and to the hospital at the top, possibly via a pedestrian sky-bridge.

Hospital access is to be provided in a fully accessible way, both for patients in wheelchairs but also for patients to be transferred on a stretcher from and to the cable car. The cable car has ambulance gondolas that allow for a patient on a stretcher to be transported. Such ambulance gondolas are proven standard equipment in many mountain resort operations.

The schematic site proposals for "Sikkim Manipal Hospital" Station are shown in Figure 8-22, Figure 8-23 & *Figure 8-24*".

8.5.4. Station-4 "Gangtok Municipal Corporation"

This station serves the Deorali Taxi Stand and the local community. Level access from National Highway 10 is to be provided via the lower part of the station complex.

The schematic site proposals for "Gangtok Municipal Corporation" Station are shown in Figure 8-25, Figure 8-26 & *Figure 8-27*".

8.5.5. Station-5 "Denzong Cinema/Supermarket"

The station serves the high frequencies generated both by the densely populated neighborhoods, as well as by the nearby Kanchanjunga Shopping Complex/Old Lal Bazar, linked to the cable car station by a pedestrian sky-bridge. The shopping complex regularly sees farmers from the surrounding region sell agricultural products. It is a major generator of passenger demand.

It is important to note that Old Lal Bazaar has a taxi stand on its ground floor, from where local connections are served.

The station also serves nearby MG Marg, a former market and pedestrianized street very popular with both locals and tourists.

The schematic site proposals for "Denzong Cinema/Supermarket" Station are shown in Figure 8-28, Figure 8-29 & Figure 8-30".

Figure 8-22: Schematic Placement of Proposed MDG System at Identified Site at Sikkim Manipal Hospital Station Location

Figure 8-23: Aerial View of Proposed Sikkim Manipal Hospital MDG Station and Surrounding Areas

Figure 8-24: Schematic Placement of Proposed Sikkim Manipal Hospital MDG Station on Topographical Survey Map of 2017

Figure 8-25: Schematic Placement of Proposed MDG System at Identified Site at Gangtok Municipal Corporation Station Location

Figure 8-26: Aerial View of Proposed Gangtok Municipal Corporation MDG Station and Surrounding Areas

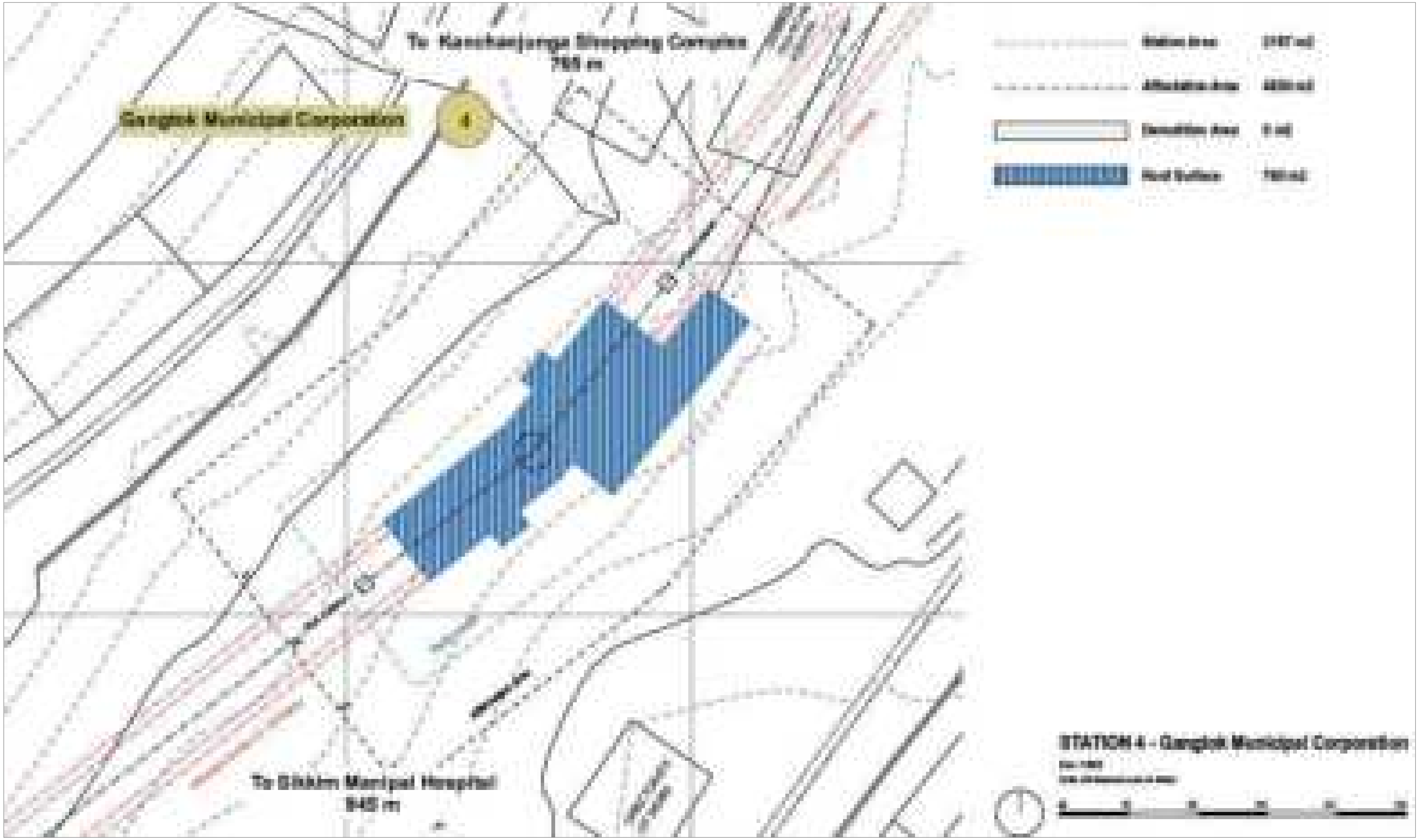


Figure 8-27: Schematic Placement of Proposed Gangtok Municipal Corporation MDG Station on Topographical Survey Map of 2017

Figure 8-28: Schematic Placement of Proposed MDG System at Identified Site at Denzong Cinema/Supermarket Station Location

Figure 8-29: Aerial View of Proposed Kanchanjunga Shopping Complex MDG Station and Surrounding Areas

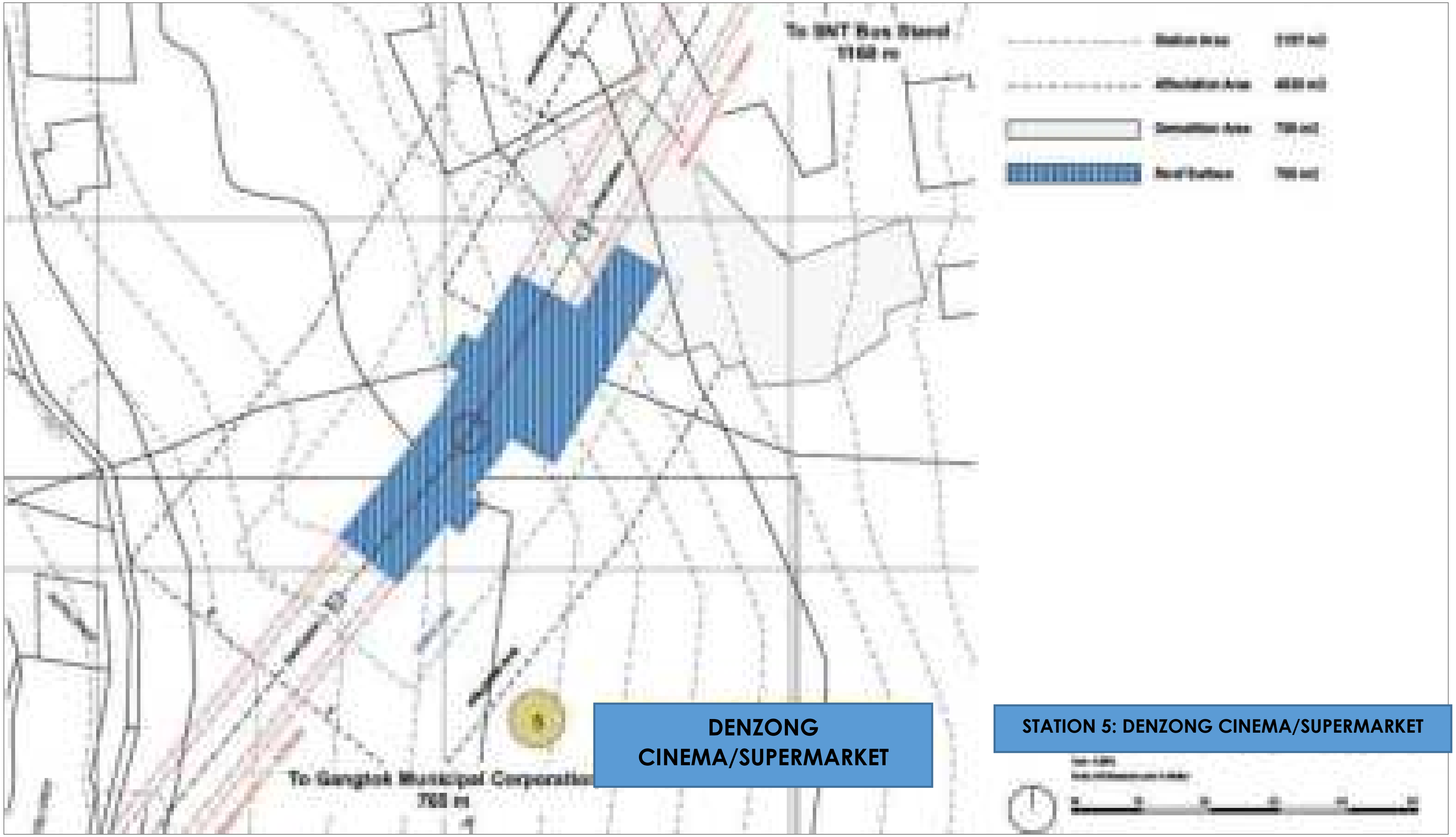


Figure 8-30: Schematic Placement of Proposed Kanchanjunga Shopping Complex MDG Station on Topographical Survey Map of 2017

8.5.6. Station-6 "Old STNM Hospital"

The station mainly serves the socially and economically dense neighborhoods. It has a walkable proximity to the Ranka taxi stand and SNT bus stand. Pedestrian links between these three transport hub are to be fully accessible and barrier-free, allowing for transfer of luggage and small cargo on hand carts/travellators. Two platform elevators are projected instead of one to facilitate baggage and cargo transfer. Also, the station connects to the East line connecting This station to Chandmari taxi stand and 2nd Mile area.

The schematic site proposals for "Old STNM Hospital" Station are shown in Figure 8-31, Figure 8-32 & *Figure 8-33*".

8.5.7. Station-7 "Taxi Stand North District"

This station mainly serves for transfer to regional jeep taxis, as well as the local neighborhood. Due to expectably important volumes of baggage transferred, three platform elevators are projected instead of one to facilitate baggage transfer. The taxi stand is seamlessly linked to the station by escalators/lifts and sky-bridges.

Due to the focus on regional taxi passenger and luggage transfer, no e-Biking docks are provided at this station, helping reduce mobility in the immediate station environs.

The schematic site proposals for "Taxi Stand North District" Station are shown in Figure 8-34, Figure 8-35 & *Figure 8-36*".

8.5.8. Station-8 "Helipad"

Located at the northern extension of the Gangtok municipal settlement area, the station serves as a transfer station to the helipad, but foremost serves the broader local community.

The e-Bike docks provided allow for easy self-service access also to more remote locations.

N.B. For the exact routing of the cable car line between stations 7 and 8, close coordination with the army is essential since a major part of plots overflown by the cable car between stations 7 and 8 are classified as military land.

The schematic site proposals for "Helipad" Station are shown in Figure 8-37, Figure 8-38 & Figure 8-39".

Figure 8-31: Schematic Placement of Proposed MDG System at Identified Site at 'STNM Hospital' Station Location

Figure 8-32: Aerial View of Proposed 'Old STNM Hospital Station' and Surrounding Areas

Figure 8-33: Schematic Placement of Proposed 'Old STNM Hospital Station' on Topographical Survey Map of 2017

Figure 8-34: Schematic Placement of Proposed MDG System at Identified Site at Taxi Stand North District Station Location

Figure 8-35: Aerial View of Proposed Taxi Stand North District MDG Station and Surrounding Areas

Figure 8-36: Schematic Placement of Proposed Taxi Stand North District MDG Station on Topographical Survey Map of 2017

Figure 8-37: Schematic Placement of Proposed MDG System at Identified Site at Helipad Station Location

Figure 8-38: Aerial View of Proposed Helipad MDG Station and Surrounding Areas

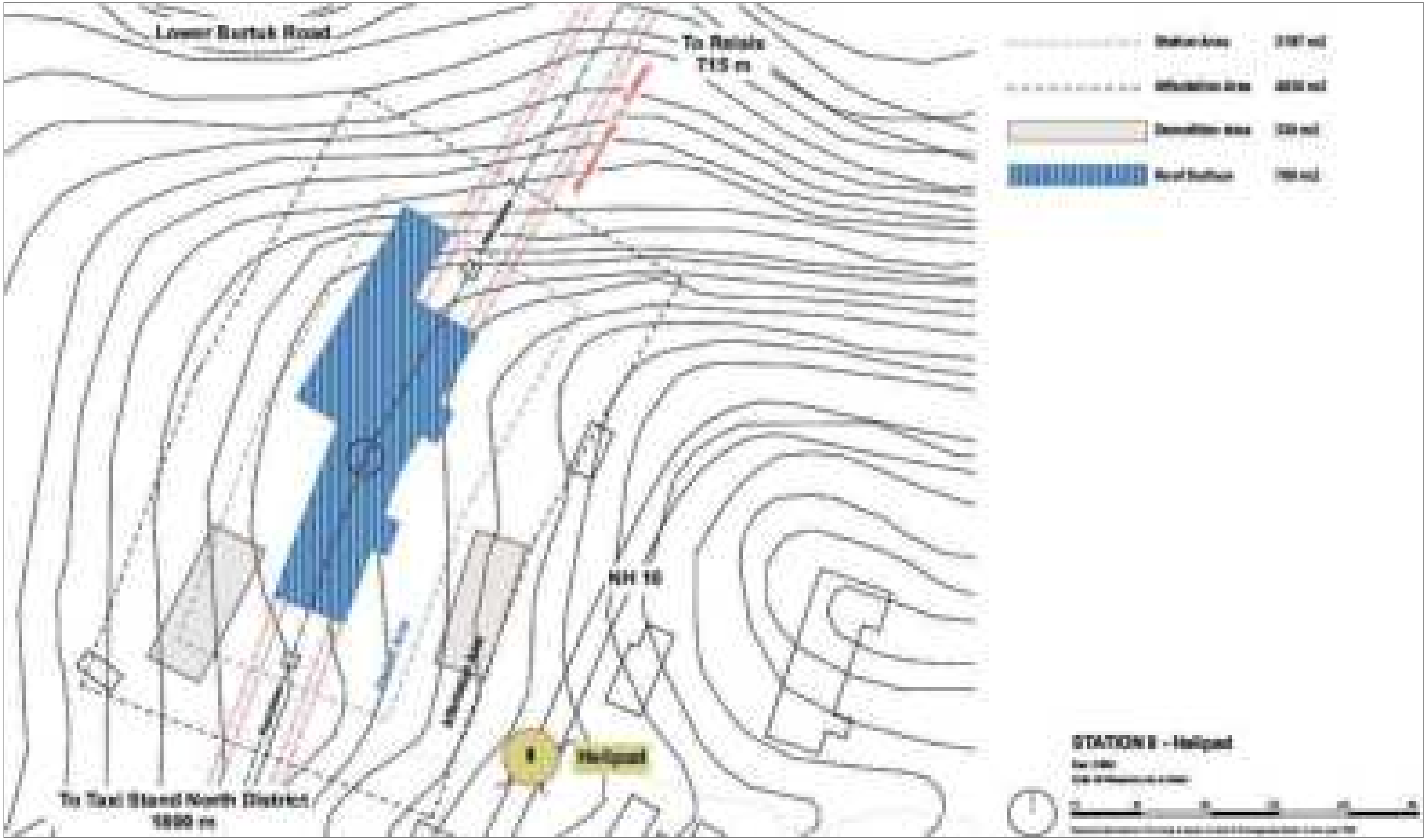


Figure 8-39: Schematic Placement of Proposed Helipad MDG Station on Topographical Survey Map of 2017

8.5.9. Station-9 “Relais”

This station in the current layout has only technical functionality and allows for no boarding and alighting of passengers nor for any other revenue function. While it can be upgraded to a passenger station at a later stage, it is required to allow the line to circumnavigate the fly zone around the helipad. The insertion of the Relais station into the line allows to do so without having the line too steep between stations 8 and 10.

The schematic site proposals for “Relias” Station are shown in Figure 8-40 & Figure 8-41”.

8.5.10. Station-10 “Upper Burtuk”

This station serves the northernmost area of Gangtok area, as well as more remote settlement areas. It offers transfers to local taxis, additional commercial functionalities are included in the station building. As with most other stations, e-Bikes are also available.

This station being entirely surrounded by what is currently classified as military area, the future potential for development and a possible swap of army ground is to be investigated.

The schematic site proposals for “Upper Burtuk” Station are shown in Figure 8-42, Figure 8-43 & Figure 8-44”.

Figure 8-40: Schematic Placement of Proposed MDG System at Identified Site at Relias Station Location

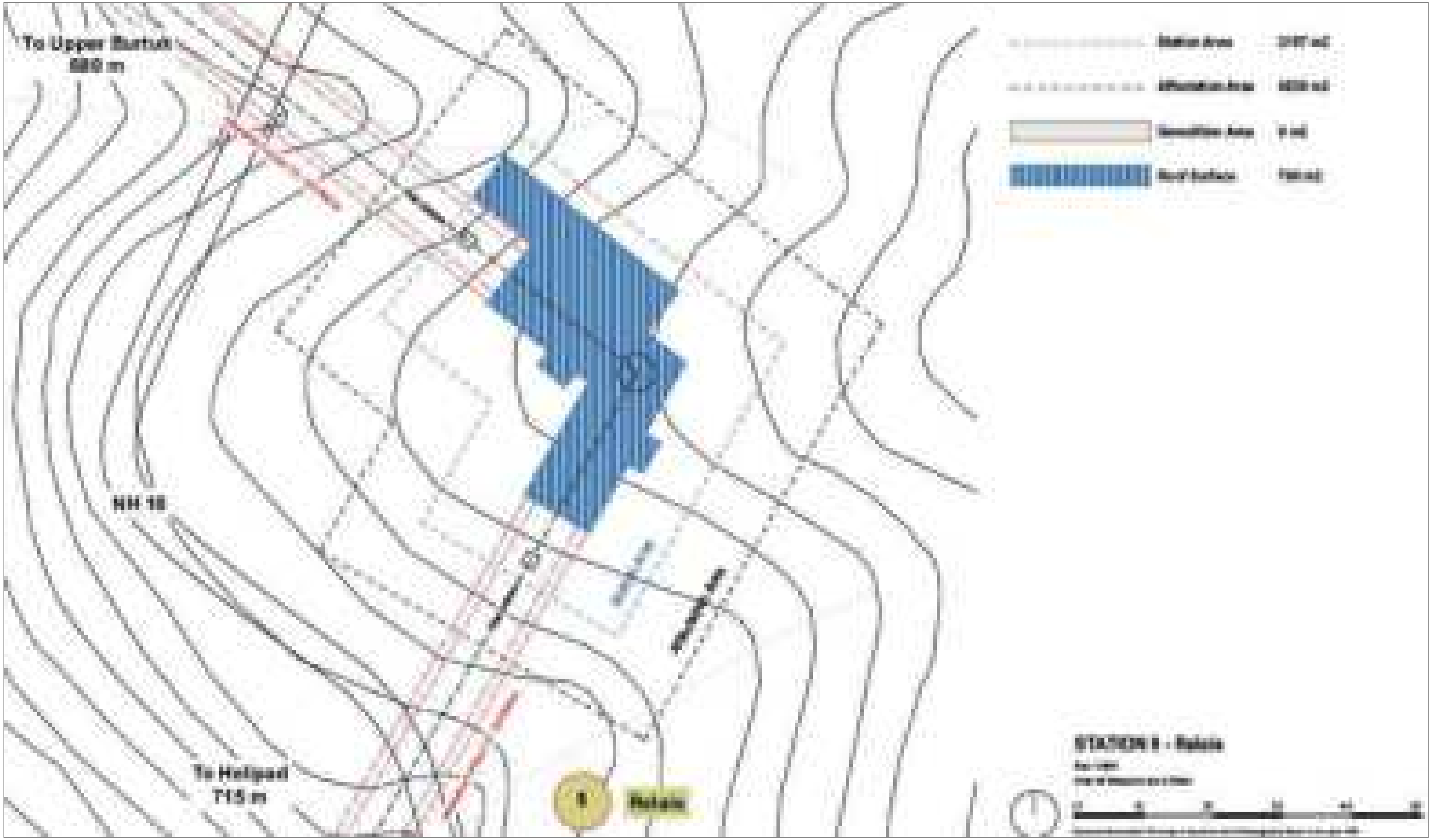


Figure 8-41: Schematic Placement of Proposed Relias MDG Station on Topographical Survey Map of 2017

Figure 8-42: Schematic Placement of Proposed MDG System at Identified Site at Upper Burtuk Station Location

Figure 8-43: Aerial View of Proposed Upper Burtuk MDG Station and Surrounding Areas

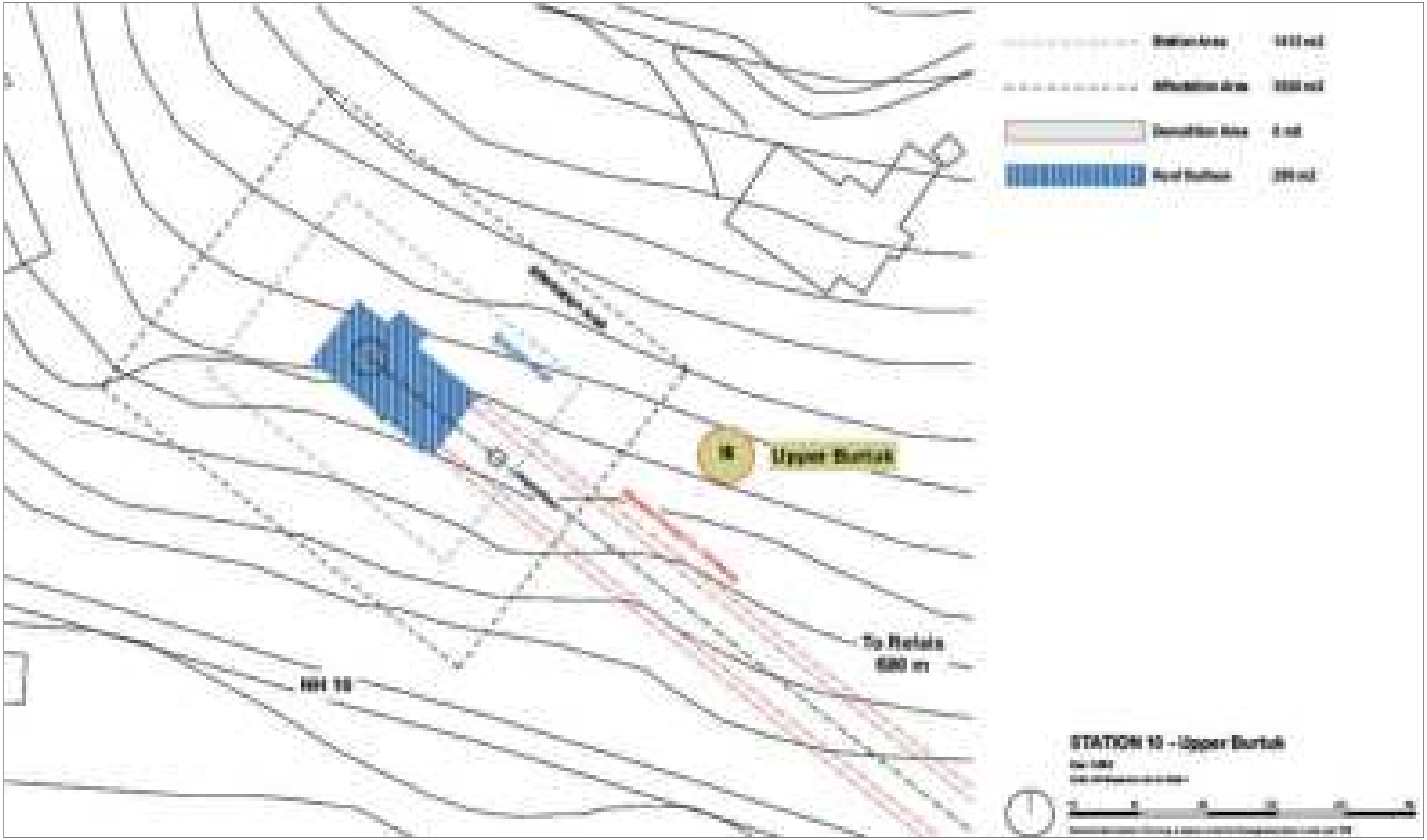


Figure 8-44: Schematic Placement of Proposed Upper Burtuk MDG Station on Topographical Survey Map of 2017

8.5.11. Station-11 “District Administrative center”

The station lies on west line. This station serves the demand from District Administrative center and upper Sichey ward of Gangtok area, as well as more remote settlement areas. It offers transfers to local taxis, additional commercial functionalities are included in the station building. As with most other stations, e-Bikes are also available.

8.5.12. Station-12 “Hospital at Sichey”

This station serves the demand from upcoming 1000 bedded hospital, Easternmost area of Gangtok area, and more remote settlement areas. It also offers transfers to local taxis, additional commercial functionalities are included in the station building.

8.5.13. Station-13 “Chandmari Taxi stand”

The station lies on the east line and is Located at the northern part of the Gangtok municipal settlement area i.e. Core Chandmari Ward, the station serves the core development area. The e-Bike docks provided allow for easy self-service access also to more remote locations. The station is planned to be integrated with the Chandmari taxi stand.

8.5.14. Station-14 “2nd Mile HFC Church”

The station lies on the east line and Located at the upper Chandmari area, this station serves the development along the Jawaharlal Nehru road.

Figure 8-45: Schematic Placement of Proposed District Administrative Center station

Figure 8-46: Aerial View of Proposed DAC Station and Surrounding Areas

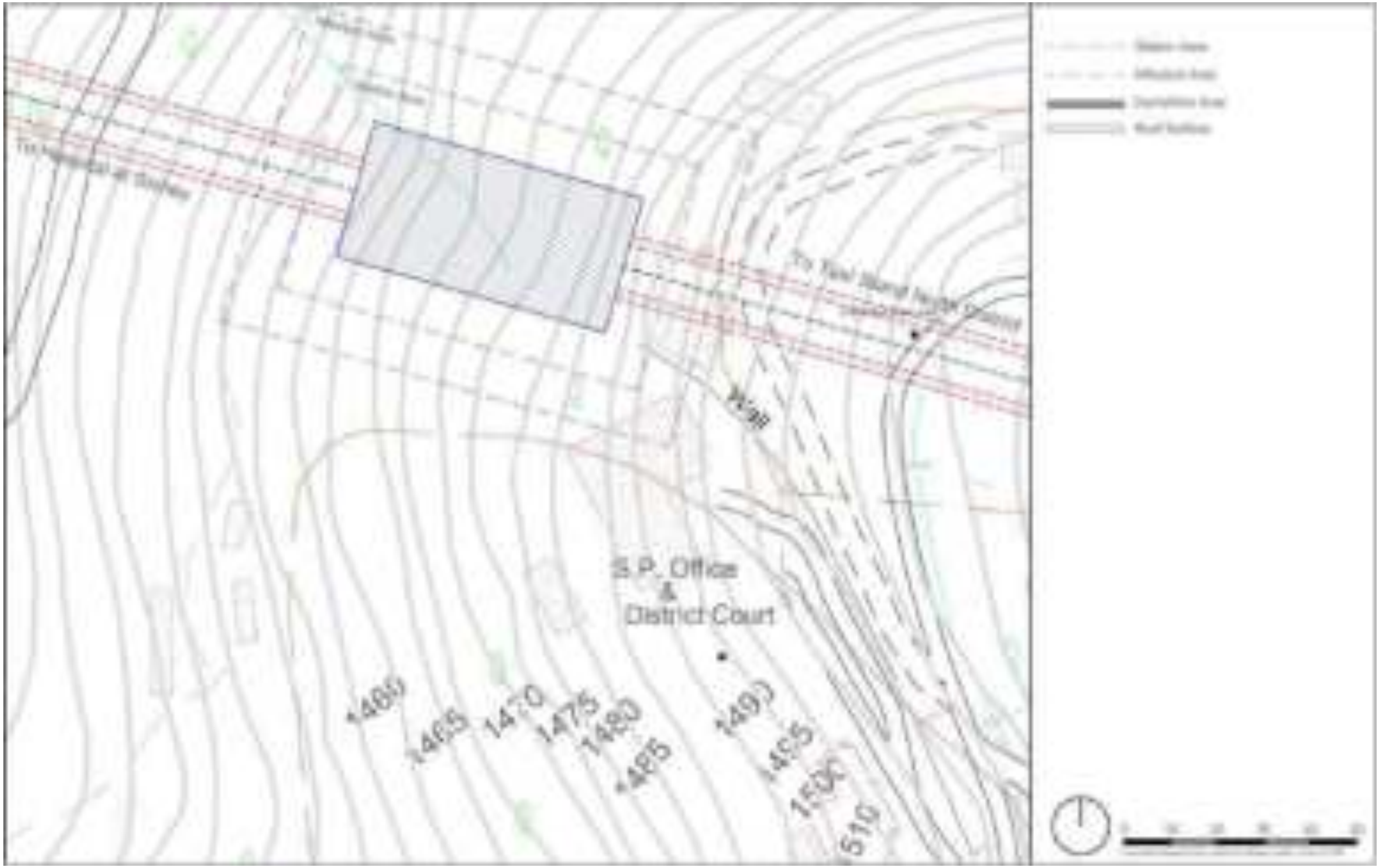


Figure 8-47: Schematic Placement of Proposed DAC Station on Topographical Survey Map of 2017

at

Figure 8-48: Schematic Placement of Proposed 'Hospital Sichey' station

Figure 8-49: Aerial View of Proposed 'Hospital at Sichey' and Surrounding Areas

Figure 8-50: Schematic Placement of Proposed 'Hospital at Sichey- Station' on Topographical Survey Map of 2017

Figure 8-51: Schematic Placement of Proposed 'Chandmari Taxi Stand' station

Figure 8-52: Aerial View of Proposed 'Chandmari Taxi Stand' and Surrounding Areas

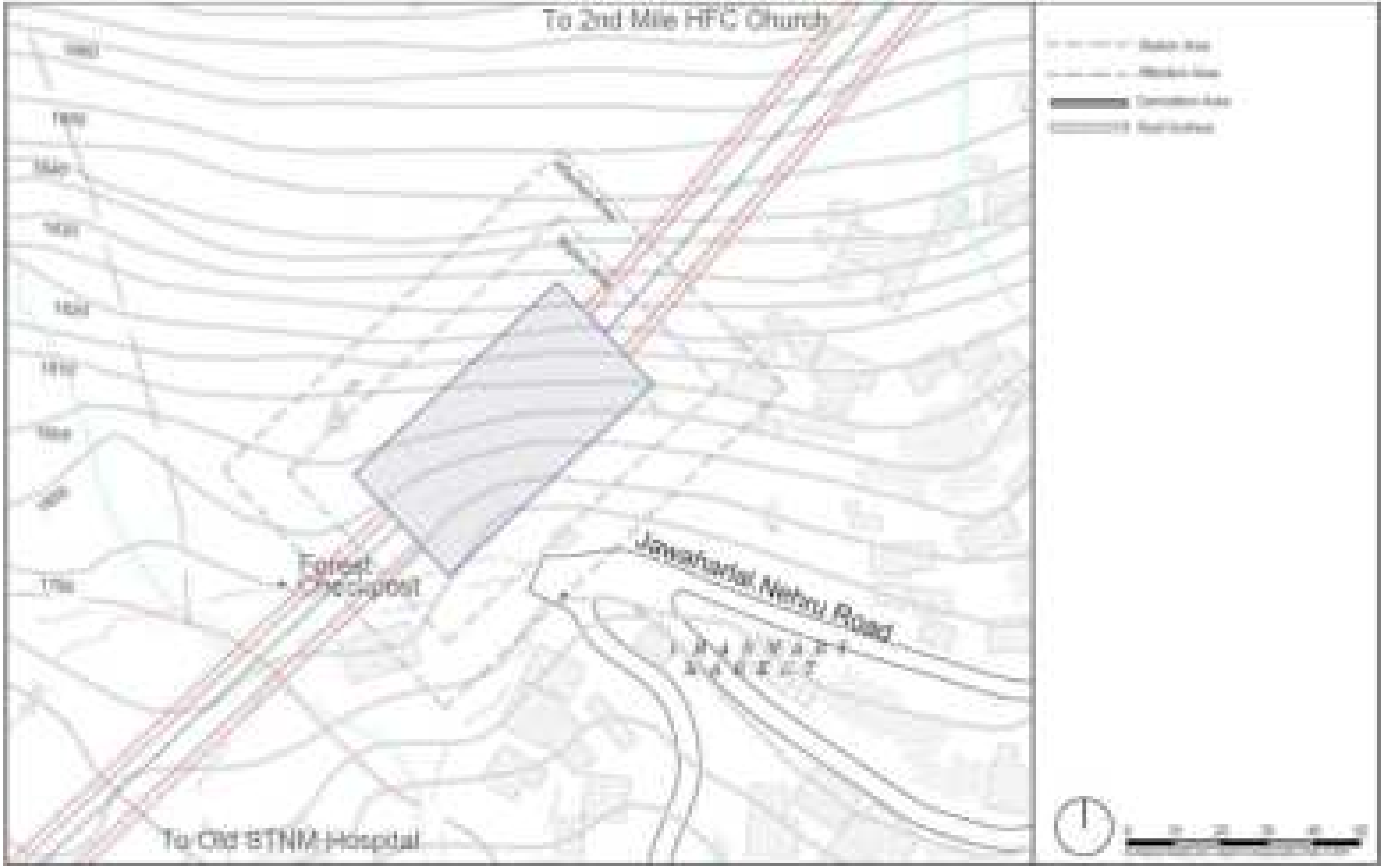


Figure 8-53: Schematic Placement of Proposed 'Chandmari Taxi Stand Station' on Topographical Survey Map of 2017

Figure 8-54: Schematic Placement of Proposed '2nd Mile HFC Church' station

Figure 8-55: Aerial View of Proposed '2nd Mile HFC Church' and Surrounding Areas

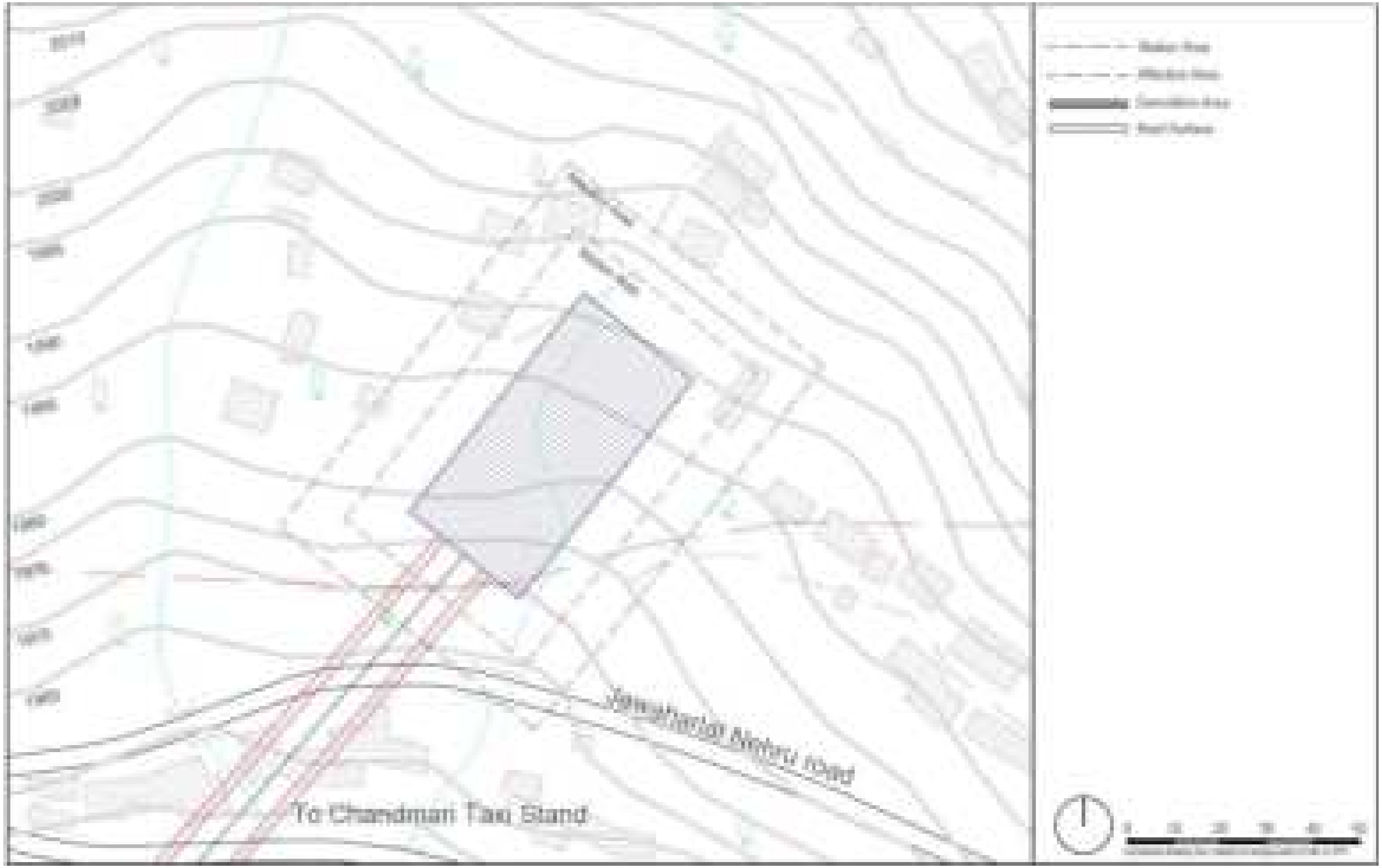


Figure 8-56: Schematic Placement of Proposed '2nd Mile HFC Church Station' on Topographical Survey Map of 2017

8.6. Multi-Modal Integration

All transport modes must function in a coordinated manner to provide seamless mobility to the people. Inter-modal integration is an essential component which is envisaged as part of Cable Car planning in Gangtok and will ensure efficient and effective coordination across various transport modes.

Multi Modal Hubs are transit facilities provided at the interaction points of different modes to facilitate seamless transfer of commuters across different modes.

Although, the integration of various modes with the proposed Cable Car system at stations are discussed during individual station planning concepts, this section illustrates the holistic approach for multi-modal integration.

8.6.1. Integration of Shared Local Taxis

Currently the alignment along which Cable Car system is proposed is being served by shared and reserved taxis. It is proposed to re-orient the shared taxi service to areas outside the catchment of Cable Car system thus shall ply as feeder system for the Cable Car system. Taxi pick-up/drop-off points shall be provided at multi-modal interchanges to facilitate seamless connectivity.

It is proposed to reorient operations of shared taxis considering minimized plying on congested sections of NH-10 and maximize plying on other major roads in the city, ultimately providing connectivity to the multi-modal interchanges having Cable Car as trunk mode, thus acting as feeder to the trunk transit system. Doing this will ensure decongestion of the most important artery i.e. NH-10 and extending Cable Car Transit system reach thus augmenting transit system usage. Figure 8-57represents schematic Multi-Modal Transportation Plan for the city of Gangtok

Figure 8-57: Schematic Representation of Multi-Modal Integration Plan

It is evident from the figure that all shared taxis shall ply as a feeder to the proposed Cable Car system and integrate seamlessly at stations. The roads shown in yellow shall be the roads on which shared taxis shall ply post implementation of phase-I of Cable Car Transit System. The multi-modal interchange details are provided in Table 8-1.

It is noteworthy here that the reserved taxis shall be allowed to ply as usual as the fares for reserved taxis are already very high and shall only be chosen by the commuters only if unavoidable.

8.6.2. Integration of Shared Regional Taxis and Regional Buses

People of Gangtok and tourists visiting Gangtok have high dependency on regional shared taxi and regional bus services for connectivity to Bagdorgra Airport and Siliguri town in West Bengal which are around 114 and 126 kms from Gangtok respectively and to the nearest railway station of Indian Railways i.e. new Jalpaiguri in West Bengal which is around 124 kms from Gangtok. In addition to these people also use these regional services for visiting other towns in Sikkim state. Although, Sikkim now has a domestic airport of its own located at pakyong but it is also located around 20 kms from Gangtok and people would be dependent on regional transport services from commuting to the new airport.

These regional shared taxis and buses connects the aforementioned locations straight away to the central areas of Gangtok, thus further congest already over-utilized limited road space. It is proposed to develop a major multi-modal hub at the proposed Ranipool Taxi Stand station of Cable Car system which is the terminal station of the Cable Car system on the southern end of Gangtok. All shared regional services from the southern side shall terminate at this multi-modal hub and people shall take Cable Car Transit services for commuting to internal parts of the city

On the Northern end of the city, proposed Taxi Stand North District station of Cable Car Transit System will be the first station, post phase–I implementation, while entering the city from northern side. This station already has a multi-level taxi stand and shall be further augmented as a multi-modal hub for terminating regional shared taxi and bus services from the north. This will again decongest central Gangtok due to restriction of regional shared services. Post phase-II implementation, Burtuk station of Cable Car Transit system shall be developed as a multi-modal transit hub

Table 8-1: Proposed Multi-Modal Interchanges in Gangtok

SN	Multi-Modal Cable Car Transit Stations	Local Shared Taxi	Regional Shared Taxi	Regional Buses
Phase-I				
1	Ranipool Taxi Stand	Yes	Yes	Yes
2	Gangtok Municipal Corporation	Yes	No	No
3	Old STNM Hospital	Yes	No	No
4	Taxi Stand North District	Yes	Yes	Yes
Phase - II				
5	DC Office	Yes	No	No
6	Burtuk	Yes	Yes	Yes
7	2nd Mile HFC Church	Yes	Yes	Yes

Chapter 9 CABLE CAR TRANSIT SYSTEM SPECIFICATIONS

9.1.Introduction

As illustrated in the previous chapters, the cable car system proposed for Gangtok based on alternative technology analysis and case study findings is A Monocable Detachable Gondola System (MDG). This chapter provides broad specifications of the proposed MDG system.

The system specification provided in this chapter are based on the primary site analysis with tentative station and pillar locations and heights. Thus, the specifications and costs of the system components may vary during the preparation of Detailed Project Report (DPR).

Since the proposed CCT system shall be operating in different weather condition throughout the year and also the reliability of system shall be ensured during peak requirements, hence the equipment proposed must ensure highest safety at extreme conditions and must fully comply with the latest international standards and stringent quality specifications.

The proposed MDG system shall be designed, manufactured and installed in accordance with the latest standards of ropeway technology, shall feature state-of-the-art equipment and operate automatically. The proposed system shall fully comply with the latest CEN standards (European standard) and safety requirements for Aerial Passenger Ropeways. CEN standards are most reliable in terms of technological and safety requirements.

The proposed CCT system is for Gangtok is a continuous detachable monocable type with the number of carriers specified under "Chapter 8". The system shall be designed to transport passengers upside and downside at a constant speed which can be selected by the operator(s) within the minimum and maximum range.

The proposed system features friction sheaves at the incoming and outgoing sides of the stations. These sheaves transmit the speed of the rope via double V-belts to the conveyors which transport the carriers through the stations. This configuration ensures positive control and synchronization of rope speed and carrier conveying speed in each station in both forward and reverse directions, irrespective of the drive selected.

Key functions of the ropeway, such as rope speed and grip opening and closing operations, shall be monitored and controlled by electronic safety circuits in order to ensure smooth operation and maximum safety.

Fixed rope tensioning shall be achieved by two hydraulic cylinders in the tensioning terminal for each rope loop.

The parking of cabins shall be carried out manually or automatically. The parking provided shall be sufficient for all cabins and shall be located in the drive station station 2, 4, 6 and 8.

The proposed MDG system is designed for one main direction of rotation. For special requirements, rescue and service purposes, reverse operation are permitted at a limited speed.

All elements of the proposed CCT system shall be mounted onto a steel structure which is anchored on concrete foundations.

In order to enhance system reliability, besides the electric main drive unit (AC motor), two independent hydrostatic emergency drive units allow for operation of the system at a reduced capacity and in emergency cases.

A hydraulic emergency drive shall be installed to bring the passengers back to the station in case of a power failure.

The rescue of stranded passengers shall be carried out by the following method:

Two independent hydrostatic emergency drives:

1) Hydraulic motor drive via gear rim on the bullwheel at the Drive station
2) Hydraulic motor drive via gear rim on the bullwheel at the Return station

In emergency cases the passengers will normally stay in the cabins and will be brought back to the stations by means of emergency drives. The innovative recovery concept which will be implicated in the Gangtok CCT project uses technical and organizational measures to ensure that all passengers can be safely returned to the stations in the carriers at all times. This concept enables you to offer your passengers maximum safety and comfort. This is achieved by duplicating all function-related parts and equipment, and making them independently operable, or ensuring that they can be restored to function at short notice so that the haul rope can always be moved. It shall be ensured that each tower is accessible for maintenance and rescue purposes.

9.2. Proposed MDG System Specifications

The proposed MDG system for Gangtok comprises of state of the art system components which are based on the latest technology available in the ropeway systems. These system components are described in detail in the following sub-sections;

9.2.1. Stations

Proposed stations will have modular design and provide same support for all grip types & sizes. The raw material used will be mainly sheet metal and all the parts will be galvanized; the steel construction is suitable for ease of automation and standardized switch rail exits will be used.

The unique design is envisaged to achieve following advantages:

- Reduction of rope gauges;
- Largest possible number of identical components;
- Enhanced manufacturing flexibility;
- Suitable design for robotic welding; and
- Reduced delivery times.

Proposed MDG stations are further classified in two types viz. (a) Drive Stations and (b) Return Stations. These are specified as under;

(a) Drive Stations

Proposed complete Drive Stations will consist of:

- Steel structure for launching and conveying system: This will be made of galvanized steel structures such as beams, claddings, channels etc. (Figure 9.1 & Figure 9.3);

- Upper machinery frame: This will be made of galvanized steel structures such as beams, claddings, channels etc.
- Torsion shaft: This will be used to provide torsional force to the underground vault drive;
- Gearbox: proposed gearbox will consist of 3 stage bevel planetary gearboxes used for cruise control of cable cars. The different sizes will be used in two mounting positions and at various angles. Depending upon the mounting position & the gear ratio, the gearboxes shall be operated with or without oil cooling (Figure 9.2);
- Double grooved bull-wheel, split design: each drive bull-wheel will be fitted with a coupling that is matched to the gearbox size. The bull-wheel coupling of the drive bull-wheel shall always be executed in a separable design (with gear coupling) as shown in Figure 9.4;
- Main AC drive;
- Main electric cabinets and controls: all the proposed control cabinets will be numbered in a specific manner to provide ease of convenience;
- Frequency converter: AC-DC Converter;
- Emergency drive unit;
- Service and emergency brakes: a disc brake type will be used for reduction gearing as service brake for all drives. Emergency brake shall be used on rim profile of the drive bull-wheel for all the drives (Figure 9.4);
- Access platforms and handrails;
- Launching/conveying system;
- Opening and closing lines; and
- Anchoring system for the overhead control cable.

Figure 9-1: Station Steel Structure including Conveyors

Figure 9-2: Machinery Frame with Gearbox and Motors – Mid Drive Bridge Type

Figure 9-3: Launching and Conveying System (Different Grip Type)

Figure 9-4: Drive Bull-wheel with Emergency Brakes

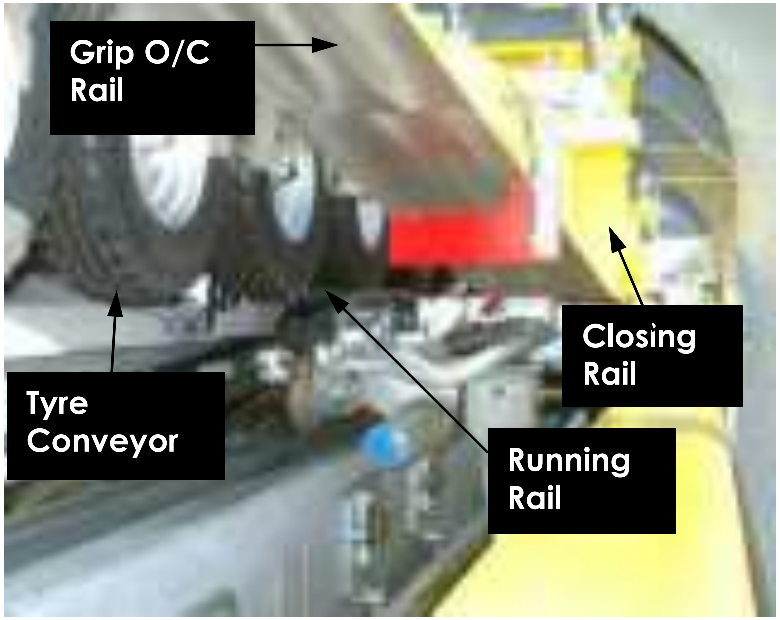


Figure 9-5: Grip Arrangement at Station (Different Grip Type)

Figure 9-6: Hydraulic Brake Unit

(b) Return Tension Stations

Proposed complete Return Stations will consist of:

- Support steel structure for launching and conveying system;
- Machinery frame;
- Bull-wheel, split design: the bull-wheel coupling also functions as a retaining unit, return bull-wheels in addition will be fitted with a pseudo coupling in the form of second support hub (Figure 9.7).
- Access platforms and handrails;
- Emergency drive unit;
- Launching/conveying system;
- Main electrical cabinets and controls;
- Hydraulic tensioning system with two hydraulic cylinders: movable hydraulic cylinders with a stroke of 5m will be used in the system (Figure 9.8); and
- Anchoring system for the overhead control cable.

9.2.2. Cabin Parking

The cabin parking will be designed to accommodate the total number of gondolas during out of operation and also for reserved gondolas during non-peak hours, the switch rail mechanism will provide flexibility for additional gondolas to be parked inside during non-peak hours and these gondolas can again be added to the system during increase in demand. Generally, the cabin parking is designed as loop parking or dead end parking. The rails for the maintenance area is proposed to be automated. A typical cabin parking area in shown in Figure 9.9.

Proposed cabin parking facility will consist of:

- Mechanical switch rail;
- Rails for curved section;
- Supports/hangers for parking rails; and
- Rail to maintenance area.

Figure 9-7: Return Station with 5 Section Bull-wheel

Figure 9-8: Hydraulic Tensioning

Figure 9-9: Cabin Parking Facility

9.2.3. Cabins/Carriers

The proposed cabins for Gangtok MDG system will be designed to accommodate maximum of 10 passengers (all seated), selected based on the future transit demand estimated. These being the most important interaction component between the passengers and the system will be designed to provide maximum safety and comfort and wide view of the scenic beauty of the city.

Specifications of the proposed Cabins/Carriers (Figure 9.10) are provided as under;

- 10 seater cabins with level walk-in arrangement for passengers.
- Steel frame and galvanized aluminum shell
- Each service carrier with hanger and grip
- Self-supporting structure without visible connecting elements
- Quiet operations
- Offers panoramic view through large panes with safety locks
- State of the art technical equipment such as infotainment, surveillance cameras, indoor and outdoor lighting.

Figure 9-10: Cabin CWA Omega-4 – LWI (10 Seater)

9.2.4. Grips

Detachable grips are proposed in MDG system for Gangtok to ensure seamless and flexible operations.

The proposed grip shall work like pincers which are held by two coil springs. The opening and closing of the grip will be activated by an opening and closing rail in the accelerator and decelerator unit. The grip is very compact and will resist any kind of adverse weather conditions.

All forged pieces (movable and fix clamp plates) shall be of Dacromet finish and the bolts shall be protected against corrosion by an appropriate coating.

A typical detachable grip proposed for Gangtok MDG system is shown in Figure 9.11 & Figure 9.12.

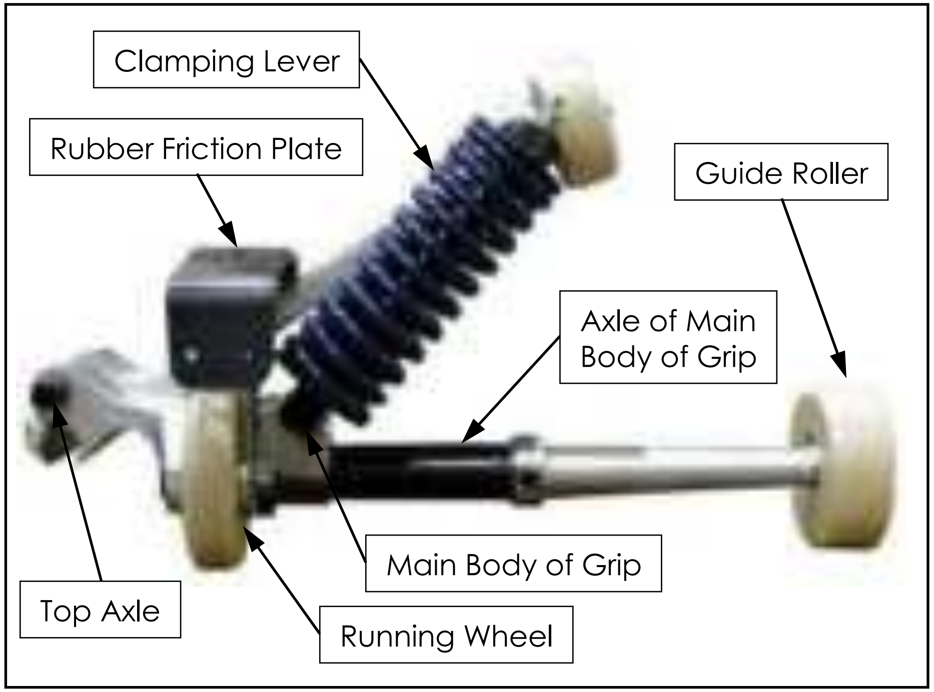


Figure 9-11: Detachable Grip (Lateral View)

Figure 9-12: Detachable Grip (Longitudinal View)

9.2.5. Haul Rope

The proposed haul rope is the 6-strand PERFORMA-DT which is characterized by its long service life and minimal elongation and vibration properties. They guarantee smooth operation without bothersome interruptions. Considering the economic aspects of the long maintenance intervals, low operating costs and ecological advantages (minimal noise emissions), this type of rope provides maximum benefits. Major specifications of the proposed rope, shown in Figure 9.13, are as under:

- Galvanized steel wire rope with plastic core; and
- Core optimized for this particular application (compact core – low stretch), therefore minimal permanent elongation, high compressive stability and excellent setting properties due to optimum internal lubrication of the rope.

Figure 9-13: 6-Stand PERFORMA DT Haul Rope

9.2.6. Sheave Assemblies

Sheave assemblies serve to track the haul rope on the towers for continuous movement of aerial ropeways. Sheave assemblies are generally manufactured in three different designs viz. Support, Hold-down & Combined Sheave Assemblies.

Proposed sheave assembly will consist of sheaves, a 2-4 wheeler frame, 6-16 wheeler rocker with backing channels & suspension bolts, as well as bearing bolts and rope catchers.

The design of the proposed sheave assemblies allows for load distribution from the rope in accordance with EN 13223.

The proposed sheave assemblies, as shown in Figure 9.14, will be CEN compliant (CEN = Latest European Code) and will be equipped with adjusting facility to ensure proper rope tracking. Major specifications of the proposed sheave assemblies are as follows:

- Use of latest generation of sheave liners, reduction of energy cost of up to 20% due to less friction;
- Boltless sheaves with conductive rubber liners;
- Rope catching shoes and break fork switches on all sheave assemblies;
- Frames and suspension galvanized;
- Nitrated main axles for higher corrosion resistance;
- Designed for easy disassembling for replacement of sheave liners (only one hydraulic sheave liner mounting tool required for different sheaves);
- Maintenance free sheave bearings, no lubrication of sheave bearings required;
- Number of sheave assemblies according to profile; and
- Spare sheave assemblies (one for each type) for quicker service during yearly shutdown.

Figure 9-14: CEN Compliant Sheave Assemblies

9.2.7. Towers

The towers serve as support structure for the sheave assemblies for the purpose of rope guidance on continuous movement of aerial ropeways.

The components of the proposed towers will be of modular design and will be composed individually based on requirements. The proposed towers will include following components:

- Tower main structure;
- Tower yokes;
- Rope lifting/installation frame;
- Service platforms and hand rails along sheave assemblies; and
- Tower number plates.

The tower shafts will be manufactured as cylindrical and tapered tubular towers or as tubular lattice towers with tubular diagonal braces and corner posts, based on the location specific requirement and soil conditions.

The tower yokes will be welded sheet metal constructions; calculated and designed based on gauge, sheave assembly type and load. In the case of hold-down sheaves, the yoke will be extended to form a rope catching arm and a rope monitoring switch is installed.

The towers will be connected to concrete foundations using special anchor bolts. The towers and foundation calculation shall be done separately using a special software and shall be designed in such a way that they meet ultimate limit state and serviceability limit state, that will show optimized fatigue strength for the corresponding effects.

Concrete for foundations with qualities below M 25/30 (as per Indian standards) is not durable or sufficiently pressure resistant and thus should not be used for these works.

Figure 9-15: Typical Cylindrical Tower Head with Yokes, Maintenance Platforms, Hand Rails

9.2.8. Electrical Equipment

The proposed MDG system for Gangtok will be entirely propelled by electricity and will have essential electrical components which are specified as under;

(a) Power Distribution

The main load at the drive station will be the frequency converter with the motor for the rope loops. Auxiliaries, like hydraulic pumps, small electric motors and control and communication equipment, will also need electric power supply.

The supplied power shall be transformed from the 33kV grid supply down to 400V to supply to the ropeway equipment and the facility power unit.

The power circuit breakers behind the transformer shall be installed for protection of the electrical equipment.

The main features of the proposed distributor are as under:

- Mains supply with low-voltage high-performance load break switch;
- Overvoltage protection at the low-voltage supply;
- Power supply auxiliary devices; and
- Circuit-breaker with remote actuation from the control room.

(b) AC Motor

The proposed MDG system will be driven by a squirrel cage motor (Figure 9.17), cooled by separately drive fan. The temperature of the motor shall be monitored in the control system through a sensor integrated in the stator monitor to prevent overheating. Encoders for speed actual value shall be installed on the drive motor.

The electric motor converts the electric energy into mechanical energy in the form of torque. A frequency-controlled asynchronous motor will be used for the proposed system. This allows infinitely variable regulation of the speed. This type of motor needs very low maintenance and has good efficiency.

Figure 9-16: AC Motor

(c) Frequency Converter

The drive motor of the proposed MDG system will be controlled by an AC/AC converter with a non-reacting system line connection (Figure 9.18). The main task of the propulsion electrical system shall be to control and monitor the mechanical and electrical propulsion equipment. It shall be based on the hardware modules VACON power converter, AC drive motors and various speed encoders. The driving speed will be adjusted progressively between 6 m/s and 0.3 m/s. The transition from one speed level to a higher or lower level shall be attenuated by a jerk limiter in order to offer a specially smooth ride to the passengers. The VACON power converters will be fully digitized.

Figure 9-17: Frequency Converter

All regulation and control functions will be carried out by a microprocessor. The converter features as state of the art safe torque-off function for the attached motor.

(d) Control Cabinet

A Programmable Logic Controller (PLC) pursuant to safety requirement class-4, EN 13243, will be used to control and monitor all functions of the proposed ropeway.

All the required system data will be displayed on a high-resolution touchscreen. This will provide optimal overview enabling simple handling of operations and monitoring of ropeway installations. Key status indications will be displayed by means of light-emitting diodes (LEDs) on the control cabinet (Figure 9.19). The layout of the operating elements shall be adapted to suit the specific ropeway situation in order to ensure optimal operating procedures.

For the first and last trip of the day at the start and close of operations respectively as well as for maintenance work, the proposed MDG system shall be operated from one station only in the operating mode “Station unmanned”.

The benefits of the proposed control system are as under:

- Intuitive operation;
- Fail-safe CPU;
- Modular design; and
- Test functions for drive, brakes, etc. on the touchscreen

Relevant operating parameters can be called up in all stations.

Figure 9-18: Control Cabinets

(e) Remote Maintenance System

The remote maintenance system (Figure 9.20) will give access to the proposed MDG system at any time from the head office in the event of a malfunction. This enables rapid analysis of the cause and increases the availability of the system. An internet connection shall be required.

Figure 9-19: Remote Maintenance System

(f) Electrical Installation and Wiring Materials

The materials required for the electrical installation of the stations, drives and all auxiliary drives shall be preferably obtained from the system manufacturer. This accompanies several benefits listed ass under:

- Pre-wiring of various assembly groups is done in the factory;
- Standardized cable routing is achieved; and
- Use of high-quality materials is ensured.

(g) Control Room Panel

- The panel on the control console in the control rooms will be laid out so that the operators have an optimal view of the loading and unloading areas while they are working.
- The panel shall be distinguished by the following features:
- All the operating elements required for smooth operating procedures;
- Clear layout of operating elements; and
- Telephone socket with bracket for internal telephone.

Figure 9-20: Platform Control Panel

(h) Electric Controls

The proposed MDG system will be equipped with several electrical controls in the control rooms. Major controls are listed as under:

- For main drive;
- For emergency drive;
- For tension unit;
- For RPD;
- For overvoltage protection;
- 2 x Wind speed meter and direction indicator on main towers;
- For speed control;
- For anti-collision control;
- Fault indicators for launching/conveying, all control circuits, brake system, hydraulic unit;
- For communication system between stations;
- For derailment switches on towers;
- For lightning protection for line equipment; and
- For low voltage distribution.

(i) Lightening Protection Box

- The wires of all signal and line cables shall be protected against overvoltage in each station. These overvoltage protection elements shall be housed in the lightning protection box in the respective station.

Figure 9-21: Lightening Protection Box

(j) Platform Control Panel

Each station will be equipped with the required number of control panels, which shall be distinguished by following features:

- Ergonomic design;
- Installed outdoors on post with weather protection cover; and
- All the operating elements required for smooth operating procedures

Figure 9-22: Electrical Installations

(k) Battery Cabinet

The ropeway control systems shall be supplied with 24 V DC by two maintenance-free gel batteries placed at each station, so that in the event of a power outage the control system can still be operated for approximately 1.5 hours. The batteries are trickle-charged by means of an automatic charger.

the following components will be housed in the battery cabinet:

- Batteries;
- Charger;
- Charging current monitor with alarm;
- Switchgear for lighting, heating, etc.; and
- Outputs for auxiliary devices.

Figure 9-23: Control Room Panel

(l) Ropeway Telephone System

The internal ropeway telephone system will operate independent of the mains and will use batteries and a hand crank generator to ensure that it is possible to contact other telephone stations on the ropeway at all times. A headset telephone complete with battery and charger will be provided for communication at the emergency drive stand.

(m) RPD System

As a further safety device along the line, the RPD (Rope Positioning Detector) monitoring system will be installed. It will be installed additional to the break fork switch system.

The RPD is an early warning system developed by leading ropeway manufacturer and world-wide patented, whereby sensors continuously monitor the rope position on the sheave assemblies and decelerate or completely shut down the installation in an emergency.

The system is "FAILSAFE", which means that a computer is checking every 30 ms all installed switches on line for proper working.

Figure 9-24: Rope Positioning Detector (RPD) System

(n) Line Illumination

The narrow-beam line illumination will be designed to illuminate the rope spans during night trips. The power supply to the floodlights on the towers shall be by means of a power cable which shall be supplied from the battery cabinet. The generated lighting shall be particularly environmentally friendly comprising LED or Halogen system.

Figure 9-25: Line Illumination

(o) Anemometers

Sturdy and heat-able anemometers will be installed to detect wind speed and direction. The actual values will be displayed on the touchscreen at each station. Acoustic and optical signals shall be triggered if warning and alarm limits are exceeded. The limit values for wind warning and wind alarm can be adjusted independently of one another and depending on wind direction

Figure 9-26: Anemometers

(p) Overhead Control Cables

The control cables will be attached to a carrying rope which runs over the towers. The control cables shall include:

- Signal cable – through connection between the stations;
- Line cable – interrupted at each tower for the rope position monitoring system, loudspeakers and anemometers;
- Carrying rope (spiral rope);
- Sliding shoes on all towers;
- Anchoring elements at the end points; and
- Fastening (wrapping) of all cables to the carrying rope

Figure 9-27: Lightening Protection Box

(q) Earthing System – Lightning Protection

The earthing unit for the haul rope will be provided on one station for events out of operation. In case of a thunderstorm the gondolas shall be cleared of all passengers and the grounding rod shall be attached to the haul rope. Due to the proposed design of the gondolas they comply with the principle of a faraday cage, thus ensuring that the passengers are safe at all times.

All control and communication cables will be protected against overvoltage with Transient Voltage Surge Suppressors (TVSS) at the access point to each station. Power cables will be protected against overvoltage with power TVSS inside the respective feeding box. All cables from the line to any station cabinets will be protected (excluding fiber-optic cables)

Figure 9-28: Platform Control Panel

(s) Lightening Protection Ropes

Two ropes shall run over sliding shoes on the rope lifting frames on the exposed towers. They shall be used on exposed system in critical areas with heavy lightning activity. Ground shall be realized at every tower through grounding rods and bonding provisions on the tower. The lightning protection ropes system shall consist of:

- Lightning protection ropes;
- Sliding shoes on all towers; and
- Fixing drums at the end points.

9.2.9. Hydraulic Systems

The proposed MDG system for Gangtok will consist of several hydraulic components essential for its functioning and safety. These hydraulic units as part of the proposed system are described here:

- Hydraulic brake system;
- Hydraulic emergency drive system;
- Hydraulic tensioning system; and
- Hydraulic tire conveyor lifting system.

(a) Hydraulic Brake System (Emergency and Service Brakes)

The proposed emergency brake and service brake shall work according to the same hydraulic principle.

Brake shall be permanently held open by hydraulic force during normal operation. The brake force shall be generated by springs. When the brakes comes into operation the hydraulic pressure will be release by solenoid valves and the brake will be closed. A hydraulic unit for brakes shall generate the required oil pressure for both the brakes.

The brake will be connected to the hydraulic brake unit and will be controlled automatically by solenoid valves.

A manual actuating facility for the disc brake shall be provided additionally for operation with the emergency drive. In the case of manual actuation the brake shall be manually released by means of the hand pump on the hydraulic unit.

The emergency brake will be released by means of a hydraulic cylinder (item 5) with a stroke of 30 mm. The stroke shall be limited by the maximum travel of the piston.

Brakes need to be bled in given intervals (6 months) to avoid condensation water in the hydraulic system.

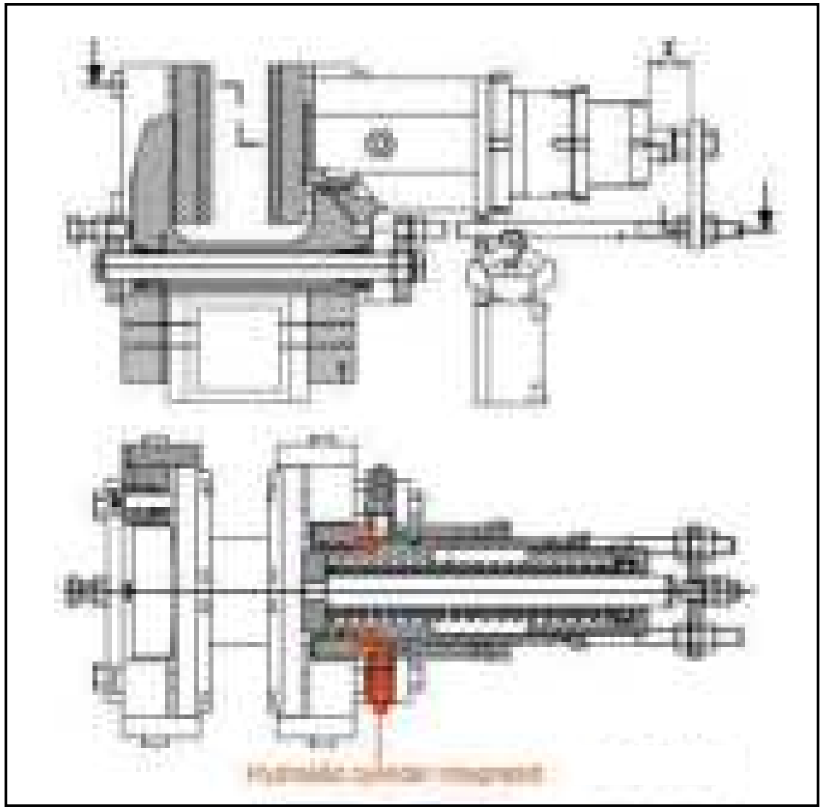


Figure 9-29: Service Brake

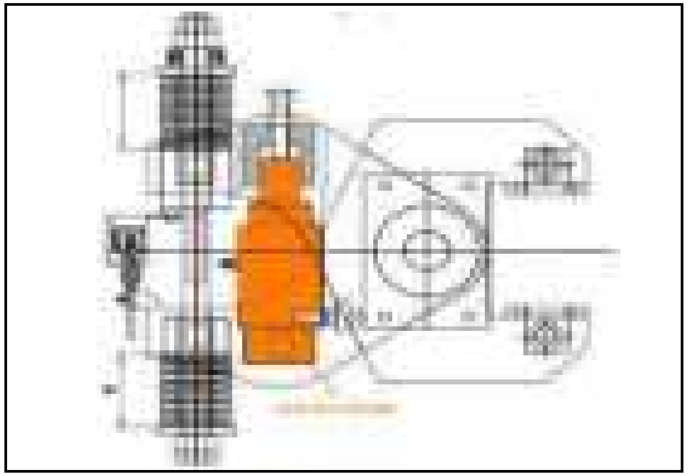


Figure 9-30: Emergency Brake

Figure 9-31: Hydraulic Unit Brakes/Emergency Drive

Figure 9-32: Drive Bull-wheel with Emergency Brakes and Gear Rim

(b) Hydraulic Emergency Drive

The emergency drive will consist of a combustion engine (diesel unit) which will drive a servo-controlled hydrostatic axial piston pump. The hydraulic flow shall be regulated from a pilot control valve. The pilot controlled valve will be actuated by a hydraulic control circuit which will be steered from a hand valve or an electric remote operation panel in the control room.

The hydraulic work circuit will be connected to one or two oil motors for the gear rim drives. In normal operation the pinion of the oil motor shall not be actuated. To use the gear rim motor the pinion shall be moved into the gear rim and locked. With a manual bypass valve it will be possible to release the oil motor to have the pinion free movable during racking it into the gear rim.

The hydraulic brakes shall be operated with hydraulic pressure from the axial piston pump in case of a power outage. The control voltage of 24V will be provided by batteries, the control system shall be working for 100% in case of a power outage.

Figure 9-33: Bull-wheel Gear Rim, Pinion with Hydraulic Oil Motor

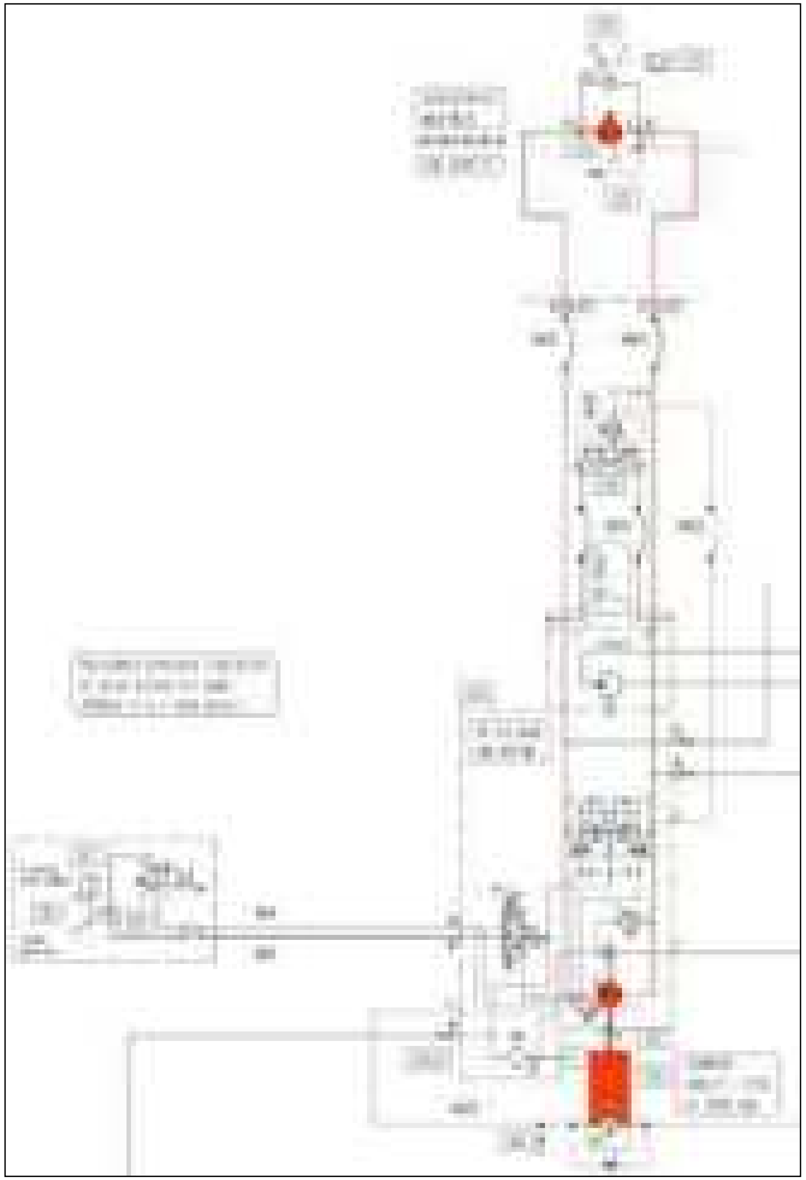


Figure 9-34: Hydraulic Circuit Emergency Drive/Oil Motor

(c) Hydraulic Tensioning System

The hydraulic tensioning system will essentially be consisting of a rope tensioning cylinder that will be installed in a movable tensioning carriage. The rope tensioning cylinder will be fitted with a backpressure lock valve. It will be operated hydraulically and shall prevent the tensioning carriage from performing any uncontrolled movements.

A force measuring system installed at the end of the hydraulic cylinders shall measure the actual rope tension. Measuring system signals will be forwarded to and evaluated by the electric controls. The hydraulic pressure will be generated by an electric pump. In case of a power outage the necessary pressure can be generated with a hand pump.

Figure 9-35: Hydraulic Tensioning Unit with Movable Carriage

The unit will be equipped with additional valves for test functions, maintenance movements of the carriage and an unpressurized start up. Several parameters (temperature, pressures, etc.) shall be monitored.

(d) Hydraulic Tyre Lifting System

The tyre conveyors lifting unit will consist of yoke-shaped support structures on which the tyre conveyors will be mounted. These support structures can be lifted and lowered hydraulically. The springs mounted on the cross beam of the support structure will keep the tyre conveyors in the operating position (lower position).

Figure 9-36: Hydraulic Lifting Unit/Tyre Conveyor with Lifting System

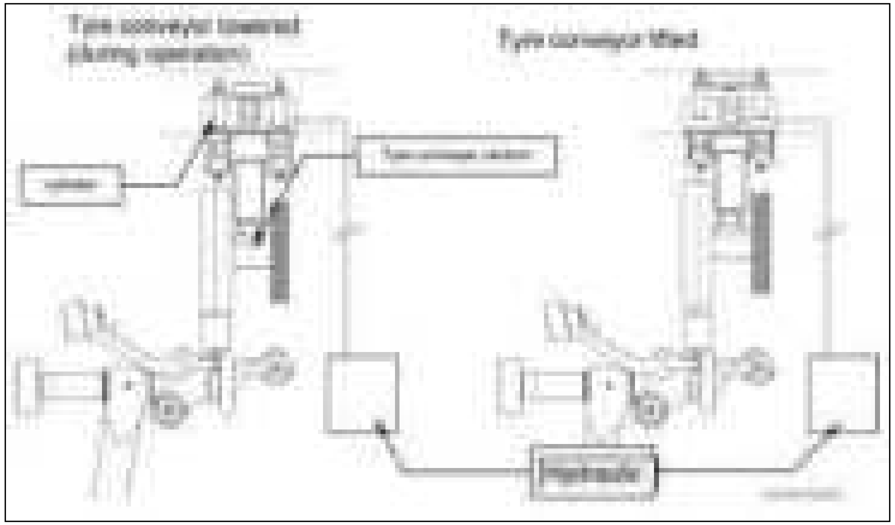


Figure 9-37: Tyre Conveyor Lifting System

Figure 9-38: Emergency Brake

9.3. Proposed Safety Features

Cable Car Systems have proved to be one of the safest transport system across the world. They have also shown high reliability in operations by ensuring minimum non-revenue operational hours thus high system availability.

The proposed MDG system will also ensure highest level of safety to its users by means of various safety, monitoring and recovery features illustrated in the following sub-sections.

9.3.1. Rope Derailment Protection

Rope derailment protection measures includes various components and systems installed to assist in preventing derailment and accidents. The MDG system in Gangtok shall be equipped with state of the art rope derailment protection components and systems described as under;

(a) Rope Catcher

Rope catcher is a metal catch attached to the sheave assembly as shown in Figure 9.39. The rope catcher ensures that in the event of rope derailment the rope is caught by the rope catchers and doesn't fall to the ground thus prevent severe accidents and loss to life. These rope catchers are proposed to be installed in the MDG system at Gangtok.

(b) Rope Position Detection (RPD) System

RPD system is a sensor based derailment protection system in which a sensor is installed over the rope to monitor its position at all times. A typical RPD sensor is shown in Figure 9.41. RPD system will be installed in the proposed MDG system at Gangtok.

The RPD sensor will monitor rope position during operations and will send warning signals to the control room in the event of any unusual displacement.

Figure 9-39: Rope Catcher

Figure 9-40: RPD Sensor

The rope position detected by the sensor shall direct the automatic control system to either slow down the speed of operations or complete stop the system.

Figure 9-41 shows the positions of rope detected by the RPD sensor at which the system will either operate normally or slow down or stops completely.

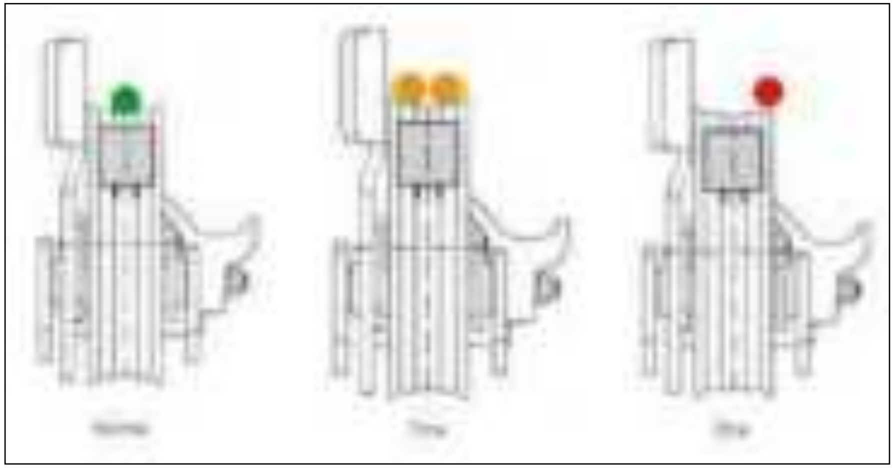


Figure 9-41: Rope Positions Detected by RPD Sensor and Subsequent Control System Responses

The proposed RPD safety system shall detect the following situation:

- Rope Deviation from the groove;
- Deropement beyond side plate;
- Deropement beyond rope catcher;
- Inward derpoement;
- Blocked sheave;
- Excessive sheave liner wear; and

- Lost sheave.

RPD sensors will be installed on critical towers only where chances of deropement is high. On remaining towers "Break Fork Switch" will be installed functioning of which is illustrated in the following point. Considerable cost reduction can be achieved by using combination of these two safety solutions.

(c) Break Fork Switch

It is a switch attached to the sheave assembly on CCT system towers (Figure 9-42 for monitoring rope derailment similar to RPD system but this is non-sensor based. As mentioned in the previous point, the Break Fork Switch is proposed to be installed on less critical towers of the proposed MDG system in Gangtok. In the event of unusual positioning of rope or likely deropement the Break Fork Switch will automatically turned on thus stopping the system completely.

Figure 9-42: Break Fork Switch

9.3.2. Recovery Tools

In the event of deropement the system completely stops with the help of safety systems described in the previous sub-section. It is very important for the system to be recovered from deropement within a shortest possible time thus ensuring maximum system availability. Considering these various recovery concepts are proposed for MDG in Gangtok. These are as under:

(a) Tool Box on each Tower

The proposed MDG system will have a set of tool box on each tower of the system. In this way the efforts of carrying all the tools up to the sheave level of the towers will be reduced thus minimizing recovery time. A typical tool box placement is shown in Figure 9-43.

Figure 9-43: Tool Box

(b) Deropement Tool

A special tool will be positioned on each tower of the proposed MDG system in Gangtok and will be used to bring the fully loaded derailed rope back to its normal position. Shown in Figure 9-44, the toll is easy to use and takes minimum time for the recovery.

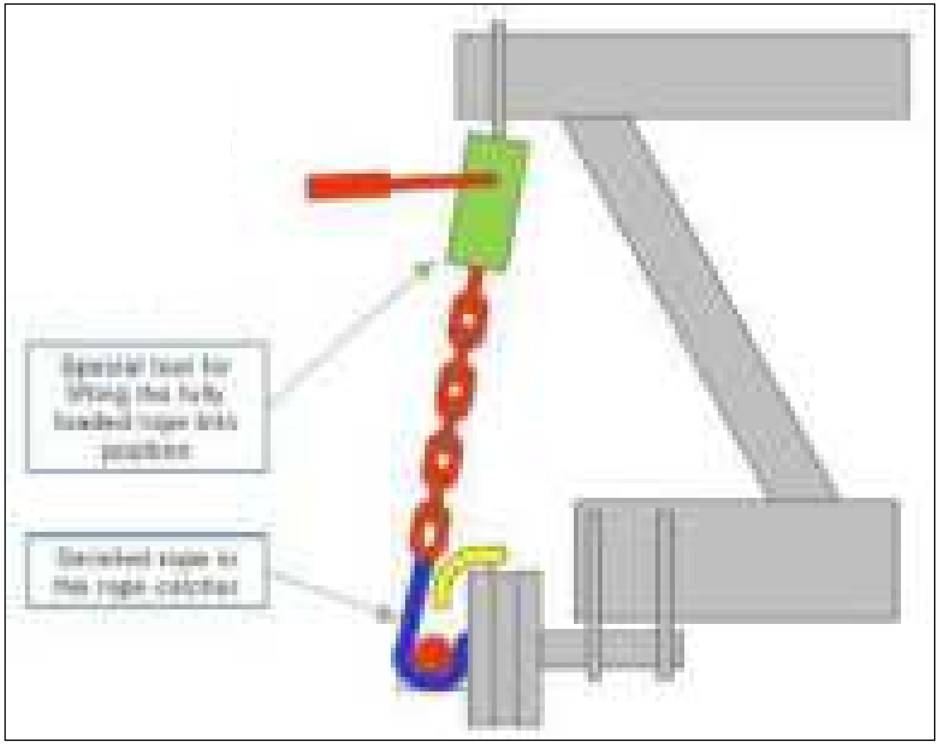


Figure 9-44: Special Tool for Deropement Recovery

9.3.3. Safety Devices at Stations

The mechanism of the proposed MDG system at the stations will be highly dynamic in nature, as shown in Figure 9-45, and will be monitored at every stage with the help of proposed safety devices which are illustrated in the following point.

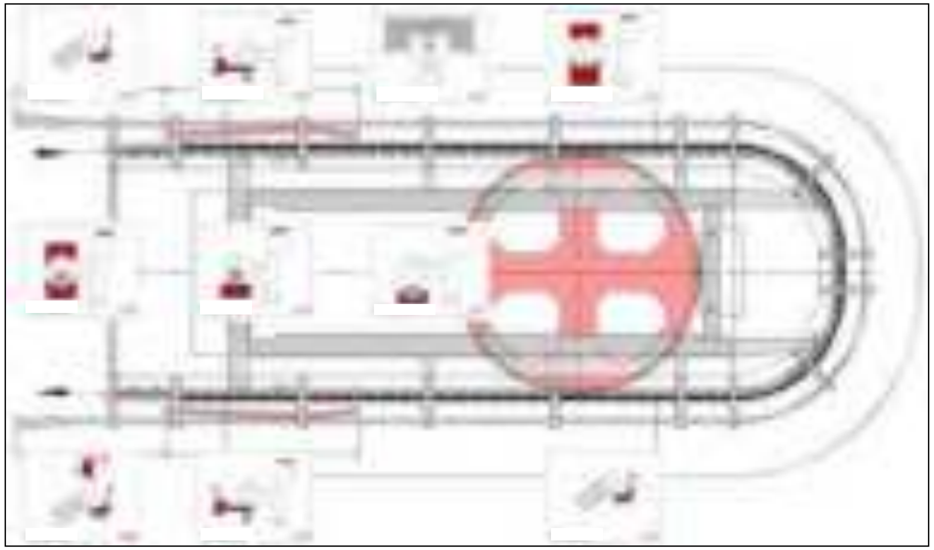


Figure 9-45: MDG System Station Dynamics

(a) Grip Opening/Closing Equipment Position Monitoring

Position monitoring of grip jaw and grip leaver – As shown in Figure 9-46(encircled in red)the position of grip jaw and grip leaver will be monitored through equipments installed near the haul rope.

Position monitoring of Rope – As shown in Figure 9-47(encircled in red) the position of rope will be monitored by the equipments installed along the haul rope at an appropriate gap so that any displacement of rope from its normal position will lead to touching of rope to these devices thus stopping the system.

Figure 9-46: Position Monitoring of Grip Jaw & Grip Leaver

Figure 9-47: Position Monitoring of Haul Rope

Position monitoring of Grip before attaching to Rope – As shown in Figure 9-48 (encircled in red), the position of grip will be monitored through equipments installed in the movement path of the grip before the grip attaches to the haul rope. Any abnormal position of the grip will lead to touching of the grip to the monitoring equipment thus stopping the system.

Figure 9-48: Position Monitoring of Grip before attaching to the Haul Rope

(b) Station Rail Switches Position Monitoring

Position monitoring of Station Rail switches – As shown in Figure 9-49(encircled in red), the position of switch rail, which decides the onward movement of gondola i.e whether the gondola will continue to move in the same loop or shifts to the next loop or goes in to parking/maintenance area, will be monitored by safety equiments installed on the Gondola arm. Any deviation from the normal path of movement will be detected by these equipment and the system will be stopped

Figure 9-49: Position Monitoring of Station Rails

(c) Anti Collision System for Gondolas

Anti collision system for Gondolas will be installed to ensure that gondolas doesn't collide with each other while moving through the station. This system shall perform following safety functions:

- Zone monitoring;
- Carrier spacing monitoring and regulation; and
- Logic Monitoring.

This system will be based on sensors often know as proximity switches, shown in Figure 9-50, which are installed along the path of movement of gondolas at the station, shown in Figure 9-51, and monitors and regulates there movement based on the minimum spacing assigned.

Figure 9-50: Proximity Switches/Anti Collision Sensors

Figure 9-51: Placement of Proximity Switches in a Station

Figure 9-52 shows the typical logic monitoring and electric connections of each zone. Similar monitoring system will be provisioned for Gangtok MDG system.

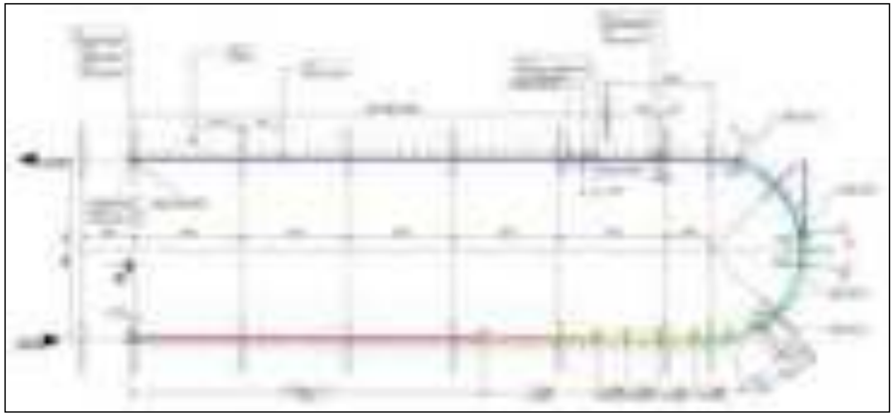


Figure 9-52: Anti Collision System Monitoring

Figure 9-53: Impulse Counter

(d) Impulse Counter

As shown in Figure 9-53, impulse counter will be installed which functions as RPM

(e) Cabin Door Close/Lock Monitoring

As shown in Figure 9-54(encircled in red), the limit beyond which the passengers shall not be allowed to board will me monitored by a floor mounted installation and the door closing and locking point is also defined

Figure 9-54: Cabin Door Close/ Lock Monitoring

(f) Bull-Wheel Position Monitoring

As shown in Figure 9-55, the position of bull-wheel will be monitored through a safety device installed at the circumference of the wheel. Any deviation in the normal alignment of the bull-wheel will be detected by the installed device and the system will be stopped.

Figure 9-55: Position Monitoring of Bull-wheel

(g) Bull-Wheel Axle/Bearing Monitoring

As shown in Figure 9-56(encircled in red), the axle/bearing of bull-wheel will be monitored through a safety device installed at the circumference of the bull-wheel axle.

Figure 9-56: Bull-wheel Axle/Bearing Monitoring

9.3.4. Recovery Concept

Innovative recovery concept is proposed for MDG system in Gangtok in which technical and organizational measures will be used to ensure that all passengers will be safely returned to the stations in the carriers at all times, in the event that they become stranded on the line. This concept will offer maximum safety and comfort to the passengers. This will be achieved by duplicating all function-related parts and equipment, and making them independently operable, or ensuring that they can be restored to function at short notice so that the haul rope can always be moved. Specific constructive requirements for the proposed CCT system Installation:

- Dimensioning of the rope lifting frame for re-aligning of a partially derailed rope with a completely loaded line.
- Tools on every tower for re-aligning of a derailed rope back into the sheaves.
- Drive bull-wheel can be separated from the complete drive system.
- In case the main drive cannot be used, an independent recovery drive, which works on Diesel will keep the ropeway moving.
- A second independent recovery drive in the return station with sufficient motive power will be provided.
- Both bull-wheels are equipped with emergency bearings.
- Various safety devices can be bridged with a key switch to ensure the recovery of the ropeway after taking the adequate alternative measures.

- Preservation of the battery charges for starting the recovery drives 1 or 2.
- Schematic operations of the proposed MDG system under normal conditions using electric motor is shown in *Figure 9-57*. The green lines shows that the main electric motor is driving the bull-wheel and running the system.

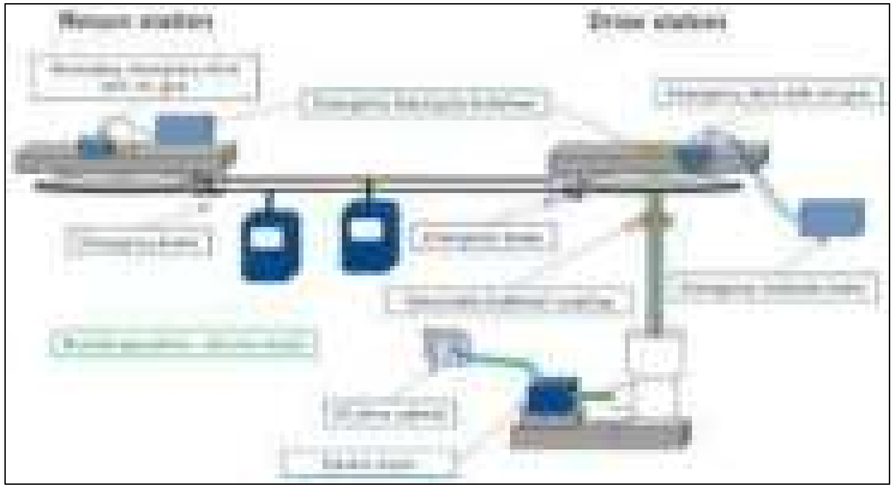


Figure 9-57: Schematic Representation of Normal Operations of MDG System

9.3.5. Recovery and Evacuation Plan

The Recovery and Evacuation Plan serves for the evacuation of the passengers, e.g., in the event of a defect or a fault, exclusively by moving the cabins back to the stations until the installation has been cleared of all passengers.

The ropeway shall be cleared using the main drive, the emergency drive in the drive station, or the second, independent emergency drive in the return station.

Each fault shall be investigated and its cause identified. The operations manager shall decide which measures should be taken and which drive system should be used to run the installation for the recovery procedure.

The operation and service manual shall list all conceivable faults along with the appropriate action.

Faults can be typically classified into 4 types:

- Faults along the line;
- Faults in the stations;
- Faults in the controls; and
- Faults in the drives and/or in the return equipment

The recovery operation shall be different from normal operation of the ropeway insofar as faults along the line, in the stations, or on the actual emergency drive is remedied, and/or the second emergency drive in the return station is taken into operation before recovery can start.

If a fault occurs along the line, the operating personnel will reach the individual towers via station – car drive to the individual tower positions and climb up the tower ladders.

The most significant and high probability faults are listed in the Table 9-1 below:

Table 9-1: Type of Faults during CCT System Operations

Fault	Category	Measures
Ground fault monitoring	Line	Check the line, restore original condition if possible. Clear the ropeway while permanently monitoring the line.

Fault	Category	Measures
Haul rope derailed into the rope catchers	Line	Ascertain on site that a derailment has occurred. Lift the haul rope back into place.
Blocked / lost sheave	Line	Ascertain the cause of the fault on site. Replace the defective parts (the various spare parts must be kept in stock at the installation).
Failure of a conveyor in one of the stations	Station	Ascertain the cause of the failure. Remedy the cause of the failure (the various spare parts must be kept in stock at the installation). If the cause cannot be remedied immediately, the carriers can be pushed through the station manually.
Blocked carrier in the station	Station	Remove the carrier from service. Check the carrier and repair/replace damaged parts, if any.
Failure of the drive chain	Drive	Ascertain the cause of the defect. Run the installation with the emergency drive; detach the complete drive chain if necessary.
Failure of a bullwheel bearing	Drive / return	Bypass torsion monitoring and, if necessary, position monitoring of the bull-wheel. Use the emergency bearing to clear the ropeway.
Failure of the service brakes (brakes remain closed)	Drive	Ascertain the cause of the defect. Open the brakes manually, detach the drive chain, etc. Use the emergency drive to clear the ropeway (emergency brake functional for manual operation).
Failure of the emergency brakes (brakes remain closed)	Drive	Ascertain the cause of the defect. Open the brakes manually or neutralize the braking force, etc. Use the emergency drive to clear the ropeway.
Failure of the emergency drive in the drive station	Drive	Take emergency drive 2 in the return station into operation.
Failure of the hydraulic tensioning system	Return	•Electrical failure: Visual monitoring of tension force by an employee; the tension force must be maintained manually. •Mechanical failure: Load holding valves respond, tensioning system is blocked.

Fault	Category	Measures
Power failure (failure of ropeway controls)	Controls / station	Run the installation with the emergency drive; power supply to all loads in the station (electrically operated station conveyors, tensioning unit, etc.) via an emergency power system or from batteries.

Operation with emergency drive by means of gear rim

In addition to the main drive, an emergency drive, shown in Figure 9-58, will be provided, which will be used to evacuate the line if this is no longer possible using the main drive. The diesel engine, will act via a hydraulic system directly on the gear rim, which shall be firmly connected to the drive bull-wheel. The drive bull-wheel can be separated from the gear unit by means of the coupling. The emergency drive will enable a rope speed of 1.0 m/s.

Figure 9-58: Emergency Hydraulic Drive

The emergency drive will serve for recovery of the installation, allowing all passengers to unload from carriers. During emergency drive operations, loading of passengers shall not be permitted.

The required speed and direction of travel can be set and changed manually by means of a mechanical adjustment on the emergency drive engine. The emergency drive batteries will be trickle-charged by means of a charger. The diesel engine shall be switched on and off and speed adjustments shall be made on the starter box fitted directly to the engine. Key parameters (rpm, operating hours, etc.) shall also be displayed on the starter box. The emergency brake shall be controlled automatically by means of the emergency drive control. If a safety function will fail, it can be deactivated by means of the key switch.

9.3.6. Rescue Mechanism

The proposed rescue mechanisms for probable failure events are illustrated in the following points.

(a) Failure of Main Drive

In the event of main electric motor failure, emergency hydraulic motor drive will be used to operate the system at a reduced speed and the stranded passengers will be evacuated safely.

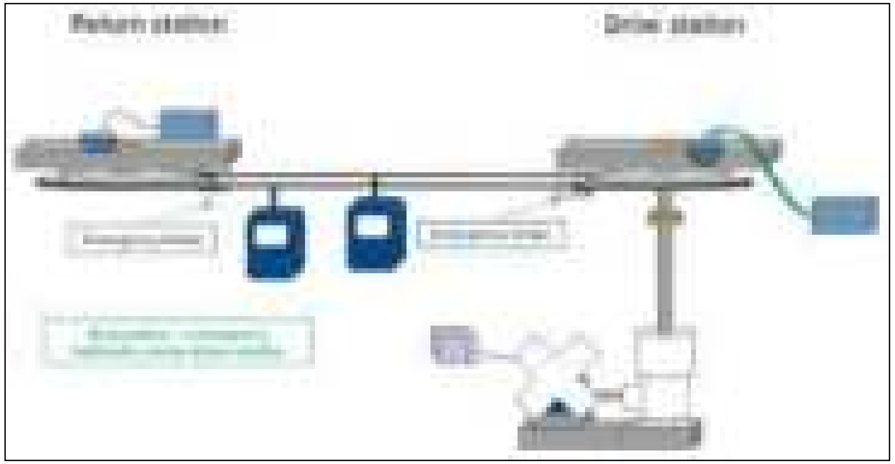


Figure 9-59: : Schematic Representation of Evacuation Mechanism During Failure of Main Drive

Figure 9-59 shows the schematic operations of the proposed MDG system for rescue during main electric motor failure. The green lines shows that the emergency hydraulic motor is driving the bull-wheel and running the system.

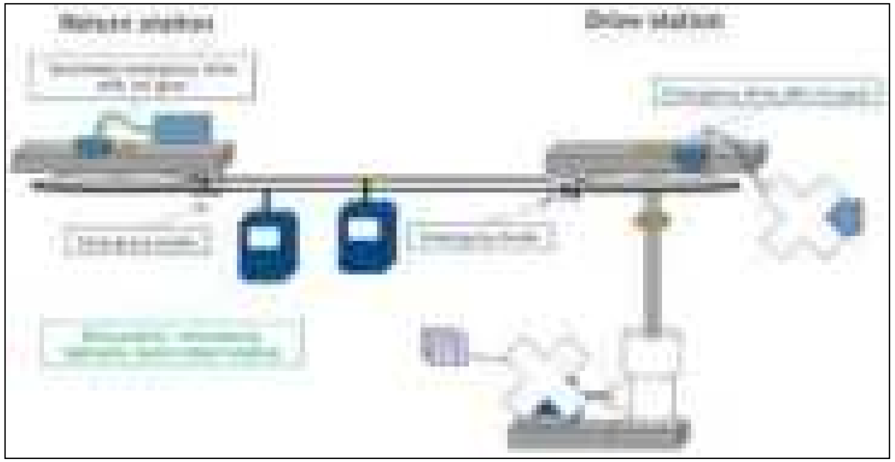


Figure 9-60: : Schematic Representation of Evacuation Mechanism During Failure of Main and Emergency Drive

(b) Failure of Main Drive and Emergency Drive

In the event of failure of both the main drive and the emergency drive, secondary emergency drive with rim gear will be used to operate the system at a reduced speed and the stranded passengers will be evacuated safely. Figure 9-60shows the schematic operations of the proposed MDG system for rescue during main and emergency drive failure.

The green lines shows that the secondary emergency drive with rim gear is driving the bull-wheel and running the system.

(c) Failure of Gear Box

In the event of gear box failure, emergency drive with rim gear will be used to operate the system at a reduced speed and the stranded passengers will be evacuated safely. *Figure 9-61*shows the schematic operations of the proposed MDG system for rescue during gear box failure.

Figure 9-61: Schematic Representation of Evacuation Mechanism During Failure of Gear Box

(d) Failure of Main Bearing

In the event of main bearing failure, emergency bearing for bull-wheels will be used to operate the system at a reduced speed and the stranded passengers will be evacuated safely.

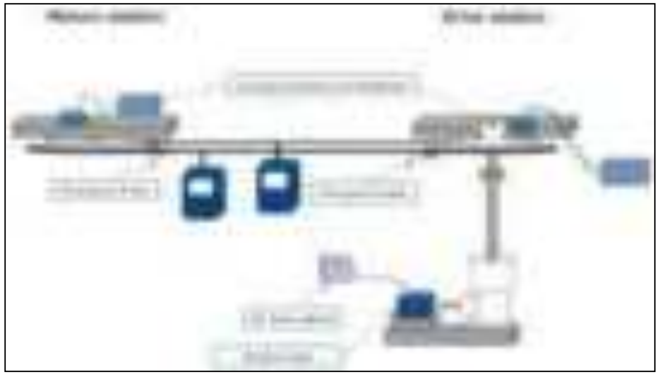


*Figure 9-62*Figure 9-62 shows the schematic operations of the proposed MDG system for rescue during main bearing failure.

Figure 9-62: Schematic Representation of Evacuation Mechanism During Failure of Main Bearing

Chapter 10 CABLE CAR TRANSIT SYSTEM OPERATIONS PLAN

Following the route network planning, estimation of fleet requirement and review of operation models of CCT have been undertaken. This Section of the report mentions the operational plan for the identified cable car corridors and suggested operational headways

10.1. Operations Philosophy

The underlying operation philosophy is to make the cable car System more attractive and economical, the main features being:

- Selecting the most optimum frequency of Fleet (Gondolas Fleet (Gondolas) services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum Fleet (Gondolas) frequency not only during peak period, but also during off-peak period.
- Ergonomically designed gondolas.
- Multi-tasking of cable car operation and maintenance staff.

10.2. Stations

List of stations for the cable car alignment of Gangtok cable car are given below:

Table 10-1: Station details and Typology

ID	Station Name	Line
Station 1	Ranipool	North-South
Station 2	Tourism office	North-South
Station 3	Sikkim Manipal Hospital	North-South
Station 4	Gangtok Municipal Corporation (GMC)	North-South
Station 5	Denzong Cinema/Supermarket	North-South
Station 6	Old STNM Hospital	North-South
Station 7	Taxi Stand North District	North-South
Station 8	Helipad	North-South
Station 9	Relias	North-South
Station 10	Burtuk	North-South
Station 11	District Administrative center	West
Station 12	Hospital at Sichey	West
Station 13	Chandmari Taxi stand	East
Station 14	2nd Mile HFC Church	East

10.3. Traffic Demand

Based on the Table 10.2 it could be observed that the current planned network of cable car would cater to 40,300 passengers in the operational year of 2021 and would increase to 1,45,749 passengers in the year 2051. Cable car System in Gangtok would account for 15% of the passenger trips in 2021 and would increase to 20% by 2051. The total travel time on the North South Corridor from Ranipool Taxi Stand to Burtuk is 28 Mins, whereas on the West Corridor from North District Taxi Stand to Hospital at Sichey is 4 Mins and East Corridor from Old STNMHospital to 2nd Mile HPC Chruch is 4 Mins.

The Peak hour peak direction traffic demands (PHPDT) along with Peak Hour & Daily Ridership for the North- South Corridor, West Corridor and East Corridor for the year 2021, 2031, 2041 and 2051 for the purpose of planning are indicated below:

Table 10-2: Section Wise Maximum Peak Hour Peak Direction Traffic (PHPDT) & Corridor Wise Peak & Daily Ridership – 2021, 2031, 2041 & 2051

Sl. No	Line Section	Corridor	Maximum PHPDT				Peak Hour Ridership				Daily Ridership			
			2021	2031	2041	2051	2021	2031	2041	2051	2021	2031	2041	2051
Section 1	Ranipool -Tourism Office Complex	North South	498	759	1144	1833	3,090	4,937	7,204	10,983	34,337	54,855	80,048	1,22,031
Section 2	Tourism Office Complex-Sikkim Manipal Hospital		896	1368	2113	3456								
Section 3	Sikkim Manipal Hospital - Gangtok Municipal Corporation		1007	1660	2547	4125								
Section 4	Gangtok Municipal Corporation-Denzong Cinema/Supermarket		647	958	1285	1877								
Section 5	Denzong Cinema/Supermarket-Old STNM Hospital		679	1062	1454	2026								
Section 6	Old STNM Hospital-Taxi Stand North District		695	1153	1676	2509								
Section 7	Taxi Stand North District-Helipad		809	1316	1903	2818								
Section 8	Helipad-Burtuk		572	866	1250	1862								
Section 9	Hospital at Sichey-District Center	West	60	81	232	355	184	494	852	1,066	2,044	5,485	9,463	11,841
Section 10	District Center-Taxi Stand North District		14	183	232	321								
Section 11	Old STNM Hospital-Chandmari Taxi Stand	East	34	759	174	242	353	588	848	979	3,919	6,533	9,427	10,876
Section 12	Chandmari Taxi Stand-2nd Mile HPC Chruch		82	125	182	258								
Total							**3,627**	**6,019**	**8,904**	**13,027**	**40,300**	**66,873**	**98,938**	**1,44,749**

Based on the estimated corridor & section wise demand for the public transport in the city, the number of cabins has been estimated. Estimation of cabin size is quite essential for any public transit facility. Surplus no. of the cabins would often lead to underutilization and eventually increase the capital and operational costs. On the other hand insufficient cabin drives the users to adopt a different mode leading to the reduction in the ridership values. So it is important that an optimal cabin size is determined and such a system needs to be developed which ensures enough cabin size to meet the ridership demand at the same time being self-sustainable.

To estimate the cabin size for the Cable Car System for Gangtok, various parameters have been considered. The assumptions for the cabin estimations are as under;

- Hours of Operations – 16 Hours
- Load Factor – 85%
- Average Speed – 6 m/s (~22 kmph)

The following formulae have been used to calculate the cabins for the cable car system in Gangtok

- Total Travel Time (secs) = Journey time (secs)+Delay at the Stations (secs)

- Headway (secs) = Passenger Capacity of the Cabin*60/Maximum PHPDT of the Section
- Cabin Requirement = Total Travel Time (secs)/Headway (secs)
- Spacing between Cabins = Total No. of Cabins/Section Length (mts)

Table 10-3: Operation Plan for 2021

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
North South Line					
Ranipool -Tourism office	5	500	51	12	147
Tourism office-Sikkim Manipal Hospital	3	1000	28	11	84
Sikkim Manipal Hospital-Gangtok Municipal Corporation (GMC)	2	1000	25	9	70
Gangtok Municipal Corporation (GMC) –Denzong Cinema/Supermarket	4	1000	39	13	109
Denzong Cinema/Supermarket-Old STNM Hospital	2	1000	37	8	107
Old STNM Hospital-Taxi Stand North District	3	1000	36	9	106
Taxi Stand North District -Helipad	4	1000	31	18	89
Helipad - Burtuk	5	1000	44	14	129
West Line					
Hospital at Sichey-District Center	1	100	421	1	380
District Center-Taxi Stand North District	3	100	1802	1	1000
East Line					
Old STNM Hospital-Chandmari Taxi Stand	3	100	745	1	1200
Chandmari Taxi Stand-2nd Mile HPC Chruch	1	100	308	1	500

Table 10-4: Operation Plan for 2031

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
North South Line					
Ranipool -Tourism office	5	1000	38	16	110
Tourism office-Sikkim Manipal Hospital	3	1500	21	15	61
Sikkim Manipal Hospital-Gangtok Municipal Corporation (GMC)	2	2000	17	13	48
Gangtok Municipal Corporation (GMC) –Denzong Cinema/Supermarket	4	1000	30	16	89
Denzong Cinema/Supermarket-Old STNM Hospital	2	1000	27	11	78
Old STNM Hospital-Taxi Stand North District	3	1500	25	13	74
Taxi Stand North District -Helipad	4	1500	22	25	64
Helipad - Burtuk	5	1000	33	19	95
West Line					
Hospital at Sichey-District Center	1	100	356	1	380
District Center-Taxi Stand North District	3	200	157	3	333
East Line					
Old STNM Hospital-Chandmari Taxi Stand	3	200	187	1	268
Chandmari Taxi Stand-2nd Mile HPC Chruch	1	200	230	1	500

Table 10-5: Operation Plan for 2041

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
North South Line					
Ranipool -Tourism office	5	1500	28	21	84
Tourism office-Sikkim Manipal Hospital	3	2000	15	21	44
Sikkim Manipal Hospital-Gangtok Municipal Corporation (GMC)	2	3000	13	17	37
Gangtok Municipal Corporation (GMC) –Denzong Cinema/Supermarket	4	1500	25	19	75
Denzong Cinema/Supermarket-Old STNM Hospital	2	1500	22	13	66
Old STNM Hospital-Taxi Stand North District	3	2000	19	17	56
Taxi Stand North District -Helipad	4	2000	17	32	50
Helipad - Burtuk	5	1500	26	24	75
West Line					
Hospital at Sichey-District Center	1	300	139	1	380

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
District Center-Taxi Stand North District	3	200	140	3	333
East Line					
Old STNM Hospital-Chandmari Taxi Stand	3	300	186	3	400
Chandmari Taxi Stand-2nd Mile HPC Chruch	1	200	178	1	500

Table 10-6: Operation Plan for 2051

Line Section	Journey Time (mins)	Design PHPDT	Headway (Secs)	Gondolas required	Fleet (Gondolas) spacing - m
North South Line					
Ranipool -Tourism office	5	2000	20	30	59
Tourism office-Sikkim Manipal Hospital	3	3500	10	30	31
Sikkim Manipal Hospital-Gangtok Municipal Corporation (GMC)	2	4000	9	24	26
Gangtok Municipal Corporation (GMC) –Denzong Cinema/Supermarket	4	2000	19	25	57
Denzong Cinema/Supermarket-Old STNM Hospital	2	2500	18	17	50
Old STNM Hospital-Taxi Stand North District	3	3000	14	23	42
Taxi Stand North District -Helipad	4	3000	13	42	38
Helipad - Burtuk	5	2000	19	32	56
West Line					
Hospital at Sichey-District Center	1	400	101	2	190
District Center-Taxi Stand North District	3	300	112	3	333
East Line					
Old STNM Hospital-Chandmari Taxi Stand	3	400	149	3	400
Chandmari Taxi Stand-2nd Mile HPC Chruch	1	300	140	2	250

Chapter 11 CABLE CAR TRANSIT SYSTEM MAINTENANCE PLAN

11.1. Maintenance Philosophy

The maintenance plan includes various checks and inspections as listed below:

- Various Checks (Pre Start checks, Daily, Weekly, Monthly, Quarterly, Half Yearly and Yearly checks)
- Preventive Maintenance Schedules
- Observations during plant running
- Monitoring Systems (Wear Debris Analysis, Sound-Temperature-Vibration Analysis)
- Various test (Nondestructive testing)

A thorough analysis of all the collected data should be done to chalk out the plan for carrying out activities.

The analysis of the system has to be carried out by:

- By Plant In charge
- By Service & Safety and Design Team

11.2. Comprehensive check plan

Comprehensive check plan for system checking is given below:

11.2.1. Checklist for daily maintenance- Everyday

Component	Check Frequency	Task to be performed	Procedure
General	Daily	Check the loading and unloading points as well as the access and exit areas and keep them in correct conditions.	Visually
		Check the signage and keep it in correct conditions.	Visually
Tower	Daily	Check the platforms, handrails, catwalks, anemometers, ladders and rope lifting frames for cracks, rust, deformation, correct position ,etc.	Visually during the test run.
Parking Switch Rails	Daily	General check	Visually
Overhead Cables - Signal Cables, Aerial Cable	Daily	During the daily test run, closely watch the lightning protection cable, especially if there is a risk of icing	The test run may only be carried out by suitably trained personnel who can judge the condition of the sags.
		Check the colour markings.	If the colour markings are no longer located before and after the sliding shoe, the overhead cable must be brought back in to its normal position.

Component	Check Frequency	Task to be performed	Procedure
		Check the overhead cable along its entire length for damage.	Visually
		Check	If the control lines have become loose from the carrying rope and thus the sag has been Increased. Special attention shall be paid to wires sticking out or hanging from the wrapping wire.
		Check the overhead cable for correct position.	Visually
		Observe the overhead cable for oscillations.	If such are found, contact the manufacturer.
Lightning Protection Rope	Daily	During the daily test run, closely watch the lightning protection cable, especially if there is a risk of icing.	The test run may only be carried out by suitably trained personnel who can judge the condition of the sags.
		Check the lightning protection cable along its entire length for damage.	Visually
		Check the overhead cable for correct position.	
		Observe the overhead cable for oscillations.	If such are found, contact the manufacturer.
Main Gearbox	Daily	Check the Main Gearbox	Refer to Gearbox manufacturer's operation manuals.
Universal Shaft	Daily	Check for unusual running noises.	Refer to Gearbox manufacturer's operation manuals.
Main Motor	Daily	General check	Refer to manufacturer's operation manuals.
Gear Rim	Daily	General check	Refer to manufacturer's operation manuals.
Service Brake	Daily	Check the surfaces of the brake disk and the brake liners.	Check the surfaces of the brake disk and the brake liners.
		Check for correct functioning.	Actuating the switch 'EMERGENCY STOP' check stopping distance.
Emergency Brake	Daily	Check the surfaces of the brake disk and the brake liners.	Check the surfaces of the brake disk and the brake liners.
		Check for correct functioning.	Actuating the switch 'EMERGENCY STOP' check stopping distance.
		Check the brake release cylinder and the hydraulic lines for any leaks.	
Drive and Return Bullwheels	Daily	General check	
		Check for any unusual noise, wobble or eccentricity in the motion of the bullwheel,	

Component	Check Frequency	Task to be performed	Procedure
		etc.	
		Check the position.	Check ropes on the bull wheels and the running behavior of the bullwheels in the stations.
		Check the ice scraper for proper functioning.	
Drive and Return Bullwheel Bearing Assemblies	Daily	General check /Check the bearing.	Listen for unusual running noises, ensure that the bearing runs true.
		Check the bearing.	For leaks
Bullwheel Coupling	Daily	General check / Check for unusual running noises.	Listen for unusual running noises, ensure that the bearing runs true.
Bullwheel Position Monitoring Unit	Daily	General check /Check for unusual running noises.	Listen for unusual running noises, ensure that the bearing runs true.
		Check the accessibility of all switch-off devices.	
Tension Carriage	Daily	Check tension carriage position	
		General check	
		Check the runway.	Remove any obstacles to the running wheels.
Hydraulic Tensioning	Daily	Check operating pressure	
		Check reading on the indicator	
		Check for leaks and loose pipe connections.	Visually
Support Structure	Daily	General check	
Grip Opening / Closing Line -General	Daily	General check	
		Check for cleanliness, etc.	
Outer Guide Rail (Trumpet)	Daily	General check	Visually
		Visually check the dampened outer guide rail	
Tyre Conveyors	Daily	General check	
		Check if all tyres in the tyre conveyors are turning.	Visually
		Keep the accelerator and decelerator clean.	
Tyre Conveyor Bearings	Daily	General check	
Hydraulic Lifting Unit	Daily	Check for leaks & loose pipe connections	By visual inspection
Brake-coupling Unit	Daily	Function test of the safety coupling	
Grip fault before launch limit switch	Daily	General check	

Component	Check Frequency	Task to be performed	Procedure
Grip not open limit switch	Daily	General check	
Rope position vertical/horizontal limit switch	Daily	General check	
Geometrical Grip Gauge	Daily	General check	
Grip operating lever fault ±10%	Daily	General check	
Electronic Grip Force Testing Device	Daily	Ensure that the measuring point is clean and free of grease.	
Switch Rails of Main Ropeway	Daily	General check	
Line Engineering	Daily	Check the rope position	
		Check the sheaves for correct concentricity	
		Observe for unusual noises and/or vibrations.	
		Check for contact of the sheaves (Combined sheaves and sheave assemblies with guide roller).	
		Before starting public operation, remove ice and snow.	
		Check the safety distances (structural clearance, ground clearance).	
Sheaves	Daily	Carry out a test run.	
Hanger	Daily	Check the passage of the carrier around the bullwheel during the test run	Visually
Grip	Daily	General inspection during station entry and exit	Check all grips for their performance during the test run.

11.2.2. Checklist – Weekly

Component	Check Frequency	Task to be performed	Procedure
Main Gearbox	Weekly	Refer to Manufacturer's operation manuals.	
Main Drive	Weekly	Refer to Manufacturer's operation manuals.	
Emergency Drive	Weekly	Ensure that the unit is ready for operation.	Start the engine.
Tacho Drive without RollbackDetector	Weekly	Check the pressure of the frictionsheave against the bullwheel.	

Component	Check Frequency	Task to be performed	Procedure
Hydraulic Tensioning	Weekly	Check for unusual noises and vibrations.	
		Level of hydraulic fluid in the tank	
Tyre Conveyors	Weekly	Check tyre pressure and readjust if necessary.	- 5.0 bar in the decelerator and accelerator
		Check tyre profile for wear and	- 3.5 to 5.0 bar in the curved section
Hydraulic Lifting Unit	Weekly	Check for unusual noises and vibrations by visual inspection	

11.2.3. Checklist - Monthly

Component	Check Frequency	Task to be performed	Procedure
Towers	Monthly	Check the platforms, handrails, catwalks, anemometers and ladders for cracks, rust, deformation, correct position, etc.	
Overhead Cables – Signal Cables	Monthly	Visual inspection of the colour markings on the towers	If it is detected that the two colour markings are no longer located before and after the sliding shoe symmetrically, the overhead cable must be brought back into its normal position.
			For this, put the assembly rollers in the upper position and displace the overhead cable in such way that the two colour markings return to their original position.
			Finally, perform an angle measurement and document the results.
			If the measured values deviate from those reference values, re-establish them by means of tensioning or releasing
Lightning Protection Rope	Monthly	Check the position monitoring device.	If it is detected that the two rope loops of the position monitoring are no longer positioned symmetrically on the lightning protection roller (distance on both sides between the aluminium roller and the grip should be approx. 500 mm), reestablish this condition. Otherwise, the availability

Component	Check Frequency	Task to be performed	Procedure
			of the installation is limited, as the smallest displacement of the lightning protection rope causes the activation of the position monitoring and the installation must not be re-started until the correct condition has been established.
Ropes	Monthly	Visual inspection of the entire haul rope	Using the inspection mirror
Main Gearbox	Monthly	Refer to manufacturer's operation manuals	
Main Motor	Monthly	Refer to manufacturer's operation manuals	
Emergency Drive	Monthly	Carry out a test run.	20 – 30 minutes
		Check amount of fuel in tank.	The tank must be full at all times.
Gear Rim	Monthly	Check the surface condition of the gear rim and pinions.	Following each emergency operation
		Check the tooth profile for inadmissible wear.	Following each emergency operation
Service Brake	Monthly	Check the brake liner clearance	On both brake pads play of 2-3 mm
		Check the thickness of the brake liners.	Check brake liners for wear.
		Moving parts	Check for ease of movement.
		Function test - manual actuation by means of the hand pump.	Clean if required and lubricate.
Emergency Brake	Monthly	Check the brake liner clearance	On both brake pads play of 1.5-2 mm
		Check the thickness of the brake liners.	Check brake liners for wear.
		Moving parts	Check for ease of movement.
		Check the cup springs.	Clean if required and lubricate.
		Check the brake components visually for corrosion.	Check for cracks, corrosion.
		Function test the manual actuation by means of the hand pump	Visually
		Check the mechanical 'Emergency brake manual' function.	
Drive and Return Bullwheel Bearing Assemblies	Monthly	Check the fastening of the bearing cover and axle for tight seat.	
		If operation is stopped for longer than a month	Perform the monthly inspection prior to resuming operation again.
Bullwheel Coupling	Monthly	Check the external condition of the bullwheel coupling	
		Check the protection against condensation water	

Component	Check Frequency	Task to be performed	Procedure
		for tightness between the torsion shaft and the protective cover.	
		Check the drainage holes on the gearbox case for free pass.	
		If operation is stopped for longer than a month	Perform the monthly inspection prior to resuming operation again.
Bullwheel Position Monitoring Unit	Monthly	Check the external condition of the bullwheel position monitoring unit.	
		Check the devices for proper functioning.	by pressing the limit switch
Tensioning Unit	Monthly	Check the piston rods for damage.	
		Check for external leaks.	
		Apply corrosion protection to the piston rods.	
Tensioning Carriage	Monthly	Check the monitoring switches for correct functioning	By actuating them
Hydraulic Tensioning	Monthly	Check for condensed water and Drain off any water.	Drain from the oil tank.
		Check saturation level of silica gel in air dehumidifying filter	
		Check the hydraulic fluid.	
		Check the filters.	Check the contamination level
Grip Opening/Closing Line -General	Monthly	Check all screws and nuts, especially set screws and counter nuts.	For firm seat and good condition
		Lubricate the running and grip opening /closing rails.	
Conveying Unit	Monthly	Check V-belts for pre-tensioning and wear.	Replace if required.
Lifting Unit for Tyre Conveyors	Monthly	General check	
Brake-coupling Unit	Monthly	Function test of clutch/brake combinations with empty carrier	
PTO Drive	Monthly	Check V-belts for pre-tensioning and wear	Replace if required.
Grip fault before launch limit switch	Monthly	Carry out a function test	Through manual actuation
		Check the triggering force.	Replace if required.
Grip not open limit switch	Monthly	Carry out a function test	Through manual actuation
		Check the triggering force.	Replace if required.
Rope position vertical and	Monthly	Carry out a function test	Through manual actuation
		Check the triggering force.	Replace if required.

Component	Check Frequency	Task to be performed	Procedure
horizontal limit switch			
Geometrical grip gauge	Monthly	Carry out a function test	Through manual actuation
		Check the triggering force.	Replace if required.
Grip operating lever fault ±10%	Monthly	Carry out a function test	Through manual actuation
Electronic Grip Force Testing Device	Monthly	At max. lift speed, record two measuring values of a reference grip (carrier no. 1)	Record Data Sheet for Grip Operating Roller Forces)
		Use the test function to effect a shut-down as the reference grip (carrier no. 1) exits the station.	Refer to the separate electrical operating manual.
Line engineering	Every Month (equivalent to approx. 250 operating hours)	Check the sheaves.	Record Data Sheet for Grip Operating Roller Forces)
		Check the sheave assemblies and evener frames, rope deflectors, bolts and retaining elements of the main pins, the position and fastening of the sheave assemblies, etc.	Visually for their condition
		In the case of combined sheave assemblies and sheave assemblies with guiding sheaves, check the compression springs for spring fracture.	Visually
		Check the position and fastening of the break fork switches.	Visually
		If operation is stopped for longer than a month	Perform the monthly inspection prior to resuming operation again.
Sheaves	Monthly	Check the sheaves for grease flowing out of the bearing.	Visually
		Dark grease seeping out of the bearings may be an indication for imminent bearing damage	
		Condition of the sheave liners	Visually
		Open:	
		Damage caused by unsuitable lubricants (corroded rubber);Non-circularity, flattening (e.g. Caused by stuck sheave);Wear in the rope groove (width, depth, lateral wear);Deposits of lubricant in the rope groove; Cracks at an angle to the groove (deep cracks are not permissible); Unusual patches on the surface, e.g. suspensions, carbonization, notches,	

Component	Check Frequency	Task to be performed	Procedure
		etc. caused by overheating	
		The snap rings must fit snugly into the groove around the entire sheave hub.	
		Visual check for loose side plates.	If any of the mentioned signs is found, replace the sheave and contact the manufacturer
		The following may be indicators of loose side plates:	
		· Excessive axial run out of the side plates during operation;	
		· Excessive radial run out of the rubber liners during operation;	
		· Excessive rubber dust (abrasion) in the area of the side plate;	
		or carbonization due to overheating;	
		· Well-marked gap between the rubber liner and the side plate	
Break Fork Switch	Monthly	Check the position and fastening of the break fork switches.	Visually
Carrier	Monthly	If operation is stopped for longer than a month	Perform the monthly inspection prior to resuming operation.
Hanger	Monthly	Fastening elements	Check all fastening elements for integrity and firm seating. Replace if necessary.
		Lubrication of Components	
		Visually inspect all hangers (including hangers of the special carriers) for possible deformation and cracks. Inspect immediately following storms	
Grip	Monthly	Check the plastic rollers on the grip for wear.	Perform the monthly inspection prior to resuming operation.
		Check the grip tongues for wear	
		If operation is stopped for longer than a month	

11.2.4. Checklist – Three Months

Component	Check Frequency	Task to be performed	Procedure

Component	Check Frequency	Task to be performed	Procedure
Drive and Return Bullwheels	Every three months	Visually check all components for cracks at the weld seams and for intactness. Check the bolts for tight seat.	
Drive and Return Bullwheels	In case of uninterrupted operation: Every 3 months or every 1000 operating hours. In Case of interrupted operation: before and after each Season	Check the external condition of the bullwheels.	
Bullwheel Liner	Every three months / every 1000 operating hours	Max. permissible wear	(V max. = 5 mm)
		Maximum permitted groove depth:	(R max. = 24 mm)
		Centered position of the groove	± 5 mm
		Cleanliness of the groove	
		General check	
Bullwheel Couplings	Three to six months / after the first start-up	Visually check all visible coupling components for cracks and intactness. Check the bolts for tight seat.	
Bullwheel Position Monitoring Unit	Three to six months / after the first start-up	Visually check all visible coupling components for cracks and intactness. Check the bolts for tight seat.	
Bullwheel Axle Position Monitoring	Three to six months/ after the first start-up	Visually check all visible coupling components for cracks and intactness. Check the bolts for tight seat	
Devices for Lubrication of the Grip Operating Rollers	Every Three Months	Check the level in the LC unit.	Replace if required.
Hanger		Lubricate the hanger head.	
		Lubricate the connecting bolts between the hanger arm and the 4-point suspension frame	

11.2.5. Checklist – Six Months

Component	Check Frequency	Task to be performed	Procedure
Overhead Cables -	Every Six months	Check the overhead cable for wire breakage, signs of	Visually

Component	Check Frequency	Task to be performed	Procedure
Signal Cables		abrasion, wires sticking out, pressure marks, corrosion, damage to the coating and fastening of the signal cable, etc.	
		Check the clamping points, return and deflection units, end fixtures and their components	Visually
		Check the rope tension	
		Check the support areas of the overhead cables.	
		Lift them off the support points to allow all-round visual inspection	
		Check the support brackets on the towers and the end fixtures for cracks, rust, deformation, proper position, etc.	
		Measure the angles.	
Lightning Protection Rope	Every Six months	Check the lightning protection cable for wire breakage, signs of abrasion, wires sticking out, pressure marks, corrosion, damage to the coating and fastening of the signal cable, etc.	Visually
		Check the clamping points, return and deflection units, end fixtures and their components	Visually
		Check the rope tension	
		Check the support areas of the overhead cables.	
		Lift them off the support points to	
		allow all-round visual inspection	
		Check the support brackets on the	
		towers and the end fixtures for cracks, rust, deformation, proper position, etc.	
		Measure the angles.	
Universal Shafts	Every Six months: Before and after each season	Lubricate the universal shafts	Lubricate at all grease nipples
Service Brake		Bleed the brake hydraulics	see Bleeding the Brake Hydraulics
Emergency Brake		Bleed the brake hydraulics	see Bleeding the Brake Hydraulics
Drive and Return Bullwheels		If operation is stopped for longer than six months	Perform the annual inspection prior to resuming operation again.
Bullwheel Couplings		If operation is stopped for longer than six months	Perform the annual

Component	Check Frequency	Task to be performed	Procedure
			inspection prior to resuming operation again.
Bullwheel Position Monitoring Unit		If operation is stopped for longer than six months	Perform the annual inspection prior to resuming operation again.
Bullwheel Axle Position Monitoring		If operation is stopped for longer than six months	Perform the annual inspection prior to resuming operation again.
Tension Carriage		Lubricate the running wheels.	Lubricate before and after each season.
Electronic Grip Force TestingDevice		Check the electronic grip force testing unit.	By means of the calibration device.
Door Opening/Closing Mechanism Gondolas		General check and Lubricate the joints.	lubricate
Access Control Barrier		General check and Lubricate the joints.	lubricate
Sheave Assemblies	Every Six months / (equivalent to approx. 1500 operating hours)	If operation is stopped for longer than six months	Perform the annual inspection prior to resuming operation again.
Carrier		If operation is stopped for longer than six months	Perform the annual inspection prior to resuming operation
Grip		Seasonal (i.e. after each winter and summer season):	Perform the annual inspection prior to resuming operation.
		Check all grips for tight fitting of all fastening components.	
		Check the grip operating roller force.	
		If operation is stopped for longer than six months	
		Seasonal (i.e. after each winter and summer season):	Perform the annual inspection prior to resuming operation.
		Check all grips for tight fitting of all fastening components.	
		Check the grip operating roller force. If operation is stopped for longer than six months	

11.2.6. Checklist –Yearly

Component	Check Frequency	Task to be performed	Procedure
Hydraulic Equipment General	Yearly	Check the hydraulic fluid.	follow detailed instructions on Hydraulic Systems Manual'
		Check the filters.	Check the contamination level.
Towers	Yearly	Check the cavity inside the tower for water accumulation.	On towers filled with concrete
		Check the drainage holes	If required, clean drainage holes
		Check the drainage pipes or drainage hoses	On towers with cemented-in foundations
		Check the access protection equipment according to the manufacturer's operation and service manual.	
Foundations	Yearly	Check the tower foundations for cracks, displacement and other damage.	
Safety nets at Station Exits	Yearly	Visually inspect the safety nets for the following.	Meshes in correct condition
			Edge rope or eye clips in correct condition
			No rub marks or visible damage
			Damaged safety nets must be replaced immediately
Parking switch rails	Yearly	Check the fastening and correct position of the switch rail monitoring devices.	Meshes in correct condition
			Edge rope or eye clips in correct condition
			No rub marks or visible damage
			Damaged safety nets must be replaced immediately
		Lubricate the joints	
		Clean and lubricate the fall switches and check them for correct functioning and ease of movement.	
Emergency Rail	Yearly	General check	
		Clean and lubricate the running rails.	
Parking Area	Yearly	General check	
		Clean the equipment if necessary	
Overhead Cables - Signal Cables	Yearly	Angle measurement	Must be carried out prior to every season or at least once a year.
Lightning protection rope	Yearly	Angle measurement	Must be carried out prior to every season or at least once a year.
Ropes	Yearly	Visual inspection of the entire haul rope	Using the inspection mirror

Component	Check Frequency	Task to be performed	Procedure
Main Gearbox	Yearly	Main gearbox	Refer to manufacturer's operation manuals.
Universal Shafts	Yearly	Check play for universal shafts	Longitudinal expansion – play20 mm
		Check bolted connections	For firm seating
		Main motor	Refer to manufacturer's operation manuals.
Main Motor	Yearly	Main motor	Refer to manufacturer's operation manuals.
Gear Rim	Yearly	Visual inspection of all components for crack formation. Check bolts for firm seating and completeness	
Tacho Drive without Rollback Detector	Yearly	General check	
Service Brake	Yearly	Perform load tests with carriers and loads (no passengers).	
		Check the release force.	
Emergency Brake	Yearly	Perform load tests with carriers and loads (no passengers).	
Drive and Return Bullwheels	Yearly	Visual inspection and test run of the power transmitting components.	(Main, emergency, and auxiliary drive)
		Check the bolt connections on divided bullwheels.	For firm seating
Bullwheel Coupling	Yearly	Visual inspection and test run of the power transmitting components.	(Main, emergency, and auxiliary drive)
		Function test - Bullwheel Coupling.	
		Check the rubber-metal bushing for wear: Check the space (connecting hub and support ring) for abrasion and whether the gap dimension between the connecting hub and the support ring exceeds a dimension of 1 mm.	
		Clean the chain and renew the anticorrosion protection.	
Bullwheel Position Monitoring Unit	Yearly	Visually check the bullwheel position monitoring unit and perform a mechanical test run.	
Bullwheel Axle Position Monitoring	Yearly	Visually check the bullwheel position monitoring unit and perform a mechanical test run.	
Grip Opening/Closing Line -General	Yearly	Check the correct position of the grip opening and closing line using the position setting gauge and compare with the original records.	
Outer Guide Rail (Trumpet)	Yearly	Check for correct alignment.	
Tyre Conveyors	Yearly	V-belt pulleys and tyres :	
		Ensure that the fastening screws are firmly seated.	

Component	**Check Frequency**	**Task to be performed**	**Procedure**
		Check tyre compression on the friction plate of the grip.	
Tyre Conveyor Bearings	Yearly	Check the tyre bearings for their bearing clearance	
		Re-tighten the fastening screws of the tyre bearings by means of a torque wrench.	
Brake-coupling Unit	Yearly	General check	
		Check the ventilation slot.	
Grip fault before launch limit switch	Yearly	Check position and mounting of the gauge.	Readjust if necessary.
		Clear gauges and switches of rope grease etc.	
Grip not open limit switch	Yearly	Check position and mounting of the gauge.	Readjust if necessary.
		Clear gauges and switches of rope grease etc.	
		Lubricate the pivots and cup springs.	
Rope position vertical and horizontal limit switch	Yearly	Check position and mounting of the gauge.	Readjust if necessary.
		Clear gauges and switches of rope grease etc.	
		Lubricate the pivots and cup springs.	
Geometrical Grip Gauge	Yearly	Check position and mounting of the gauge.	Readjust if necessary.
		Clear gauges and switches of rope	
		grease etc.	
		Lubricate the pivots and cup springs.	
Grip Operating Lever Fault ±10%	Yearly	Check position and mounting of the gauge.	Readjust if necessary.
		Clear gauges and switches of rope grease etc.	
		Lubricate the pivots and cup springs.	
Anti-Collision System	Yearly	Check the distance between proximity switch and switching surface.	
		Check the mounting of the proximity switches.	
		Check the connections of the proximity switches.	
		Clean the proximity switches and mountings if necessary	
Electronic Grip Force Testing Device	Yearly	Pull testing of reference grip	
		Check vertical position of grip O/Crail.	Readjust if necessary
		Check adjustment of measuring sensors	Readjust if necessary
		Record all grip values at max. speed	
Counting Sheave	Yearly	Check the rubber liner in the counting sheave for wear	
Switch Rails of Main Ropeway	Yearly	Check the mountings and position of the monitoring devices.	
		Lubricate the joints.	

Component	Check Frequency	Task to be performed	Procedure
		Lubricate the cable drums of the switch rail.	
		Check the linear drives.	
		Clean and lightly lubricate the running rails.	
Devices for Lubrication of the Grip Operating Rollers	Yearly	Check the lubricating brush for wear.	If the brush is worn and longer coats the grip operating rollers with grease, the lubricating brush must be replaced.
Sheave Assemblies	Yearly	Check the rope position.	
		Visual inspection of the complete sheave assembly and attachments for:	Visually
		· Cracks	
		· Deformation	
		· Wear	
		· Corrosion	
		Check with the haul rope lifted off:	
		Ease of movement of sheave assembly bearings and evener frames	
Sheaves	Yearly	Check with the haul rope lifted off:	
		Check round and axial run out of the sheaves	
		Condition of the deep groove ball bearings (unusual noises, running properties and play compared with new bearings)	
		Condition of the grooves.	
		Axial play	
		Loose side plates of the sheaves (for procedure: see Inspection and Maintenance - Every Month)	
		Visual inspection:	
		Check for cracks in the sheave hub in the area of the snap ring groove	
		Check sheaves hub and side plates for cracks and deformation.	
Break Fork Switch	Yearly	Check that the break fork switches are functioning correctly. Check if the command arrives at the indicator in the drive station.	By pulling the break fork

Component	Check Frequency	Task to be performed	Procedure
		Perform a function test of the break fork switches on drop sheaves.	Pull the Lift off the haul rope and check the function and ease of movement of the drop sheave frame.
Hanger	Yearly	Inspect all carriers for cracks and deformations.	Visually
		Check the special tools for cracks and deformation.	Visually
		Additionally, at least 10% of the hangers (a minimum of 2 hangers) must be stripped down completely and visually inspected.	After a maximum period of ten years all hangers must have been stripped down, inspected and the respective maintenance work performed at least once.
Special Carriers	Yearly	Check the bail for cracks and deformation.	Visually
		Check that all bolts and retaining elements are firmly seated and in good condition.	
		Check the zinc layer for damage	
		Check for cracks.	
		Ensure that the elastic buffers are centered below the hanger arm and between the stoppers of the chair frame reinforcement plates.	
		Check the elastic buffers	For cracks and deformation
Grip	Yearly	Inspection and maintenance	At least 5 grips must be stripped down and subjected to a visual inspection.
		Pull test	10% of the grips
		Check when stripping down the grips	For cracks
		- Check for wear	- No cracks permissible
		- Check of components	

11.2.7. Checklist –Every Two Years

Component	Check Frequency	Task to be performed	Procedure
Grip	Two Years	Check of the measuring accuracy of the calibration device by an authorized body	

11.2.8. Checklist –Every Three Years

Component	Check Frequency	Task to be performed	Procedure
Ropes	Three years	Non-destructive rope testing	
Devices for Lubrication of the Grip Operating Rollers	Three years	Non-destructive rope testing	

11.2.9. Checklist –Every Four Years

Component	Check	Task to be performed	Procedure

	Frequency		
Overhead Cables - Signal Cables Aerial cable	Every Four Years	Relocation of the overhead cable	
Lightning Protection Rope	Every Four Years	Relocation of the Lightning Protection Rope	
Service Brake	Every Four Years	Completely strip down the disc brake, thoroughly clean all components, renew anti-corrosion protection and grease bearings	
		Clean the coil spring and visually inspect for cracks. Renew anticorrosion protection.	
		Replace wear parts.	
Emergency Brake	Every Four Years	Completely strip down the disc brake, thoroughly clean all components, renew anti-corrosion protection and grease bearings	
		Clean the coil spring and visually inspect for cracks. Renew anticorrosion protection.	
		Replace wear parts.	
Bullwheel Coupling	Every Four Years	Lift the torsion shaft, clean the teeth on the side of the gearbox and the coupling hub and re-lubricate (fill up the cavities and the room between the teeth).	

11.2.10. Checklist –Every Five Years

Component	Check Frequency	Task to be performed	Procedure
Towers	Five Years	Check the bolt tensioning and re-tighten the bolts using a torque wrench.	Visual
Foundations	Five Years	Check the anchor pre tensioning.	Visual
Grip	Five Years	After 5 years or 50,000 bullwheel cycles at the latest, all grips must be completely stripped down and maintained.	Visual

11.2.11. Checklist –Special Checks

Component	Task to be performed	Procedure
Drive and Return Bullwheels	1st special inspection: After 22,500 operating hours but not later than 15 years after the first start-up.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	
Drive and Return Bullwheel Bearing Assemblies	1st special inspection: After 22,500 operating hours but not later than 15 years after the first start-up.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	

Component	Task to be performed	Procedure
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	
Bullwheel Couplings	1st special inspection: After 22,500 operating hours but not later than 15 years after the first start-up.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	
Sheave Assemblies	First stripping-down of all sheave assemblies	After 22,500 operating hours but not later than 15 years after the first start-up
	Second stripping-down of all sheave assemblies	Second stripping-down of all sheave assemblies
	Stripping-down of all sheave assemblies	After 7,500 operating hours but not later than 5 years after the second stripping-down
Carrier	1st special inspection: After 22,500 operating hours but not later than 15 years after the first start-up.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	
	2nd special inspection: After 15,000 operating hours upon the first special inspection but not later than 10 years after it.	

11.3. Non-destructive testing Checks

The following assembly groups and components must periodically be subjected to non-destructive tests.

- Haul ropes and track ropes
- Support hub of the bullwheel bearing assembly
- Bolts of the sheave assemblies
- Carriers
- Grips

Consult the maintenance manual of the corresponding assembly group for the intervals and additional instructions.

11.4. Maintenance Guidelines

Maintenance guidelines are listed below for reference:

A pre-start check should be done in all ropeway sections to check the fitness of ropeway system and all safety devices etc.

- Pre Start Checks

1. Should be done before commercial operation of the unit
2. Should be done in presence of authorized engineer
3. Should involve team of qualified and trained engineers

- Team of Trained operators for Operation and Maintenance should be deputed for O&M.
- Continual training program for staff for up gradation
- Display of Operation and Maintenance guidelines all locations for understanding of all operators.
- Display of safety instructions in cabin for passengers
- Proper illumination along line for night operation and unlikely event of rescue
- Public address system for passing instruction to staff and passengers should be installed in ropeway
- All Safety Devices mounted for monitoring of critical assembly function should be in proper state all the time and in no case it should be by bypassed.
- Full capacity DG as alternate source of power during power failure case should be installed and it should always be in working condition.
- Three independent sources of Rescue arrangements for evacuating passenger to safe place in case of emergency should be installed and should always be functional.
- Monthly rescue drills should be conducted at one position at least for manual rescue to check the preparedness of the system.
- Various checklists should be made for engineers and operators for observation during plant running.

Chapter 12 ENVIRONMENT & SOCIAL IMPACT ASSESSMENT

Aerial ropeway development will have a wide range of impact on the environment through activities like construction work, reclamation, excavation and other related activities. Aerial ropeway development and operation should therefore be planned with careful consideration of their environmental impact. Aerial ropeways are particularly important in regions where the facility of surmounting natural barriers gives them an advantage over railways or road in high altitude regions. The choice of a particular type depends upon the length and topography of the route, the type and intensity of traffic and the relative inaccessibility of the site.

12.1. Land Environment

The Project construction activities will minimally affect the topography (station sites only) and drainage pattern. It will result in Top soil erosion and soil contamination due to project activities but in a very less footprint. At the similar footprint, there will be loss of productive soil and impact on natural drainage pattern. Tentatively, permanent land requirement for the project is 3.73 ha. Additionally, about 1.76 ha land is required temporarily. Station wise land requirement is given in Table 12.1. There will be requirement of 37300 sq.m. area for construction of 13 stations for Gangtok cable car project. Out of this 10475 sq.m. area is roof area of stations, about 3755 sq.m. area is likely to be cleared of few houses and commercial establishments through demolition and the affected parties will have to be compensated as per R & R Act 2013 and state Government Rules. It is estimated that during construction activities an additional area of 17630 sq.m. would be affected due to movement of men, material and machinery. Thus a total of 54930 m2 area would be affected due to the project.

Table 12-1: Station wise land requirement

STATION	Roof Surface	Station Area	Demolition Required	Affected Area during Construction
1. Ranipool	1,685	3,370	0	3,520
2. Tourism office	900	3,600	350	4,830
3. Sikkim Manipal Hospital	760	2,280	0	4,830
4. Gangtok Municipal Corporation (GMC)	525	3,150	0	4,830
5. Denzong Cinema/Supermarket	760	4,560	750	4,830
6. Old STNM Hospital	525	2,100	1600	4,830
7. Taxi Stand North District	760	3,040	735	4,830
8. Station near Helipad	760	3,040	320	4,830
9. Station near Upper Burtuk	760	3,040	0	3,520
10. District Administrative center	760	1,520	0	3,520

STATION	Roof Surface	Station Area	Demolition Required	Affected Area during Construction
11. Hospital at Sichey	760	3,040	0	3,520
12. Chandmari Taxi stand	760	1,520	0	3,520
13. 2nd Mile HFC Church	760	3,040	0	3,520
Total	10475	**37300**	**3755**	54930

The affected area is mostly green area. While finalizing the station sites care will have to be taken to minimize displacement of structures and felling of trees.

As mitigation measures, Natural drainage patterns can be maintained by preparing sodden waterways or installing culverts; Engineering plans shall be drawn to reduce the area of earth cuts or fills, provide physical support for exposed soil or rock faces, concentrate or distribute - as appropriate the weight loading of foundations to areas able to support the weight, the top soil stockpile is to be protected and shall be utilized.

12.2. Water Environment

Water resources will be impacted due to shifting of some water courses during the course of construction activity. There will be water requirement for construction activities of the project so there will be impact of water withdrawal on surface water/ ground water resources. The water shall be sourced from municipal body. During operations also water will be required for drinking and domestic purposes on stations, car washings on depot etc. There will also be generation of waste water from washing of cable cars and toilets which will have to be treated before discharge from source.

As mitigation measure there is a requirement of water conservation measures. The construction water shall be sourced from municipal body and it is suggested to use treated sewage from municipal body responsible for treatment and disposal of sewage in the city. During operations the sewage generated at stations shall be treated in septic tanks and disposed to sewerage system. For drinking and domestic purpose the ground water source will be tapped by installing bore-wells with due permission from Central Ground Water Authority (CGWA).

12.3. Air Environment

Construction phase would involve site clearances and preparation, infrastructure development, aerial ropeway construction and other related activities which will lead to generation of little dust and emission of gases from construction machinery. There will be movement of men, material and machinery leading to generation of dust and smaller particles. Similarly, operational phase would involve emission from vehicular movement and backup diesel generators (very less). As a mitigation measure, there shall be provision for spraying water to reduce dust emissions during the construction phase. Proper maintenance of vehicles and DG sets shall be carried out as per manufacturer schedule.

12.4. Noise Environment

Noise will be generated due to demolition/ construction activities of the project. There will be impact of vibration during construction due to working of heavy machinery and movement of heavy vehicles. There will also be Noise effects due to transportation activities and operation of DG sets. Adoption of mitigating measures for noise abatement such as use of acoustic enclosures, use of ear muffs by workers and job rotation at places of high noise is suggested. Additionally, there will be use of noise barriers for point sources and line sources and the measures to minimize effect of vibrations due to construction activities shall be adopted.

12.5. Ecological Environment

There will be loss of forest cover at the proposed stations and adjoining areas, at the location of Towers and other project infrastructures. There will be loss of plants of economic importance.

Simultaneously, there will be habitat fragmentation in the vicinity of stations. There will also be blocking of migratory corridors due to project activities. As mitigation measure compensatory plantation shall be undertaken and a minimum of three saplings against one tree felled shall be planted and maintained for 3 years for getting proper survival rates. It is suggested to bypass the forest and ecologically sensitive locations. An all-out effort shall be made to minimize disturbance to natural habitats.

12.6. Socio-Economic and Health

Precise survey of project affected families has not been carried out to identify PAPs since the location of stations and other infrastructure has not yet been finalized. However, it is observed that there will be no impact on any historical or cultural sites due to this project. Since, the Gangtok city is a tourist place and its economy is dependent on tourists and their movement from one place to other. There was a theoretical apprehension that the project activity of developing cable car for public transport will affect the income potential of local people engaged in transport business. Therefore, Social survey was carried out in which main respondents were taxi drivers, travel and tour operators and people of different walks of life. The survey was carried out at four locations, viz.,

1. Ranipool,

2. Ranka Taxi Stand,

3. Market near Denzong Cinema,

4. Taxi Stand North District.

The specific questions were about their perception about the proposed cable car project?, how it will affect their economic condition and income prospects?, what will be impact on tourists to the city etc.

In their response, most of the taxi drivers and tour and travel operators welcome the coming up of the project. They foresee more influx of tourists to the city. They do not see it as competitor to their occupation, rather they see it as complementary to their activities. They conveyed that their main tourist activity is outside Gangtok city. Therefore, when more tourists will visit the city their income prospects will improve. Similar was the response of traders and other class of respondents. Since proposed cable car project is providing access to Hospitals with provision of ambulance cars as well, people consider the project to be helpful in providing access to health facilities. Construction activities are emitting large pollution to environment. Large volumes of suspended particulate matters are released during construction work leading to air pollution. Unhygienic site sanitation facilities cause damage to environment and to the health of the construction workers. The health and safety of the workers during construction is to be ensured with effective provisions for the basic facilities of sanitation, drinking water, safety of equipment or machinery etc. Following are some of the recommendations to be followed:

- Comply with the safety procedures, norms and guidelines as outlined in IS 5228, IS 5229 and IS 5230, code of practice for construction of aerial ropeways, Bureau of Indian Standards
- Provide clean drinking water to all workers
- Provide adequate number of decentralized toilets and urinals to construction workers.
- Guarding all parts of dangerous machinery.
- Precautions for working on machinery.
- Maintaining hoists and lifts, lifting machines, chains, ropes, and other lifting tackles in good condition.
- Durable and reusable formwork systems to replace timber formwork and ensure that formwork where used is properly maintained.
- Ensuring that walking surfaces or boards at height are of sound construction and are provided with safety rails or belts.
- Provide protective equipment; helmets etc.
- Provide measures to prevent fires.
- Fire extinguishers and buckets of sand to be provided in the fire-prone area and elsewhere.
- Provide sufficient and suitable light for working during night time.
- Dangers, health hazards, and measures to protect workers from materials of construction, transportation, storage etc.
- Safety policies of the construction firm/division/company to be prepared.

12.7. Solid Waste Management

There will be impact due to non-hazardous and hazardous solid waste generated during the construction and operational stages. Options for minimization of solid waste and environmentally compacting/ recycling of waste to conserve natural resources should be planned. Management and disposal of temporary structures, made during construction phase should be planned. C& D waste should be minimized, reused and recycled within the project so far as possible. The excess C & D waste shall be disposed off at site allocated by Municipal body

12.8. Risk Assessment and Disaster Management

Ropeways are liable to suffer from environmentally induced threats, risks and hazards as well as human -caused occurrences. Disasters will be due to technical failures and natural causes. Natural disasters include earthquakes, landslides, rock falls, storms, avalanches, lightening etc and technical failures will include rope with broken wires in service, drive / return sheave shaft failure / tension system failure, mount assembly parts failure, over speeding of ropeway /

brake failure, rollback, slippage / fall of cabin, entanglement of cabin, swinging of cabin resulting in fall of passengers outside cabin, cabin derailment at station etc. while accidents include fire in fuel storage areas.

Personnel for disaster failure need to be identified and properly documented in the disaster management plan before start of any project activity. The various cells - technical, team for rescue (trained and skilled operators) are to be clearly indicated.

The following are the issues to be addressed with reference to technical and natural failures:

Table 12-2: Issues to be addressed with reference to technical and natural failures

Reason	Prevention	Action required to be taken
Socketing failure	Proper material used, design of socket and periodic inspection	Maintenance guidelines to be followed regularly
Splicing failure	Periodic inspection	Training manpower, tools and tackles
Fall / slippage of cabin (Grip failure, Hanger failure, failure of joints, overloading)	Components to be replaced as per life cycles	Replacement at proper time intervals to be done
Cabin door opening (collisions, jerking, component failure)	Simple precaution like locking before leaving cabin follow rules	Seat fasteners for seats to prevent falling of passengers
Mount assembly parts failure, tower failure (rusting, over-usage, deterioration, natural calamity)	Continuous monitoring, life cycle of components to be ascertained	Life cycle monitoring
to check for fatigue or corrosion of the anchor bolts on a sample tower	whether a continuous uphill load imposed by the subtended angle of the haul rope on any vertical tower might lead to excessive fluctuating loads on the anchor bolts;	Prevent water retention and resultant corrosion
Hitting of cabin (Improper demarcation of area, improper passenger management)	Proper signage, proper demarcation and cordoning of cabin, training of operators	Training of operators, proper maintenance
Electrocution (Lighting)	Proper rope earthing	Periodic monitoring
Entanglement of cabin (High wind, breakage of catenary wire)	Install and monitor Wind speed,	Periodic inspection of catenary wire, monitoring condition of wires
Natural causes like earthquakes, landslides, wind storm, hailstorm, flood, jungle fire	Earthquake resistant constructions, proper retention of landslide prone areas, early	Early warning systems

Reason	Prevention	Action required to be taken
	warning systems	

Activities associated with aerial ropeway construction and operations also give rise to associated hazards and accidents. It is therefore desirable that based on the categories of hazards prevailing at the project site, risk assessment will be carried out by specialists in the field and recommendations will be implemented appropriately.

Risk assessment should be carried out for seismicity, slope stability, soil erodibility, and flood hazard. Disaster Management Plan must include emergency planning, emergency procedures, and details on safety measures adopted for the ropeway. Maintenance of the ropeway for all structural, mechanical, and electrical components has to be done regularly and kept in a state of good repair. A systematic maintenance needs to be followed. Procedures for maintenance and specific frequencies for periodic lubrication, inspection and adjustment are to be clearly mentioned.

The ropeway designer, wire rope/strand manufacturer should mention the frequency and methods for maintenance or inspections of wire rope or strand in the specification. These will include, but not limited to, the following:

a) Conveyor belting;

b) Drums and rollers;

c) Conveyor belt tensioning system;

d) Braking systems;

e) Electrical control systems;

f) Communications systems;

g) Structures.

12.9. Maintenance Personnel

Conveyors need to be maintained by trained and competent personnel, and the owner shall be responsible for the supervision and training of such personnel, and such training shall be documented. All personnel need to practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel must also comply with the operational rules and safety regulations of the specific conveyor. Each conveyor shall be inspected periodically by a conveyor specialist independent of the owner. The inspection need to verify preservation of the original design integrity and cover the requirements of maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance need to be noted and action taken by the competent authority. Operational log needs to be maintained for each conveyor. Daily entries should be made giving the following minimum information:

Date;

Names and work position of operating personnel;

Temperature, wind, and weather conditions;

Record of compliance with daily operational inspection including signs, loading and unloading zones;

Accidents, malfunctions, or abnormal occurrences during operation;

Signature of the operator.

Maintenance log should be maintained wherein the actual execution of maintenance work shall be recorded. The log will state the components serviced, and the condition of the components. A record shall be kept of replacement of components.

12.10. Quantifiable Positive Impacts

12.10.1. Savings of Travel Time

The two parameters that significantly influence mode choice are travel time and cost. When it comes to shift to alternative modes of transport, then other parameters such as comfort and safety also play a crucial role. The various aspects were computed for each mode surveyed. Based on the probability of passengers travelling on the cable car has been evaluated. Based on the various underlying assumptions for the estimations of demand as mentioned in the previous chapter of the report, the two most influencing factors of savings in Travel Time, Savings in Vehicular Kms have been estimated for Without Cable Car and with Cable Car Scenarios.

Based on the Table 12-3 below it could be observed that with the introduction of cable car system in Gangtok, there would be a significant savings in travel time from the year 2031, which would account for ~5% in 2021 to ~40% in 2051.

12.10.2. Savings of Vehicular Kms

Similarly, the savings in Vehicular kms have been assessed for the Gangtok City in the Do Nothing Scenario and with Cable Car Scenario 2021, 2031, 2041 and 2051 as represented in Table 12-4. It could be observed from the table below that the total vehicular kms savings in project scenario works out to be 40,581 vehicular kms (including 2W, 4W (cars and taxis), Bus, Trucks etc) in 202, which would increase to 57333 vehicular kms in 2031 to 84, 717 vehicular kms in 2041 and 142650 vehicular kms in 2051, which would account for ~10% in 2021 and ~12% in 2051 .

Table 12-3:Average Travel Time savings including Outer Zone in Project Scenario compared with Do Nothing Scenario (Peak Hour) (in minutes)

Parameter	Do Nothing Scenario				With Cable Car Scenario				Savings			
Year	2021	2031	2041	2051	2021	2031	2041	2051	2021	2031	2041	2051
Home based Work Trips												
Private Car	32	117	231	394	31	60	179	236	1	57	52	158
Taxi	36	120	243	402	36	69	202	241	0	51	41	161
Two Wheeler	33	118	244	414	32	64	193	248	1	54	51	166
Home based education trips												
Private Car	27	99	195	332	25	28	117	199	2	71	78	133
Taxi	28	93	189	313	26	29	113	188	2	64	76	125

Parameter / Year	Do Nothing Scenario				With Cable Car Scenario				Savings			
	2021	2031	2041	2051	2021	2031	2041	2051	2021	2031	2041	2051
Two Wheeler	27	97	210	339	25	28	130	203	2	69	80	136
Home based other trips												
Private Car	23	27	162	183	22	23	97	110	1	4	65	73
Taxi	24.4	28.9	158	190	22	24	95	114	2.4	4.9	63	76
Two Wheeler	23	28.8	167	210	21	22	100	126	2	6.8	67	84

Table 12-4: Vehicle Km Savings including Outer Zone in Project Scenario compared with Do Nothing Scenario

Parameter	Without Cable Car				With Cable Car				Savings			
	2021	**2031**	**2041**	**2051**	**2021**	**2031**	**2041**	**2051**	**2021**	**2031**	**2041**	**2051**
Walk	63,689	98,051	1,60,034	2,71,972	72,630	1,08,158	1,86,699	3,91,808	8,942	10,107	26,665	1,19,836
Cycle	-	-	-	-	-	-	-	-	-	-	-	-
2W	1,15,049	1,76,711	2,82,269	4,72,827	1,04,914	1,65,455	2,62,447	4,27,552	-10,136	-11,256	-19,822	-45,274
Car	21,585	33,210	54,030	91,258	19,144	29,570	46,721	68,782	-2,441	-3,640	-7,309	-22,476
Taxi	1,43,863	2,21,239	3,57,460	6,03,426	87,242	1,33,181	2,15,474	3,16,268	-56,621	-88,058	-1,41,985	-2,87,158
Bus	970	1,490	2,383	3,994	1,140	1,401	2,175	3,169	170	-89	-208	-825
Truck	-	-	-	-	-	-	-	-	-	-	-	-
Cable Car	-	-	-	-	19,505	35,603	57,942	93,248	19,505	35,603	57,942	93,248
Total	**3,45,156**	**5,30,701**	**8,56,175**	**14,43,477**	**3,04,575**	**4,73,368**	**7,71,458**	**13,00,827**	**-40,581**	**-57,333**	**-84,717**	**-1,42,650**

12.10.3. Saving of fuel

Estimates of savings of fuel and reduction in emissions have been worked out based on calculated traffic estimates in project scenario and do nothing scenario. The project scenario represents the existing road network, proposed cable car network and travel demand (2021, 2031,2041 and 2051) of the city. The project scenario can be compared with do nothing scenario to ascertain benefits of cable car as a transit mode. The road network length is 88 km and two line of cable car have been provided. Table 12.3 shows the average travel time in do nothing scenario and introduction of Cable Car project in Gangtok and the savings of travel time with the project up to 2051.

12.10.4. Reduction in Emission of Green House Gases

According to preliminary estimates, this would lead to saving in Fuel and emissions from vehicular exhaust which have been worked out using ADB's "Appraisal of Road Transport Pollutant Emission" model. There will be Daily saving of 920 liter Petrol and 156 liter Diesel in 2021 and 5890 liter Petrol and 1051 liter Diesel in 2031 in the project scenario as compared to do nothing scenario.

Table 12-5: Daily Savings of Fuel Consumption in Project Scenario compared with Do Nothing Scenario

S. No.	Year	Petrol litres	Diesel litres
1	2021	4819	986
2	2031	8231	1592
3	2041	11681	2502
4	2051	19530	4183

The table clearly indicates that there will be significant reduction of Green House Gases from saving of fossil fuels spent on operation of vehicles. Moreover, there will be lesser congestion on roads. The noise on the roads will reduce which would significantly improve the environment. It is also anticipated that the project will improve the quality of life of local people of Gangtok city be providing them an affordable and convenient public transport system.

Table 12-6: Daily Reduction of Emission of Green House Gases in Project Scenario Compared with Do Nothing Scenario (In Tonnes) -2021, 2031, 2041 & 2051

Parameters	2021					2031					2041					2051				
	CO	HC	Nox	Co2	PM	CO	HC	Nox	Co2	PM	CO	HC	Nox	Co2	PM	CO	HC	Nox	Co2	PM
Without Cable Car	0.15	0.21	0.07	22.70	0.02	0.23	0.32	0.11	35.04	0.02	0.36	0.51	0.18	56.51	0.04	0.61	0.87	0.30	95.21	0.06
With Cable Car	0.11	0.14	0.05	16.69	0.01	0.17	0.22	0.08	25.57	0.01	0.28	0.35	0.12	40.91	0.02	0.43	0.53	0.19	61.99	0.04
Savings	0.03	0.07	0.02	6.00	0.01	0.05	0.10	0.03	9.47	0.01	0.08	0.16	0.05	15.60	0.01	0.18	0.33	0.11	33.22	0.03
% Savings	23%	32%	26%	26%	35%	23%	32%	29%	27%	36%	23%	32%	29%	28%	36%	29%	38%	37%	35%	44%

Chapter 13 COST ESTIMATES & FINANCIAL FEASIBILITY

13.1. Introduction

Generally public investment decisions are to be made based on two types of Analysis (1) Economic Analysis which estimates the benefits and costs to the society (2) Financial Analysis which is carried out to assess the return on investment. It is observed that Urban Transport Projects, in spite of being capital intensive in nature hugely contributes in terms of social benefits. However often financial viability remains elusive in urban transport projects, but these projects remain socially and economically important.

This chapter attempts to estimate the financial and economic feasibility and operational sustainability of proposed CCT system in Gangtok. It discusses inputs and estimates related to ridership and project cost, sources of funding, revenues, and operations cost.

13.2. Analysis Period

The CCT service is expected to kick off in 2021 (i.e 2021-22, April 2022) after around 1 year of DPR preparation period and 2 years of construction period for Phase 1 and Phase 2 is expected to be operationalized by in 2025-26. The financial analysis for CCT project is carried for operation period of 30 years, starting from 2021and ending in 2051. The revenue, expense, taxes and cash flow are estimated for this period. (It may be noted that the reference to year 2021 refers to financial year 2021-22 and so on)

13.3. Ridership Estimate

The Daily trips by cable car system calculated for Gangtok and presented in Table 13-1 is based on the assumption that the overall transportation infrastructure (feeder network, real estate etc.) of the city is developed in line with the proposals made as part of the cable car.

Table 13-1: Estimated Daily Ridership of Cable Car in Gangtok

	2021	2031	2041	2051
Passengers/Day	40,300	66,873	98,938	1,44,749

13.4. Project Cost

Public Transport (PT) services which are adequate, accessible, reliable, regular and safe need to be affordable for acceptance by majority of commuters. Provision of such services call for large investments in system technology and station infrastructure. Estimation of capital investment is an important component of any proposed infrastructure project as it provides vital inputs to both financial and economic evaluation. The total project expenditure can be categorized into the various components as mentioned below;

1. **System Components:** This includes the capital cost of the Electro-Mechanical Components such as cables, carriers, grips, drive motors, bull wheels, towers with sheave assemblies, control panels, control room etc. along with Technical Assistance during Installations, Transportation Costs, Import Clearance and Ware housing etc. along with Rotatable Spares for 1 year.
2. **Civil Infrastructure:** This includes the capital cost attached with the civil infrastructure development at the stations and towers including the cost of commercial area development within CCT Station premises.
3. **Operation and Maintenance Cost:** This component consists of operational and maintenance cost of the

overall operations over a period of 30 years of operations.

Besides structuring user tariffs at affordable levels simultaneously ensuring recovery of cost of inputs and reasonable return on investments, operating costs and revenues, and overall financial performance of the system along with quantum of financial support required, if any, for its sustainability. This section of the report attempts to estimate the cost of the System Components of the Cable car system along with Station development cost, revenues, and the gaps between the costs and revenues for various phases of CCT System Development and Operations.

The aforementioned CCT system costs are estimated and summarized in Table 13-2 below.

Table 13-2: Total Project Cost of CCT System for Gangtok along with Phase Wise Distribution of CCT (As per September, 2018 Prices)

Sl. No	Components (September, 2018 Prices)	Total Project Cost (Cr)	Phase 1	Phase 2
1	System Mechanical & Electrical Component Cost	₹584	₹ 250.57	₹ 333.43
2	Station Civil Development Cost	₹152	₹ 86.78	₹ 65.22
	Sub - Total	**₹ 736**	**₹ 337.35**	**₹ 398.65**
3	Soft Cost - Project Development/Supervision/PMC	₹ 36	₹ 15.45	₹ 20.55
4	Freight Cost	₹ 10	₹ 4.29	₹ 5.71
5	Contingency (10% of System Cost)	₹ 85	₹ 36.47	₹ 48.53
	Total Project Cost (excluding GST)	**₹ 867**	**₹ 393.56**	**₹ 473.44**
6	GST on Taxable Components and Spares @ 18%	₹ 156	₹ 70.84	₹ 85.22
	Total	**₹1023**	**₹ 464.40**	**₹ 558.66**

The total project cost estimated covering the electro mechanical components and Station Civil Development works out to be Rs 1023 Crores. Of the Rs 1023 Crores required to be implemented during the Phase I would require Rs 464.40 Crores, whereas for the Phase 2 would require Rs 558.66 Crores.

13.5. Fare Formulation

13.5.1. Fare Fixation

Fare structure plays an important role in promoting the Urban Transport project as it affects Demand, System sustainability and contributes in reducing the congestion. It is observed that demand is highly price elastic in urban transport as observed the world over. Thus high fare/ tariff could shift away demand if affordability is compromised. It also impacts financial viability/sustainability of the System thus contributing to the system's long term sustainability. Fare structure impacts on mode change decisions of the commuters and thus impact the congestion levels that the public transit seeks to reduce.

Given the vital role that the fare structure plays, essential guiding principles have been fixed for fare determination as below:

Table 13-3: Guiding Principles for Fare Determination

Principles	Description
Affordability	The fares should be within the means of middle income and lower income groups of the society. Majority populace from above groups uses cheaper modes of transportation for short and

Principles	Description
	long distances. Thus price elasticity is very high.
Quality	Low fare structure should not affect the quality of services of the transportation system. Inferior service level would discourage the class of commuters who appreciate time saving and comfortable journey.
Sustainability	The fare structure should also offer the system financial sustainability during the operation period. Fare should ideally cover Operation and Maintenance (O&M) Costs and capital maintenance. Ideally the system also needs to generate operating surplus (Operating Revenue - Operating cost) over a reasonable period of time to recover the investment made initially (if not fully then partially), so that funds become available for regular asset replacement
Competitiveness	Fare structure should be competitive with other modes of transport. The principle is interconnected with Affordability. Fares should not exceed the nearest competing transportation system, meaning the system which offers similar benefits in terms of time, comfort level etc. At the same time fares should not be very low or they could impact affordability. The lower fares would decrease the quality and sustainability of the system while higher side would harm the principle of affordability.
Flexibility	The fare structure should be linked with a periodic revision method. The method should be acceptable to the public and should stand legal scrutiny. It should also be able to maintain the compatibility and integrity of the fare structure.
Equity	Fares should distribute financial and other burdens fairly among citizens and assure the availability of a suitable public transport system to all income groups.

In above background the modal share pattern of Gangtok and existing fare structure are analyzed. Analysis of existing modal share of total passenger trips in Gangtok indicates that shared taxi is the most popular mode of transport (45%) followed by walk (44%), Car (8%), Two Wheeler (4%) and Buses (0.2%).

Thus it can be observed that shared taxi users are the potential demand for CCT system and hence fare structure should be formulated, in large part, considering the affordability level of the shared taxi users within the ambit of Guiding Principles (i.e. not at the cost of quality and Sustainability). This could contribute in attracting higher ridership due to modal shift.

It is observed that at present a shared taxi user pay on an average Rs 30 per trip and the average trip distance is 2.98 km. This implies that the travel by shared taxi costs around Rs 10 per km.

It can be depicted from the prevailing shared taxi fare structure specified above that passengers are habituated to pay Rs 10 per km. Considering this along with the fact that proposed CCT system would have shorter travel time in comparison to the road based shared taxi service and augmented safety and comfort, the fare for proposed CCT services at Gangtok have been broadly kept equivalent to prevailing shared taxi fares. This is due to the need for attracting a higher share of ridership from shared taxis thus decongesting roads. Thus an average fare per kilometer of Rs 10 have been adopted which on applying escalation for first year of CCT services i.e. 2021 comes out to be Rs 10.8. A fare inflation rate of 5% every year has been assumed.

13.5.2. Fare Revision

Fare Revision is also one of the key considerations to achieve sustainability and viability of the CCT system. Currently, no fare revision formula has been adopted by the Govt. of Sikkim for revising shared taxis and city bus fares.

An appropriate fare revision formula shall be identified and adopted by the Govt. of Sikkim which should be automatic and free from any political interference.

The fare revision method/formula shall be linked to revision in electricity price and revision in other costs. Presently, around 20% of the present cost is on account of electricity consumption, whereas about 80% is on account of operation and maintenance including manpower and consumables.

In the absence of any fare revision formula and for the purpose of this study it is assumed that the average fare per kilometer shall inflate at a growth rate of 8% in every 2 years.

13.5.3. Fare Collection

The fare collection process recommended for CCT is an off board system through AFCS, which is validated by the ticket collector. The AFCS machines shall be capable of verification of/charging from the contact less cards, magnetic cards/smart cards and other traffic charging instruments such as seasonal passes, prepaid cards, single journey tickets, integrated tickets etc issued off board.

13.6. Financial Assessment

The analysis shows that the investment of Rs 1023 Crores is required for the introduction of Cable Car System in Gangtok. With the introduction of Cable Car system the dependence of residents of Gangtok on shared taxi services would be reduced while increasing the ridership of organized Cable Car. It will help amortize the fixed costs over a larger quantum of supply. However, its major benefit will be improved public transport ridership, partly due to increased supply and partly due to more attractive and convenient vehicles.

The objective of the current study is two-fold. First, it seeks to introduce Cable Car Systems in Gangtok in order to meet the increasing demand for public transport in the city. Secondly, it seeks to bring about a significant improvement in the quality of the public transport system, so that a section of the private vehicle users and taxi users are also attracted to PT and with the introduction of cable car system in the city, there would be considerable reduction in the air and noise pollution. This two pronged approach would help in reducing the level of congestion on the roads of Gangtok by attracting people to use Cable Car. The fact has been taken into account in assessing the financial viability of the system.

A detailed financial model has been prepared considering the main assumptions such as bus cost, interest rate, loan tenure, life of the project, mileage, depreciations, operations in years, cost of manpower and maintenance. The model describes the revenue parameters and cost parameters calculating the total annual surplus or deficit. All the aspects of operation, repair and maintenance of rolling stock and other assets, revenue collections etc. are worked out irrespective of who provides the services. The assumptions and outcomes have been described in the following sections;

13.6.1. Assumptions for Financial Analysis

Various assumptions have been taken for carrying out the financial analysis for the Introduction of Cable Car as Public Transport Mode in Gangtok based on which the calculation have been undertaken.

1. The gestation period of the project has been assumed to be 2 years from the date of availability of funds for both the phases.
2. Operation Start Year Phase 1 – 2021 & Operation Start Year Phase 2 - 2025
3. Contingencies for the project have been assumed at the rate of 3%.
4. Operational hours - 16 Hours per day
5. No. of Days of Operations – 360 Days
6. The initial fare has been fixed at the rate of Rs 10 per Kms and has been escalated at the rate of 5% per year.
7. Power expenses – Rs 6.57 Per Unit and has been escalated at the rate of 2.50% per annum
8. Maintenance expenses have been assumed @ 3.5% of the initial project cost, increasing at the rate of 3.50% per annum.
9. Operating expenses have been assumed @5% of the initial project cost, increasing at the rate of 2% per annum.
10. Depreciation has been provided based on the SLV method assuming the project life to be 30 years.
11. Manpower cost escalation at 7.50% per annum
12. Life Span of the Project – 30 Years
13. Capacity of the Cabin – 10 Passengers
14. Load Factor – 80%
15. Advertisement Revenue from Station and Cabin – 5% per annum

13.6.2. Outcomes of Financial Analysis

A) Project Revenue

Proposed CCT project lead to a number of benefits to users of the system. The benefits are both direct and indirect in nature. Direct benefits include availability of transit service, opportunities for advertising at transit stations and corridor etc. Indirect benefits from commercial development at CCT stations (in the spirit of developing Transit Oriented Development (TOD) etc.) arise through positive externalities flowing from project proximity.

Since revenue generated from direct benefit capture would be insufficient for recovery of capital in a project of this magnitude, commercial development at CCT stations is proposed. This income supports the fare box income. The absorption of commercial space have been assumed to reach 100% in fifteen years period from commencement of CCT services considering that the development will happen around the stations only gradually. Further, creation of Urban Transport Fund could be considered which shall capture the sources from proximity benefits such as sale of additional FSI, cess on property tax etc.

Fare Box Revenue

Fare box revenue is the income received by sales of tickets for travelling in a public transit system. It will be a major direct revenue source for Gangtok CCT Project. This fare revenue estimates do not include fares for any feeder system or integrated system. Based on ridership estimates and fare as adopted and discussed in sections 13.5.1, fare box revenues have been projected and presented in Table 13.4 below.

As discussed in section 13.5.1, fare of Rs 10 per km have been adopted for proposed CCT system considering prevailing shared taxi fare rates. Inflation rate of 8% in every 2 years have been assumed to estimate future year fares. Thus the average fare per km during first year of operations i.e. 2021 shall be Rs 10.8.

Non Fare Box Revenue

As the name suggests, non-fare box revenues are those incomes which are generated by sources other then the sales of transit travel tickets. Non fare box revenue sources may be categorized in to three types, these are (1) Revenue from Advertisement, (2) Revenue from Commercial Development/TOD, (3) Supplementing income from Urban Transport Fund-UTF. All the aforementioned three nonfare box revenue sources w.r.t. proposed CCT system in Gangtok are illustrated in the following sub-sections;

1) Advertisement Revenue: Advertisement revenue refers to the income generated from selling of advertisement spaces within the CCT system infrastructure such as Stations, Towers etc. or selling of station naming rights to the potential parties. Advertisement revenue is assumed to be around 5% of the fare box revenue in proposed CCT system for Gangtok based on the existing trends in public transport systems and considering that the system would be the trunk transit mode with integrated commercial activities within the station premises and also considering the sizeable tourist influx in the city throughout the year.

2) Real Estate Revenue: Real Estate revenue refers to the income generated in the form of rentals from leased-out station floors for commercial activities. Number of floors for commercial use have been estimated at each CCT station based on the height requirement of a station and its surrounding land-use. Thus, the total built-up area for commercial exploitation is estimated to be around 16350 sqm which is 43% of the total built-up area of the stations. Rental value of Rs 1000 per sqm per month have been assumed based on the prevailing commercial rentals in Gangtok. Based on these the estimated real estate revenue during first year of service considering 25% absorption is 20 Crores. Escalation in rental value is assumed to be 8% per annum and 5% of total commercial space is assumed to be absorbed every passing year. The construction cost for development of commercial floors is assumed to be Rs 40,000 per sqm considering the hilly terrains of Gangtok, seismic sensitivity and higher material and transportation costs.

3) Urban Transport Fund-UTF: UTF may be set up at city level which can provide additional support to the CCT system revenue. UTF typically comprises of betterment levies, fuel cess, development tax etc.

The estimated non fare box revenues in proposed CCT system in Gangtok are presented in Table 13-4 below;

Table 13-4: Estimated Fare Box and Non Fare Box Revenues (Rs in Crores)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Ridership	40300	42393	44595	46912	49349	51913	54610	57447	60431	63570	66873	69544	72322	75211	78216	81341
Fare Revenue (1)	**₹ 54.7**	**₹ 60.4**	**₹ 66.7**	**₹ 73.7**	**₹ 81.4**	**₹ 89.1**	**₹ 97.5**	**₹ 106.7**	**₹ 116.8**	**₹ 127.8**	**₹ 139.8**	**₹ 153.0**	**₹ 167.5**	**₹ 183.3**	**₹ 200.6**	**₹ 219.5**
Rental Revenue (A)	₹ 8.9	₹ 9.5	₹ 10.0	₹ 10.6	₹ 11.3	₹ 25.4	₹ 26.9	₹ 28.6	₹ 30.3	₹ 32.1	₹ 34.1	₹ 36.1	₹ 38.3	₹ 40.6	₹ 43.1	₹ 45.7
Parking Revenue (B)	₹ 0.2	₹ 0.2	₹ 0.2	₹ 0.2	₹ 0.2	₹ 0.5	₹ 0.5	₹ 0.5	₹ 0.5	₹ 0.6	₹ 0.6	₹ 0.6	₹ 0.6	₹ 0.7	₹ 0.7	₹ 0.7
Advertisement Revenue (C)	₹ 0.9	₹ 1.0	₹ 1.1	₹ 1.2	₹ 1.2	₹ 1.9	₹ 2.0	₹ 2.1	₹ 2.3	₹ 2.4	₹ 2.6	₹ 2.7	₹ 2.9	₹ 3.1	₹ 3.3	₹ 3.5
Non Fare Box Revenue 2 = (A+B+C)	**₹ 10.0**	**₹ 10.7**	**₹ 11.3**	**₹ 12.0**	**₹ 12.7**	**₹ 27.7**	**₹ 29.4**	**₹ 31.2**	**₹ 33.1**	**₹ 35.1**	**₹ 37.2**	**₹ 39.5**	**₹ 41.9**	**₹ 44.4**	**₹ 47.1**	**₹ 49.9**
Total Revenue (3 = 1+2)	**₹ 64.73**	**₹ 71.06**	**₹ 78.03**	**₹ 85.69**	**₹ 94.13**	**₹ 116.79**	**₹ 126.88**	**₹ 137.87**	**₹ 149.83**	**₹ 162.86**	**₹ 177.06**	**₹ 192.51**	**₹ 209.33**	**₹ 227.68**	**₹ 247.67**	**₹ 269.45**

Year	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
Ridership	84590	87969	91483	95138	98938	102775	106761	110902	115203	119671	124312	129133	134141	139343	144749
Fare Revenue (1)	**₹ 240.2**	**₹ 262.9**	**₹ 287.7**	**₹ 314.8**	**₹ 344.6**	**₹ 377.1**	**₹ 412.7**	**₹ 451.6**	**₹ 494.2**	**₹ 540.9**	**₹ 591.9**	**₹ 647.8**	**₹ 708.8**	**₹ 775.7**	**₹ 848.9**
Rental Revenue (A)	₹ 48.6	₹ 51.0	₹ 53.6	₹ 56.3	₹ 59.1	₹ 62.0	₹ 65.2	₹ 68.4	₹ 71.8	₹ 75.4	₹ 79.2	₹ 83.2	₹ 87.3	₹ 91.6	₹ 96.2
Parking Revenue (B)	₹ 0.8	₹ 0.8	₹ 0.9	₹ 0.9	₹ 0.9	₹ 1.0	₹ 1.0	₹ 1.1	₹ 1.1	₹ 1.2	₹ 1.3	₹ 1.3	₹ 1.3	₹ 1.4	₹ 1.5
Advertisement Revenue (C)	₹ 3.7	₹ 4.0	₹ 4.2	₹ 4.5	₹ 4.8	₹ 5.1	₹ 5.5	₹ 5.9	₹ 6.3	₹ 6.7	₹ 7.2	₹ 7.7	₹ 8.2	₹ 8.8	₹ 9.4
Non Fare Box Revenue 2 = (A+B+C)	**₹ 53.1**	**₹ 55.9**	**₹ 58.7**	**₹ 61.7**	**₹ 64.8**	**₹ 68.2**	**₹ 71.7**	**₹ 75.4**	**₹ 79.2**	**₹ 83.3**	**₹ 87.6**	**₹ 92.1**	**₹ 96.9**	**₹ 101.9**	**₹ 107.2**
Total Revenue (3 = 1+2)	**₹ 293.36**	**₹ 318.74**	**₹ 346.40**	**₹ 376.54**	**₹ 409.40**	**₹ 445.24**	**₹ 484.32**	**₹ 526.96**	**₹ 573.46**	**₹ 624.18**	**₹ 679.52**	**₹ 739.89**	**₹ 805.79**	**₹ 877.70**	**₹ 956.19**

Summary of Revenue

Cumulative Project Revenue of Rs 10,869.26 Crores has been estimated over an operation period of 30 years. It is evident from the above that overall fare box collection contributes to around 84% of the cumulative total revenue to revenue basket. This is in line with the trends observed in public transport system world over.

While remaining sources such as commercial development income and income from advertisement could contribute 16% of cumulative total revenue. Source wise revenue stream from the project is summarized in the Table 13-4 above.

B) Project Maintenance Expenditure

The CCT infrastructure needs to be maintained during the operation period of 30 years. Thus costs with respects to maintenance need to be accounted for in the financial analysis. An inflation rate of 6% per annum have been assumed. Various maintenance cost heads are illustrated as under;

Maintenance Cost of Mechanical and Electrical Components of CCT System:

Proposed CCT system will have huge mechanical and electrical components which is typical in any ropeway system and would incur substantial maintenance cost. Extensive deliberations with the modern ropeway system suppliers having experience in construction and operations of some of the most successful CCT systems as public transport world-over concluded that 2.5% of the capital cost may be assumed as yearly maintenance for proposed CCT system in Gangtok.

Civil Maintenance Cost of CCT System:

Civil maintenance cost primarily includes routine maintenance cost of passenger and commercial areas in CCT stations with regard to electricity cost, HVAC cost, building maintenance cost etc. Civil maintenance rate of Rs 2400 per sqm per annum have been assumed during first year of CCT services. The assumed rate is kept on a higher side considering high electricity rates and power backup expenses.

Maintenance Cost of ITS Components in CCT System:

This is assumed at 8% of hardware and software cost as per industry practice

C) Project Operations Expenditure

The primary expenditure in running the CCT System would be electricity cost. Other costs such as SPV admin and staff salary costs, security staff and housekeeping staff salary cost also forms a substantial amount. These cost have been estimated based on inputs from ropeway technology providers and experience from other public transport system operations.

1. **Electricity Consumption Cost:**

Electricity is the propulsion fuel for CCT systems, thus an essential requisite for running the system. Electricity is consumed primarily for running drive motors which in turn moves the haul rope and the gondolas attached to it. Electricity is also consumed at the stations for lighting, HVAC, lift operations, running AFCS and ITS equipment, etc. Electricity will also be required for CCT system control rooms. Thus, electricity consumption and corresponding cost forms a major share of expenditure in overall operating cost of the CCT system. Broad estimates based on power rating of drive components of proposed CCT system suggests that the electricity consumption for driving the haul rope will be 26000 megawatts per annum. The prevailing electricity rates in Gangtok is Rs 6.57 per unit for high tension bulk supply connection. Additional electricity cost with regard to consumption at CCT stations have been accounted for in the adopted civil maintenance rate. Considering these the total cost of electricity for CCT services in first year i.e. 2021 is estimated to be around Rs.17 Crores

2. Staffing Salary Cost:

There would be a sizeable requirement of manpower to operate, maintain and secure the proposed CCT system. Skilled personnel would be required for Special Purpose Vehicle (SPV), Operations and Maintenance of the CCT System whereas semi-skilled personnel would be required for housekeeping and security services.

The estimated manpower for proposed CCT system in Gangtok is based on the past experiences in public transit system operations and provided in Table 13-5. The total estimated staff requirement for running proposed Gangtok CCT system would be 324 personnel and the estimated total salary cost during first year of operations would be around Rs 8 Crores which is assumed to escalate at 6% per annum based on the past trends in average rise in salary in Sikkim. This 324 personnel's would be introduced in the phase wise manner.

3. ITS Equipment Replacement Cost:

The life of ITS equipment has been considered as 8 years. This implies that ITS equipment shall be replaced at regular interval of 8 years. The present cost is escalated at 6% to estimate the cost of ITS during replacement years.

Table 13-5: Estimate of Staff Salary and Admin Cost

	Staff	Salary/ employee /month	Shift	Total/Annum
SPV				

	Staff	Salary/ employee /month	Shift	Total/Annum
CEO	1	150,000	1	1,800,000
General Manager	1	100,000	1	1,200,000
DGM - Operations and Civil	1	85,000	1	1,020,000
DGM - Admin and Finance	1	85,000	1	1,020,000
AM- Operations	1	50,000	1	600,000
AM- IT	1	50,000	1	600,000
AM-Civil	1	50,000	1	600,000
AM-Electrical	1	50,000	1	600,000
AM-Mechanical	1	50,000	1	600,000
AM-(WS/Depot)	1	50,000	1	600,000
Chief Security Officer	1	85,000	1	1,020,000
AM- HR (training)	1	50,000	1	600,000
AM - Finance	1	50,000	1	600,000
Assistant IT	1	25,000	1	300,000
Assistant Civil	1	25,000	1	300,000
Assistant Electrical	1	25,000	1	300,000
Assistant Mechanical	1	25,000	1	300,000
Assistant (WS and Depot)	1	25,000	1	300,000
Assistant (Chief Security Officer)	1	25,000	1	300,000
Assistant -AM-HR	1	25,000	1	300,000
Assistant- Finance	1	25,000	1	300,000
O&M Staff				
Skilled Operator	13	30,000	2	9,360,000
Operator Assistant	13	15,000	2	4,680,000
Platform staff for guidance	48	20,000	2	23,040,000
Security Staff	26	20,000	2	12,480,000
Ticketing staff	26	20,000	2	12,480,000
Housekeeping staff	26	12000	2	7,488,000
			Total	**82,788,000**

Summary of Operations and Maintenance Expenditure

Cumulative Project Expenditure of Rs 2,297 Crores has been estimated over an operation period of 30 years.

It is evident from the above that the project is operationally viable as the Expenditure accounts for only 20% of the revenue to generated from the project. Source Wise Expenditure from the project is summarized in the Table 13-6, whereas the Operational Ratio is summarized in the Table 13-7.

Table 13-6: Estimated Operations and Maintenance Expenditure (Rs in Crores)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051

Cost of Electricity (1)	₹ 0.426	₹ 0.436	₹ 0.447	₹ 0.458	₹ 0.470	₹ 1.004	₹ 1.029	₹ 1.054	₹ 1.081	₹ 1.108	₹ 1.135	₹ 1.164	₹ 1.193	₹ 1.223	₹ 1.253	₹ 1.285	₹ 1.317	₹ 1.350	₹ 1.383	₹ 1.418	₹ 1.453	₹ 1.490	₹ 1.527	₹ 1.565	₹ 1.604	₹ 1.644	₹ 1.685	₹ 1.728	₹ 1.771	₹ 1.815	₹ 1.860
Cost of Manpower (2)	₹ 4.450	₹ 4.673	₹ 4.907	₹ 5.152	₹ 5.410	₹ 5.680	₹ 5.964	₹ 6.262	₹ 6.575	₹ 6.904	₹ 7.249	₹ 7.612	₹ 7.992	₹ 8.392	₹ 8.812	₹ 9.252	₹ 9.715	₹ 10.201	₹ 10.711	₹ 11.246	₹ 11.808	₹ 12.399	₹ 13.019	₹ 13.670	₹ 14.353	₹ 15.071	₹ 15.824	₹ 16.616	₹ 17.446	₹ 18.319	₹ 19.235
Cost of Maintenance (3)	₹ 35.714	₹ 36.964	₹ 38.258	₹ 39.597	₹ 40.983	₹ 42.417	₹ 43.902	₹ 45.438	₹ 47.029	₹ 48.675	₹ 50.378	₹ 52.142	₹ 53.967	₹ 55.855	₹ 57.810	₹ 59.834	₹ 61.928	₹ 64.095	₹ 66.339	₹ 68.661	₹ 71.064	₹ 73.551	₹ 76.125	₹ 78.790	₹ 81.547	₹ 84.401	₹ 87.355	₹ 90.413	₹ 93.577	₹ 96.852	₹ 100.242
Total Expenditure (4 = 1+2+3)	₹ 40.59	₹ 42.07	₹ 43.61	₹ 45.21	₹ 46.86	₹ 49.10	₹ 50.89	₹ 52.75	₹ 54.68	₹ 56.69	₹ 58.76	₹ 60.92	₹ 63.15	₹ 65.47	₹ 67.88	₹ 70.37	₹ 72.96	₹ 75.65	₹ 78.43	₹ 81.32	₹ 84.33	₹ 87.44	₹ 90.67	₹ 94.02	₹ 97.50	₹ 101.12	₹ 104.87	₹ 108.76	₹ 112.79	₹ 116.99	₹ 121.34

Table 13-7: Net Surplus/Deficit (Rs in Crores)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
Total Revenue (1)	₹ 64.73	₹ 71.06	₹ 78.03	₹ 85.69	₹ 94.13	₹ 116.79	₹ 126.88	₹ 137.87	₹ 149.83	₹ 162.86	₹ 177.06	₹ 192.51	₹ 209.33	₹ 227.68	₹ 247.67	₹ 269.45	₹ 293.36	₹ 318.74	₹ 346.40	₹ 376.54	₹ 409.40	₹ 445.24	₹ 484.32	₹ 526.96	₹ 573.46	₹ 624.18	₹ 679.52	₹ 739.89	₹ 805.79	₹ 877.70	₹ 956.19
Total Expenditure (2)	₹ 40.59	₹ 42.07	₹ 43.61	₹ 45.21	₹ 46.86	₹ 49.10	₹ 50.89	₹ 52.75	₹ 54.68	₹ 56.69	₹ 58.76	₹ 60.92	₹ 63.15	₹ 65.47	₹ 67.88	₹ 70.37	₹ 72.96	₹ 75.65	₹ 78.43	₹ 81.32	₹ 84.33	₹ 87.44	₹ 90.67	₹ 94.02	₹ 97.50	₹ 101.12	₹ 104.87	₹ 108.76	₹ 112.79	₹ 116.99	₹ 121.34
Operating Ratio (3 = 1-2)	₹ 24.14	₹ 28.99	₹ 34.41	₹ 40.49	₹ 47.27	₹ 67.69	₹ 75.99	₹ 85.12	₹ 95.15	₹ 106.17	₹ 118.30	₹ 131.59	₹ 146.18	₹ 162.21	₹ 179.79	₹ 199.08	₹ 220.40	₹ 243.09	₹ 267.96	₹ 295.22	₹ 325.08	₹ 357.80	₹ 393.65	₹ 432.93	₹ 475.96	₹ 523.07	₹ 574.65	₹ 631.13	₹ 692.99	₹ 760.72	₹ 834.85

13.7. Assessment of Financial Returns & Viability

The financial returns are calculated in terms of Internal Rate of Return (IRR) to assess the viability of the project. These returns are calculated for SPV/ULB's share considering the grant flow from the Govt. of India and Govt. of Sikkim.

13.7.1. Funding Pattern

The project shall be funded through 70% share as long term loan from financial institutions, 20% share as grant from the Government of India and 10% share as grant from the Government of Sikkim. The project funding pattern is specified in the Table below;

Table 13-8: Project Funding Pattern (Cost includes escalation of 5% per annum on the Base cost of Rs 1023 Crores estimated in September, 2018 during the construction of the Project)

S.No	Funding Agency Share	FY 2020 (in Cr.)	FY 2021 (in Cr.)	Total (in Cr.)
1	**Financial Institutions - Long Term Loan @70% (A)**	**370.25**	**436.49**	**806.73**
a	1st Installment @40%	148.10	174.60	322.69
b	2nd Installment @30%	111.08	130.95	242.02
c	3rd Installment @30%	111.08	130.95	242.02
2	**Government of India (GOI)-20% (B)**	**105.78**	**124.71**	**230.5**
a	**1st Installment @40%**	42.31	49.88	92.20
b	2nd Installment @30%	31.73	37.41	69.15
c	3rd Installment @30%	31.73	37.41	69.15
3	**Government of Sikkim (GoS) - 10% (C)**	**52.89**	**62.36**	**115.25**
a	**1st Installment @40%**	21.16	24.94	46.10
b	**2nd Installment @30%**	15.87	18.71	34.58
c	**3rd Installment @30%**	15.87	18.71	34.58
4	**Grand Total (A+B+C)**	528.92	623.56	1152.48

Table 13-9: Project Funding Pattern with Phasing Plan (Cost includes escalation of 5% per annum on the Base cost of Rs 1023 Crores estimated in September, 2018 during the construction of the Project)

Funding Agency Share	Phase 1		Phase 2		Total
	2019	2020	2023	2024	
Financial Institutions - Long Term Loan @70%	₹ 170.6	₹ 178.7	₹ 244.4	₹ 254.1	₹ 848.0
GoI - 20%	₹ 48.76	₹ 51.08	₹ 69.83	₹ 72.63	₹ 242.3

GoS - 10%	₹ 24.38	₹ 25.54	₹ 34.92	₹ 36.31	₹ 121.1
Total	₹ 243.8	₹ 255.4	₹ 349.1	₹ 363.1	₹ 1,211.5

13.7.2. Cash Flow & Financial Returns

Based on assumptions and inputs discussed above, the projection of cash flow for the project has been estimated. The projected cash flow provides an IRR of 9.67% with the assistance of innovative financing from real estate development at stations and grants, but without supplementing income from the Urban Transport Fund (UTF).

This is to be noted that in case of constraints in achieving the potential ridership or eventualities where fare could not be revised as envisaged, creation of UTF shall be required to achieve desired project IRR as per MOUD directives and/or make Cable Car system operationally sustainable/viable.

Table 13-10: Project IRR and NPV (Rs in Crores)

FIRR	**9.67%**
NPV @12% Discount Rate	**-₹ 354.24**

13.8. Assessment of Economic Returns & Viability

The purpose of this section is to explore the economic feasibility of the current project. In order to do that the report focus on the following;

- The quantifiable economic benefits from the project
- The economic viability of the project
- The balance economic benefits and costs of these expressed in present value terms or in terms of economic IRR

13.8.1. Methodology

The objective of Economic evaluation is to enable authorities to determine whether the project is economically viable and whether it should be taken up for implementation. Economic evaluation is based on an analysis of economic cost and benefits over a fixed analysis period.

The economic appraisal of the project has been carried out within the broad framework of Social Cost-Benefit Analysis Technique. In the analysis, the cost and benefit streams arising under the 'with' and 'without' project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate values. The annual streams of project costs and benefit have been compared over the analysis period of 12 years to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of Economic Internal Rate of Return (EIRR).

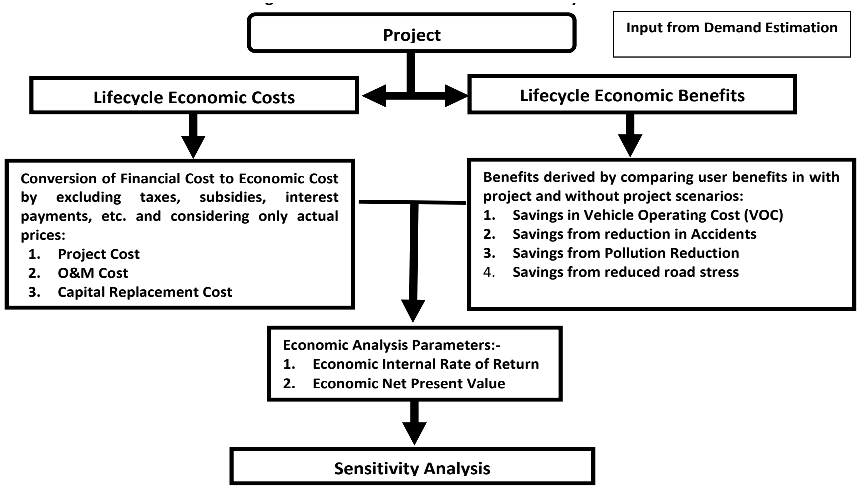


Figure 13-1: Framework for Economic Analysis

13.8.2. Benefits

The project is being implemented primarily for providing agencies:

- Quantifiable economic benefits such as savings in vehicle operating cost
- Reduction in Accidents which is direct resultant of reduction in number of vehicles on road
- Provision of NMT infrastructure along the Metro Corridors thereby reducing carbon emissions as well as other pollutants which have adverse effects on health of the citizens and commuters
- Savings due to reduced road stress such as reduced need for road maintenance.
- Provide better accessibility to mass transit system to reduce overall travel time and motivate users to use more efficient public transport
- Reduction in fuel consumption resulting from the modal shift
- The estimation of economic benefits of the above are explained in the following sections

Savings in Vehicle Operating Cost

Savings in Vehicle Operating Cost arise owing to following;

- Absence of vehicles of passengers that have shifted to Cable Car
- Smoother operations of passenger trips of other mode vehicles owing to congestion reduction.

The first step is to calculate the value of vehicle operating cost per km for different vehicle types. The VOC for future years is calculated by multiplying it with the annual CPI or WPI, which is taken as flat 5% annually. The VOC is based on the following parameters as per the manual:

- Cost of Fuel Consumption
- Spare parts Costs
- Maintenance labour
- Tyre Life
- Engine oil/other oil/Grease
- Speed considerations
- Utilization
- Fixed cost
- Depreciation of vehicle costs

The VOC savings are calculated by multiplying the unit VOC cost with the number of vehicle trips and with the average lead distance for the particular vehicle category.

VOC savings = VOC [Rs. /km] x Average Lead [km] x No. of vehicle trips

The year wise savings vehicle operating cost is given in Table Table 13-11

B. Savings in Accident Reduction

The reduction in traffic volumes on roads due to modal shift to metro rail project is expected to reduce the accidents on the project corridor owing to following:

- Lower number of vehicles on roads due to reduction of vehicles of modal shift passengers.
- Lower accidents from vehicles due to decongested roads / other modes.

The steps involved in estimating the accidents benefits are specified below

- Step 1: Projection of accidents in with and without project scenario
- Step 2: Estimation of unit cost of accidents – The unit cost of accidents is taken from Toolkit on Finance and Financial Analysis, 2013 by MoHUA

The year wise Savings from Accident Reduction is given in the Table 13.10

C. Savings from Pollution Reduction

The project significantly contributes to pollution reduction and is thus a pre-requisite for sustainable development. The project lead to modal shift and hence fewer vehicles on road. This leads to reduction in the use of fuel. Thus, absence of Green House Gas emission (GHG) from the vehicles of modal shift passengers' and lower emission due to decongested roads contributes in reduction in GHG emissions in the region.

The major environmental savings come from the reduction in air pollution. Due to the modal shift, the air pollutants released are significantly reduced.

Saving from pollution reduction is calculated as follows:

Annual Treatment Cost = [Volume of pollutant] x [Treatment cost/ton]

D. Savings from Reduced Road Stress

This benefit arises due to a reduced need for road maintenance owing to reduced traffic on account of modal shift.

13.8.3. Economic Analysis of Project Scenario

The steps in economic analysis of scenario 1 are as described below

Step 1: Defining Project Horizon

Project horizon comprises of the construction and operation period of the project. During the project horizon, the cost and benefits associated with project should be estimated. The horizon period for the purpose of economic analysis should be taken as 32 years which is shown in table below:

Table 13-11: Project Horizon Year

			Phase 1		Phase 2	
Period			**From**	**To**	**From**	**To**
Construction Period	Years	2	2019-20	2020-21	2023-24	2024-25
Operation Period	Years	30	2021-22	2049-51	2025-26	2049-51
Project Horizon Period	Years	32	2019-20	2049-51	2023-24	2049-51

Table 13-12: Savings in Economic Benefits

Year	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34
Saving in Vehicle Operating Cost			₹ 59.76	₹ 64.53	₹ 69.94	₹ 75.73	₹ 81.93	₹ 88.55	₹ 95.64	₹ 103.21	₹ 111.29	₹ 146.66	₹ 158.04	₹ 169.79	₹ 182.31
Saving from Accident Reduction			₹ 10.42	₹ 11.38	₹ 12.42	₹ 13.57	₹ 14.81	₹ 16.18	₹ 17.67	₹ 19.29	₹ 21.07	₹ 16.16	₹ 17.65	₹ 19.27	₹ 21.05

Year	2034-35	2035-36	2036-37	2037-38	2038-39	2039-40	2040-41	2041-42	2042-43	2043-44	2044-45	2045-46	2046-47	2047-48	2048-49	2049-50	2050-51
Saving in Vehicle Operating Cost	₹ 195.67	₹ 209.90	₹ 225.07	₹ 241.23	₹ 258.45	₹ 276.78	₹ 392.76	₹ 421.48	₹ 453.96	₹ 488.64	₹ 526.07	₹ 566.01	₹ 608.63	₹ 654.10	₹ 702.60	₹ 754.83	₹ 1,365.63
Saving from Accident Reduction	₹ 22.98	₹ 25.10	₹ 27.41	₹ 29.93	₹ 32.68	₹ 35.69	₹ 42.74	₹ 46.67	₹ 50.96	₹ 55.65	₹ 60.77	₹ 66.36	₹ 72.47	₹ 79.13	₹ 86.41	₹ 94.37	₹ 143.79

Saving from Pollution Reduction			₹ 45.02	₹ 46.43	₹ 47.96	₹ 49.49	₹ 51.02	₹ 52.54	₹ 54.07	₹ 55.60	₹ 57.13	₹ 71.55	₹ 73.41	₹ 75.05	₹ 76.69	₹ 78.32	₹ 79.96	₹ 81.60	₹ 83.24	₹ 84.87	₹ 86.51	₹ 117.51	₹ 120.01	₹ 123.12	₹ 126.24	₹ 129.40	₹ 132.57	₹ 135.73	₹ 138.90	₹ 142.07	₹ 145.29	₹ 0.00
Saving due to Reduced Road Stress			₹ 9.49	₹ 9.73	₹ 10.02	₹ 10.31	₹ 10.61	₹ 10.90	₹ 11.19	₹ 11.48	₹ 11.77	₹ 15.03	₹ 15.42	₹ 15.81	₹ 16.20	₹ 16.59	₹ 16.98	₹ 17.37	₹ 17.76	₹ 18.15	₹ 18.54	₹ 24.44	₹ 25.01	₹ 25.64	₹ 26.27	₹ 26.95	₹ 27.63	₹ 28.31	₹ 29.00	₹ 29.68	₹ 30.41	₹ 0.00
Total Benefits	₹ 0.00	₹ 0.00	₹ 124.68	₹ 132.07	₹ 140.35	₹ 149.10	₹ 158.36	₹ 168.17	₹ 178.56	₹ 189.58	₹ 201.26	₹ 249.41	₹ 264.52	₹ 279.92	₹ 296.25	₹ 313.56	₹ 331.94	₹ 351.44	₹ 372.15	₹ 394.15	₹ 417.51	₹ 577.45	₹ 613.17	₹ 653.69	₹ 696.80	₹ 743.19	₹ 792.57	₹ 845.15	₹ 901.13	₹ 960.76	₹ 1,024.89	₹ 1,509.43

Step 2: Determining Economic Cost of the Project

Develop lifecycle cost during the analysis period converting the Financial Cost of the following to Economic Cost:

1. Capital Cost
2. Maintenance Cost
3. Capital Replacement Cost

Only real prices are considered in determining the economic costs. Thus, any price escalations are removed using the conversion factors.

Cost components considered for the purpose of estimation of economic cost of the project include:

Lifecycle Economic Cost:

The project horizon is 20 years including construction period of 02 years starting from year 2019-20 and the operation and maintenance period of 30 years starting from year 2021-2022 till 2050-51. It includes conversion of financial cost to economic cost by excluding taxes, subsidies, interest payments, etc. and considering only actual prices. The year wise lifecycle economic cost is given in the Table 13-13.

Project Cost: It includes Capital Cost of Infrastructure Table 13-14 represents the Economic Cost of the Project.

Phasing of Project Cost: The total construction period for the Project is 2 years for Phase 1 and 2 Years for Phase 2.

Operating & Maintenance Cost of Infrastructure: The O & M Costs is 4% per annum of the Total Project Cost.

Capital Replacement Cost: Capital Replacement Cost @20% of the Total Project Cost for infrastructure comprising is added every 6th year of operation period.

Step 3: Determining the EIRR for 30 Years

Considering the economic lifecycle cost and economic benefit. The economic internal rate of return (EIRR) for the Project comes out to be 21.7% for the duration of 32 years of project period which is above the established cut-off criterion of 14% as per Appraisal Guidelines for Metro Rail Project Proposals by MoHUA, GoI. This implies that the economic benefits accruing out of this project are substantial and will yield high savings to the economy as a whole.

Table 13-13: Life Cycle Economic Cost (Rs in Crores)

Year	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37	2037-38	2038-39	2039-40	2040-41	2041-42	2042-43	2043-44	2044-45	2045-46	2046-47	2047-48	2048-49	2049-50	2050-51
Economic Capex	₹	₹	₹ 0.00	₹ 0.00	₹	₹	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹

	182.57	182.57			242.00	242.00																										0.00
Economic Maintenance Cost	₹ 0.00	₹ 0.00	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15
Economic Capital Replacement Cost	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 169.83	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 169.83	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 169.83	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 169.83	₹ 0.00
Life Cycle Cost	₹ 182.57	₹ 182.57	₹ 31.15	₹ 31.15	₹ 273.16	₹ 273.16	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15

Table 13-14: Economic Cost of the Project (Rs in Crores)

Particulars	Amount
Project Cost Excluding Price Contingencies, Import duties & taxes, IDC, etc	₹ 1023
Conversion Factor	0.83
Economic Cost of Project	₹ 849

Table 13-15: Economic O & M Cost Rs in Crores)

Particulars	Amount (Rs in Crores)
Total Maintenance Cost	₹ 35.8
Conversion Factor	0.87
Economic Maintenance Cost	₹ 31.2

Table 13-16: Economic Capital Replacement Cost

Particulars	Amount (Rs in Crores)
Project Cost Excluding Price Contingencies, Import duties & taxes, IDC, etc	₹ 204.6
Conversion Factor	0.83
Economic Cost of Project	₹ 169.8

Table 13-17: Outcomes of Economic Analysis

Economic Internal Rate of Return	Economic Net Present Value (ENPV) @ 14% Discount rate (Rs in Crores)	Benefits to cost ratio
21.7%	446	1.57

Table 13-18: Economic Internal Rate of Return Analysis

Particular	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37	2037-38	2038-39	2039-40	2040-41	2041-42	2042-43	2043-44	2044-45	2045-46	2046-47	2047-48	2048-49	2049-50	2050-51
Life Cycle Cost																																
Economic Capex	₹ 182.57	₹ 182.57	₹ 0.00	₹ 0.00	₹ 242.00	₹ 242.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00
Economic Maintenance Cost	₹ 0.00	₹ 0.00	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15
Economic Capital	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 169.83	₹ 0.00

Replacement Cost										169.83							169.83							169.83								
Life Cycle Cost	₹ 182.57	₹ 182.57	₹ 31.15	₹ 31.15	₹ 273.16	₹ 273.16	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 31.15	₹ 200.98	₹ 31.15
Project Benefits																																
Saving in Vehicle Operating Cost			₹ 59.76	₹ 64.53	₹ 69.94	₹ 75.73	₹ 81.93	₹ 88.55	₹ 95.64	₹ 103.21	₹ 111.29	₹ 146.66	₹ 158.04	₹ 169.79	₹ 182.31	₹ 195.67	₹ 209.90	₹ 225.07	₹ 241.23	₹ 258.45	₹ 276.78	₹ 392.76	₹ 421.48	₹ 453.96	₹ 488.64	₹ 526.07	₹ 566.01	₹ 608.63	₹ 654.10	₹ 702.60	₹ 754.83	₹ 1,365.63
Saving from Accident Reduction			₹ 10.42	₹ 11.38	₹ 12.42	₹ 13.57	₹ 14.81	₹ 16.18	₹ 17.67	₹ 19.29	₹ 21.07	₹ 16.16	₹ 17.65	₹ 19.27	₹ 21.05	₹ 22.98	₹ 25.10	₹ 27.41	₹ 29.93	₹ 32.68	₹ 35.69	₹ 42.74	₹ 46.67	₹ 50.96	₹ 55.65	₹ 60.77	₹ 66.36	₹ 72.47	₹ 79.13	₹ 86.41	₹ 94.37	₹ 143.79
Saving from Pollution Reduction			₹ 45.02	₹ 46.43	₹ 47.96	₹ 49.49	₹ 51.02	₹ 52.54	₹ 54.07	₹ 55.60	₹ 57.13	₹ 71.55	₹ 73.41	₹ 75.05	₹ 76.69	₹ 78.32	₹ 79.96	₹ 81.60	₹ 83.24	₹ 84.87	₹ 86.51	₹ 117.51	₹ 120.01	₹ 123.12	₹ 126.24	₹ 129.40	₹ 132.57	₹ 135.73	₹ 138.90	₹ 142.07	₹ 145.29	₹ 0.00
Saving due to Reduced Road Stress			₹ 9.49	₹ 9.73	₹ 10.02	₹ 10.31	₹ 10.61	₹ 10.90	₹ 11.19	₹ 11.48	₹ 11.77	₹ 15.03	₹ 15.42	₹ 15.81	₹ 16.20	₹ 16.59	₹ 16.98	₹ 17.37	₹ 17.76	₹ 18.15	₹ 18.54	₹ 24.44	₹ 25.01	₹ 25.64	₹ 26.27	₹ 26.95	₹ 27.63	₹ 28.31	₹ 29.00	₹ 29.68	₹ 30.41	₹ 0.00
Total Benefits	₹ 0.00	₹ 0.00	₹ 124.68	₹ 132.07	₹ 140.35	₹ 149.10	₹ 158.36	₹ 168.17	₹ 178.56	₹ 189.58	₹ 201.26	₹ 249.41	₹ 264.52	₹ 279.92	₹ 296.25	₹ 313.56	₹ 331.94	₹ 351.44	₹ 372.15	₹ 394.15	₹ 417.51	₹ 577.45	₹ 613.17	₹ 653.69	₹ 696.80	₹ 743.19	₹ 792.57	₹ 845.15	₹ 901.13	₹ 960.76	₹ 1,024.89	₹ 1,509.43
Net Benefit	-₹ 182.57	-₹ 182.57	₹ 93.53	₹ 100.92	-₹ 132.81	-₹ 124.06	₹ 127.21	₹ 137.02	₹ 147.41	-₹ 11.40	₹ 170.11	₹ 218.26	₹ 233.37	₹ 248.77	₹ 265.09	₹ 282.41	₹ 130.96	₹ 320.29	₹ 341.00	₹ 362.99	₹ 386.36	₹ 546.29	₹ 582.01	₹ 452.71	₹ 665.65	₹ 712.04	₹ 761.42	₹ 814.00	₹ 869.98	₹ 929.60	₹ 823.91	₹ 1,478.27

13.9. Financing Options

As per the Recommendations of Working Group on Urban Transport for 12th Five Year Plan, the financing of urban transport projects in the country has largely been confined to gross budgetary support from the government and the user charges. Due to heavy investment needs of urban transport and conflicting demands on the general exchequer, the investment in urban transport in past has not kept pace with the rapidly increasing requirement of the sector.

The current level of user charges of limited urban transport facilities, do not make the system self-sustainable. At the same time, providing safe, comfortable, speedy and affordable public urban transport to all has to be a necessary goal of the governance.

The key funding sources besides GBS and fare box can be dedicated levies, land monetization, recovery from non-user beneficiaries, debt and private investments. The paradigm of financing has to clearly move towards non-users pay principle and the polluters pay principle. There is a need for long-term sustainable dedicating financing mechanism to address fast worsening scenario in the field of urban transport. All the various components in which the investment would be required in the 12th Five Year Plan would need to be funded through a combination of funding from Govt. of India, State Govt./urban local body, development agencies, property development, loan from domestic and financial institutions as well as PPP. Thus, it is imperative to identify projects that are amenable to Government funding or PPP.

13.9.1. Public Private Partnership

Public-Private Partnerships is cooperation between a public authority and private companies, created to carry out a specific project. They can take on a number of forms, and can be a useful method of capturing property value gains generated by transport infrastructure In a PPP for a new transport infrastructure development project, the public authority creates a secure environment for the private sector to carry out the project, and the private partner offers its industry know-how, provides funding and shares in the project's risk.

The objectives of the public and private sector partners appear to be quite different. The public sector aims to best serve the interests of taxpayers. The aim is not to use public money to obtain a return on capital investments. The private sector, on the other hand, aims to ensure a return on investment for its shareholders and to be as profitable as possible and yet these two contrasting goals can function perfectly well together in the framework of a PPP. The types of project to be developed are given below:

•The project context may influence the type of PPP to be implemented. The public partner must evaluate the total cost of the project, its importance in terms of public need, the time frame, the number of actors involved and the geographic area in question. Does providing this public service require a major infrastructure? Will it require high levels of human and financial resources to provide this service? Before a decision can be made, it is necessary to fully understand the context of the proposed project.

• The cost of the project is of course a critical factor, which will weigh on the choice. Many PPP concern projects for underground systems, LRT and BRT requiring significant levels of financing which the local authorities would have difficulty assuming alone.

• A well-structured institutional framework and the local authority's experience in developing transport projects are also decisive factors. Urban transport is an industrial and commercial activity, which involves financial risk. Bringing in experienced partners is one way of compensating for a lack of certain skills in this field, though a good PPP should call upon other forms of expertise on the part of the public authority. This can sometimes facilitate obtaining a loan, in particular from international funding agencies

• The tasks entrusted to the private sector (design, construction, development, operation, maintenance) will influence the type of contract.

• The sharing of responsibilities and risks will determine the degree of involvement of each partner and the type and clauses of the contract. There are many types of contracts but it is primarily the sharing of financial risk, which will determine the key characteristics. There are two categories of risk: commercial risk, related to trends in revenue, and industrial risk, related to the cost of construction and trends in operating and maintenance expenses. if both types of risk are covered by the public partner, then it would be a management contract in which the private partner is merely performing the work. The private partner must meet the specifications but will not be motivated to improve the service nor propose innovative techniques or management;

13.9.2. Government sources of funding

One of the particularities of the urban transport sector is that it depends on funding from several sources and involves various partners, public and private, individual and collective

a) Viability Gap Funding

In a recent initiative, the Government of India has established a special financing facility called "Viability Gap Funding" under the Department of Economic Affairs, Ministry of Finance, to provide support to PPP infrastructure projects that have at least 40% private equity committed to each such project. Viability Gap Funding can take various forms such as capital grants, subordinated loans, O&M support grants and interest subsidies. However, the Ministry of Finance guidelines require that the total government support to such a project, including Viability Gap Funding and the financial support of other Ministries and agencies of the Government of India, must not exceed 20% of the total project cost as estimated in the preliminary project appraisal, or the actual project cost, whichever is lower. Projects in the following sectors implemented by the Private Sector are eligible for funding:

- Roads and bridges, railways, seaports, airports, inland waterways
- Power
- •Urban transport, water supply, sewerage, solid waste management and other physical infrastructure in urban areas
- •Infrastructure projects in Special Economic Zones
- •International convention centers and other tourism infrastructure projects

b) Smart Cities Funding

The Smart City Mission will be operated as a Centrally Sponsored Scheme (CSS) and the Central Government proposes to give financial support to the Mission to the extent of Rs. 48,000 crores over five years i.e. on an average Rs. 100 crore per city per year. An equal amount, on a matching basis, will have to be contributed by the State/ULB; therefore, nearly Rupees one lakh crore of Government/ULB funds will be available for Smart Cities development.

The GOI funds and the matching contribution by the States/ULB will meet only a part of the project cost. Balance funds are expected to be mobilized from:

i. States/ ULBs own resources from collection of user fees, beneficiary charges and impact fees, land monetization, debt, loans, etc.

ii. Additional resources transferred due to acceptance of the recommendations of the Fourteenth Finance Commission (FFC).

iii. Innovative finance mechanisms such as municipal bonds with credit rating of ULBs, Pooled Finance Mechanism, Tax Increment Financing (TIF).

iv. Other Central Government schemes like Swachh Bharat Mission, AMRUT, National Heritage City Development and Augmentation Yojana (HRIDAY).

v. Leverage borrowings from financial institutions, including bilateral and multilateral institutions, both domestic and external sources.

vi. States/UTs may also access the National Investment and Infrastructure Fund (NIIF), which was announced by the Finance Minister in his 2015 Budget Speech, and is likely to be set up this year.

vii. Private sector through PPPs

The distribution of funds under the Scheme will be as follows:

I. 93% project funds.

II. 5% Administrative and Office Expenses (A&OE) funds for state/ULB (towards preparation of SCPs and for PMCs, Pilot studies connected to area-based developments and deployment and generation of Smart Solutions, capacity building as approved in the Challenge and online services).

III. 2% A&OE funds for MoUD (Mission Directorate and connected activities/structures, Research, Pilot studies, Capacity Building, and concurrent evaluation).

13.9.3. Dedicated Urban Transport fund at City level

For the projects, which are not admissible under Smart Cities Mission, or viability gap funding, the alternative sources of funding that a city could avail by setting up a dedicated urban transport fund at city level are given below:

A dedicated urban transport fund would need to be created at the city level through other sources, especially land monetization, betterment levy, land value tax, enhanced property tax or grant of development rights, advertisement, employment tax, congestion, a cess on the sales tax, parking charges reflecting a true value of the land, traffic challans etc.

Case Studies: Pimpri-Chinchwad Municipal Corporation has already set up a dedicated urban transport fund through land monetization and advertisement rights. Similarly, Karnataka has set up a dedicated urban transport fund through MRTS cess on petrol and diesel sold in Bangalore, which is being used to fund the rail based projects. The various sources of funding that can be used to set up the urban transport fund is given below:

(a) Anticipated purchase of land

This method involves public authorities buying land before announcing that an infrastructure will be built or where the route will run. In this way, the purchase can be made at market price without the infrastructure. The strategy then consists in:

• Directly selling the land to private developers including the estimated added value in the sale price, such as was done in Aguas Claras on the periphery of Brasilia, or in Copenhagen;

• Developing the area as part of an urban renewal project and then selling it at market price, as was done in Copenhagen or in Japan, where rail companies were the first to use this method to finance their operation

• A city can also levy additional stamp duty (5%) on registration of property.

(b) Betterment Tax

A betterment tax is not the same as a property tax, because the increase in value of property is not due to the action of the owner (such as would be the case with renovations and improvements) but from a community action, thus justifying the public authorities to impose such a tax. However, it is not easy to implement, which no doubt explains why this financing mechanism is still underused.

This tax must be levied on all areas that benefit from the new transport infrastructure. The land is valued each year based on an optimal use of each site, without taking into account the existing facilities. A tax based on the value of the land is then levied in order to generate funds for the public sector. Thus, if the value of the land increases, the tax collected also increases. This means that a vacant plot of land in the city centre which has been earmarked for building a residential and commercial complex will pay the same tax as an identical site which has already been developed in a similar manner. Likewise, taxes are not increased if the site is built upon. Landowners will therefore to seek to capitalise on the use of their land.

(c) Land Value Tax

Once an area is well connected by public transport and is accessible to the commercial area and also the liveability of the area increases it is possible that the price of the land will increase. Such increase in price can be source revenue for the municipality. Similar to parking, the obtained revenue needs to be utilized for improvement of the area and other areas in the vicinity. A substantial amount of revenue could be generated through cess on turnover, particularly in cities, based on industry, trade and commerce activities. Such cess has already been levied for Bangalore MRTS project. Bangalore has also levied luxury tax and professional tax towards the rail based transit fund.

(d) Advertising

This is another important source of revenue for the city. When properly utilised this source can be of immense value in supporting sustainable urban transport measures in a city. The revenues from advertising in the city can be used to improve the existing transport system and/or create new schemes in sustainable transport.

Paris, France has used the advertising money in developing a public bike scheme, which is now a well renowned model. Similarly, Transport for London (TFL) has made a deal with the advertising specialist, Clear Channel, for the regular maintenance and design of the street furniture in return for the advertising space on bus shelters. One important aspect that needs to be considered is that the advertising money needs to be utilized for improving the transport system rather than spending it on building more roads. In the similar way, the advertising should not be overdone to avoid visual pollution.

13.9.4. External Funding Agencies

A majority of the urban transport projects such as the development of a complete public bus systems, BRT, urban rail projects, etc. are capital intensive and require ongoing funding for operations, routine maintenance and asset management. Generally, funding for such projects is arranged through commercial borrowings and loan from international lending agencies such as the World Bank, Asian Development Bank, Department for International Development, and Japan International Cooperation Agency etc.

A fund with an assured revenue stream dedicated to the development of the urban transport system would facilitate the process of raising funds from the market and international funding institutions. The stream of revenue could be potentially utilized for debt servicing. For the same reason, the UTF could also raise funds from the open market by floating bonds.

Chapter 14 INSTITUTIONAL OPTIONS

City transport system generally involves several organizations that look after various forms and aspects of the transport system and network and have overlapping functions and areas of work. Therefore, to delineate areas and to remove ambiguity of functions the institutional framework has been proposed.

With the formation of a City wide UMTA, part of the problem can been sorted. However, this would have a macroscopic view of resolving policy issues for all urban centres within the city. There still remains a need to set up a localized organization that results in coordinated strategic level planning at the city level and deal with more day to day issues of urban transport.

Following is the list of departments and Organizations involved in Gangtok:

- Gangtok Municipal Corporation (GVMC)
- Urban Development and Housing Department
- Regional Transport Office (RTO)
- Pollution Control Board (PCB)
- Traffic Police
- District Supplies Office (DSO)
- Sikkim Nationalized Transport (SNT)
- Tourism Department
- Forest department

14.1. Unified Metropolitan Transport Authority

Need for Unified Metropolitan Transport Authority

In order to facilitate integration of Cable car holistically and pragmatically, an "institution" need be created to coordinate the existing multiplicity of organizations dealing various complex issues of urban transport. The proposed institutional set up should be financially sustainable and be able to perform the following tasks:

Integrated management of cable car transit system with land use/TOD management

More coordinated planning amongst the various players of urban transport (PT and IPT)

To ensure a comprehensive urban public transport system

Implementation of urban transport programs and projects

Regulatory decisions on unified platform such as fare fixation, etc.

Proposed Structure of UMTA

The National Urban Transport Policy for 2006 and GoI recommends setting up of UMTA in all million plus cities. The extract of which is reproduced here in below:

"The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. Those structures were put in place, well before the problems of urban transport began to surface in India and hence do not provide for the right co-ordination mechanisms to deal with urban transport.

The Central Government will therefore recommend the setting up of Unified Metropolitan Transport Authorities (UMTA's) in all million plus cities, to facilitate more co-ordinated planning and implementation of urban transport programs and projects and an integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful.

The Central Government would also encourage the setting up of professional bodies that have the capacity to make scientific assessment of the demand on various routes and contract services that can be properly monitored. Towards this end, it would encourage the setting up of umbrella bodies that regulate the overall performance of the Public Transport System and ensure that the city has a Comprehensive Public Transport System".

The overall aim of the UMTA will be to promote public transport in the urban areas through formulation of policies, programmes, rules and regulations related to urban transit. Its function is to facilitate/ co-ordinate planning and implementation of urban transport programs and projects in an integrated management framework. To be effective, such Metropolitan Transport Authorities would need statutory backing.

The National Urban Transport Policy clearly identifies Land use and Transport as two intricately linked elements of urban system and have bearing on each other. Hence the distinctive role of UMTA regarding formation of progressive land use and transportation policy for Metropolitan area becomes critical.

Transport planning is intrinsically linked to land use planning and both need to be developed together in a manner that serves the entire population and yet minimizes travel needs.

- An integrated master plan needs to internalize the features of sustainable transport systems.
- In developing such plans, attention should also be paid to channel the future growth of a city around a preplanned transport network rather than develop a transport system after uncontrolled sprawl has taken place. Transport plans should, therefore, enable a city to take an urban form that best suits the geographical constraints of its location and also one that best supports the key social and economic activities of its residents.
- Transport planning should receive the extent of attention it should have in drawing up strategic development and land use plans.

Operationalization of this is envisaged as below:

- UMTA, will make overall policies for integrating land use and transport.
- Agencies like Development Authority etc, will remain the sole agency responsible for preparation of Master Plans etc. Development Authority will take policies prepared by UMTA as guiding principles and preparing Master Plans.
- The representation of various agencies involved in the preparation of land use and transportation plan in UMTA is required, as per the National Urban Transport Policy (NUTP-2006).

In the light of above guidelines/ recommendations the following structure is proposed

1. Secretary UD & HD – Chairman
2. Municipal Commissioner – Member
3. Superintendent of Police – Member
4. District Collector – Member
5. Chief City Planner – Member
6. State Pollution Control Board – Member
7. Regional Transport Officer – Member
8. Urban Transport Experts
9. Legal Experts

The Technical Secretariat shall have the following structure:

1. Executive Director
2. Urban Transport Specialist
3. Financial Specialist
4. Transport Engineer

The UMTA shall have the following functions:

- Formulation of progressive land use and transportation policy for Gangtok Municipal corporation area
- Put down rules & regulations for the orderly conduct of urban transport and Service standards
- Formulation/revision in tariff policy time to time
- Routes structuring for various feeder modes to maximize the accessibility of the Metro Cable.

As already stated, the main functioning of UMTA will be to formulate policies related to the land use and transportation issues for Gangtok City including the Metro Cable. The authority would mainly focus on regulatory issues. In order to assist UMTA in decision making and give effect to the policies formed by UMTA, an executive council is also proposed. The members of the executive council shall be drawn for UMTA and the council will act as an advisory body to UMTA. The Executive council will meet on regular basis (at least once in three months) and will put forth the proposals and suggestions regarding various issues in front of UMTA for final approval.

The functions of the Executive Council shall be as under:

- Provide assistance to UMTA in decision making on the various issues and give effect to all decisions of UMTA
- Notify the routes of public transport
- Recommend a rationalized tariff policy to UMTA
- Scientific assessment of demands and services contract for different operators
- Monitoring the service standards and operations of public transport modes
- Dispute resolution amongst various operators

14.2. Special Purpose Vehicle

For operations and maintenance, there is need of Special Purpose Vehicle for Gangtok cable car system.

1. For efficient delivery of acceptable quality urban transport services at affordable price on long term basis to the satisfaction of all stake holders simultaneously maintaining financial sustainability and growth of the system, in a focused manner the Metro Cable should be administered by a professional body (An institutional setup or authority).

2. It is however a contentious issue as to which or what type of government agency should be responsible for administering Gangtok Cable Car.

3. The options range from a focused specialized Metro Cable authority to a large transport department or the proposed UMTA that oversees all forms of public/private transport besides policy formulation, etc. In the latter case, control of Metro Cable would be directly by the State Government, the municipal corporation or a new organisation involving the related agencies of the Government, are some of the possibilities.

4. State Government or Local Government may not be able to manage the Metro Cable System with a focused attention – necessary for successful delivery of quality services. Moreover, the local Government and the State Government are engaged in a host of governing and regulating, policy

framing and other complex functions. The new organization should be a lean organization for planning; sub-contracting and quality assurance of services; financial management,

5. Operation of urban transport systems is a multi-disciplinary multi-control function involving extensive coordination amongst various bodies for satisfactory service delivery.

While the government should be responsible for effective planning, regulation, and control, actual operation and management of the services should be left to the private sector.

Such a combination optimally overcomes the problem of deteriorating operational efficiency/increasing costs at the Governmental agency and the exploitative commercial nature of the private sector.

6. The Gangtok cable car SPV is proposed to perform functions mainly in the nature of administration, planning, setting standards, contracting, regulation, monitoring, coordinating and controlling the operations with the involvement of various stakeholders including government bodies as well as private stakeholders.

Institutional Set Up of Special Purpose Vehicle for Gangtok Cable Car System

As discussed in the above paragraph, the SPV shall be a Public Sector Company. The administrative set up will be as follows:

The administrative set up of the Metro Cable envisages its institutionalization as a Special Purpose Vehicle (SPV) under the Companies Act 1956 incorporated as a public limited company comprising of the Board of Director at the administrative level, the Chief Executive and other managers at the management level for its day to day management, including monitoring and control of private service providers provisioning and operation of the services. The equity of the company may be shared amongst the Development Authority, Municipal Corporation and the State Government. On obtaining favorable financial results for 3 or 4 years of operation the equity may be offered to private sector and or to the public through initial public offer (IPO).

The Board of Directors (BOD) of the SPV may consist mainly of the representatives of the government agencies and chaired by a politician or a bureaucrat having highest personal and institutional stakes in efficient operation of the Cable car The BOD may meet monthly or quarterly for policy level decisions and performance review.

SPV is proposed to perform the following main functions:

1. Planning, regulation and operational control – services planning and scheduling, setting service quality, standard, monitoring and control of services, integrating feeder services and other transit services with cable car service.

2. Data acquisition and processing – contracting of services for acquisition, communication, warehousing and processing of data for planning besides monitoring and control of services.

3. Contracting of station management and revenue collection services where-ever planned necessary equipment shall be owned and maintained by the private sector.

4. Human resource management, legal and company affairs, administration, grievance handling, etc.

5. Financial services – preferably through a separate agency.

6. Any other function necessary for the cable car System such as marketing. Creating public awareness and support, selection of technologies, advising UMTA on tariff fixing/revising etc.

7. The above mentioned set up of the SPV and the functions proposed to be managed by the SPV is expected to provide an optimal mix of Public Private Participation for operation and management of the Cable car.

It is also proposed that as the construction phases progressing, a strategic partner from the private sector could be inducted in to the SPV to take over the long term operation and maintenance of the cable car. While the State Government could appoint the chairman, the strategic partner could come up with the managing director and professional managerial team into the SPV.

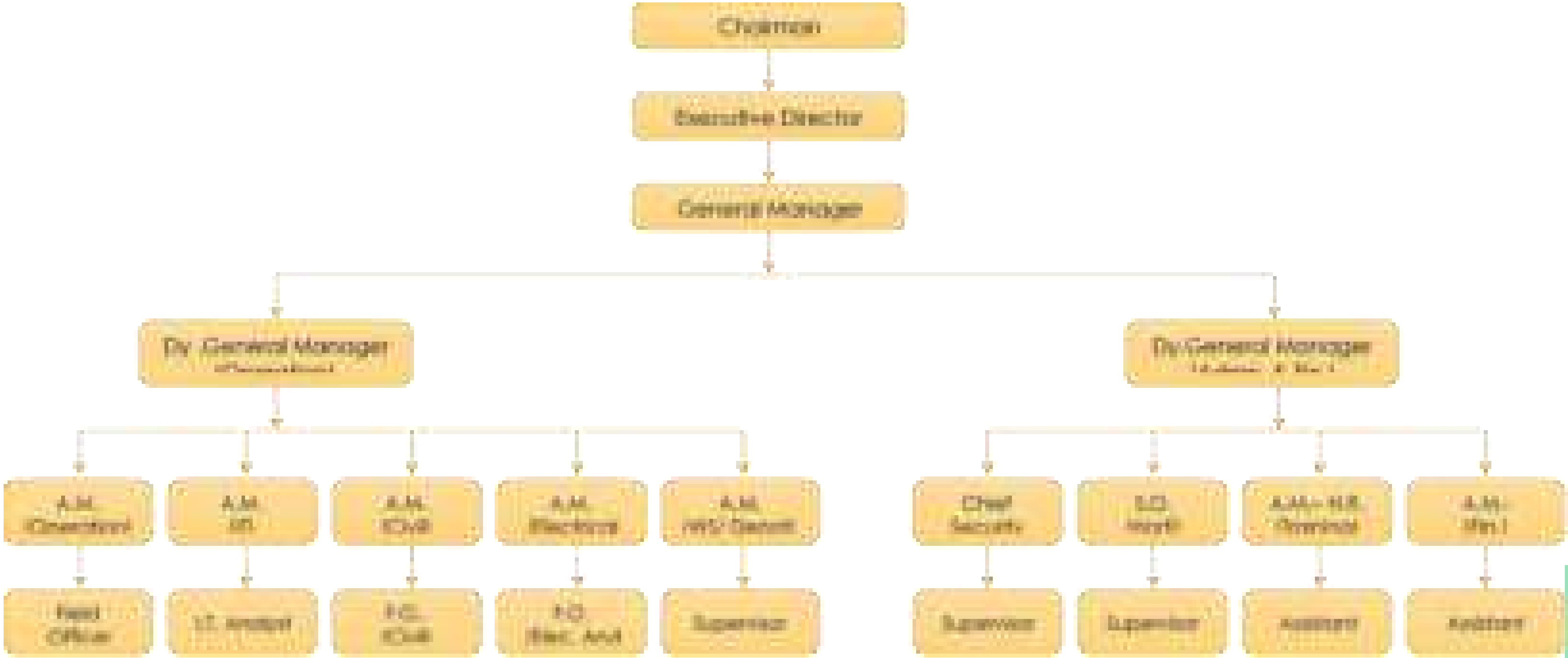


Figure 14-1: Typical Structure of Special Purpose Vehicle

Chapter 15 ANNEXURES

ANNEXURE 1

15.1. Primary surveys

15.1.1. Classified Volume Count Surveys at Outer cordon and Mid-Blocks

Objective of the Survey: To assess the traffic flowing within and outside the study area from the adjoining areas/regions.

Scope of the Survey: Counting of vehicles classified by the type of vehicle during the specified duration.

Conduct of the Survey: Manual traffic counts were carried out on a typical working day at all locations listed below. At each identified station, both directional counts were counted by vehicle type, i.e. fast moving passenger vehicles, goods vehicles etc.

No. of Locations: List of outer cordon count locations are presented in table 15.1:

Table 15-1: Classified Volume Count Surveys at Outer cordon and Mid-Blocks locations

Sno	Location Name	Lat Long (Approx.)	
	Outer Cordon Locations		
1	Ranipool Taxi Stand	27°17'44.1"N 88°35'20.1"E	27.295572, 88.588920
2	Lower Brutuk Road (Nr Helipad)	27°21'18.2"N 88°36'51.5"E	27.355044, 88.614314
3	Chandmari Shiv Mandir (on Chandmari road)	27°20'18.9"N 88°37'22.8"E	27.338578, 88.622985
	Mid block Locations		
1	Holy Cross School / saint Paul Chruch	27°18'52.8"N 88°35'43.2"E	27.314679, 88.595331
2	Sikkim continental	27°19'30.4"N 88°36'36.6"E	27.325096, 88.610170
3	Neat Holidays-Gangtok Rangpo Road	27°19'53.9"N 88°36'23.5"E	27.331636, 88.606524
4	SNT Bus Stand	27°20'03.9"N 88°36'55.0"E	27.334415, 88.615267
5	Taxi Stand North District	27°20'32.6"N 88°36'46.4"E	27.342383, 88.612875

Figure 15-1: Classified Volume Count Surveys at Outer cordon and Mid-Blocks locations

15.1.2. Road Side Interview at Outer Cordon and Mid-Blocks

Objective of the Survey: to access the travel Characteristics (Assessment of Origin Destination i.e. interaction of Internal-External zones) of passengers entering /leaving city (at outer cordons) during the specified duration.

Scope of the Survey: Interviews are carried out on a sample basis on a typical working day by stopping the vehicles with the help of police.

Conduct of the Survey: These surveys were conducted at 3 outer cordon for 16 hrs (06:00 to 22:00) and 5 mid block points. At each identified location, the origin and destination along with other trip characteristics of the passengers by vehicle type was recorded.

No. of Locations: Outer Cordon Locations: 8

Table 15-2: Road Side Interview locations

Sno	Location Name	Lat Long (Approx.)	
	Outer Cordon Locations		
1	Ranipool Taxi Stand	27°17'44.1"N 88°35'20.1"E	27.295572, 88.588920
2	Lower Brutuk Road (Nr Helipad)	27°21'18.2"N 88°36'51.5"E	27.355044, 88.614314
3	Chandmari Shiv Mandir (on Chandmari road)	27°20'18.9"N 88°37'22.8"E	27.338578, 88.622985
	Mid block Locations		
1	Holy Cross School / saint Paul Chruch	27°18'52.8"N 88°35'43.2"E	27.314679, 88.595331
2	Sikkim continental	27°19'30.4"N 88°36'36.6"E	27.325096, 88.610170
3	Neat Holidays- Gangtok Rangpo Road	27°19'53.9"N 88°36'23.5"E	27.331636, 88.606524

Sno	Location Name	Lat Long (Approx.)	
4	SNT Bus Stand	27°20'03.9"N 88°36'55.0"E	27.334415, 88.615267
5	Taxi Stand North District	27°20'32.6"N 88°36'46.4"E	27.342383, 88.612875

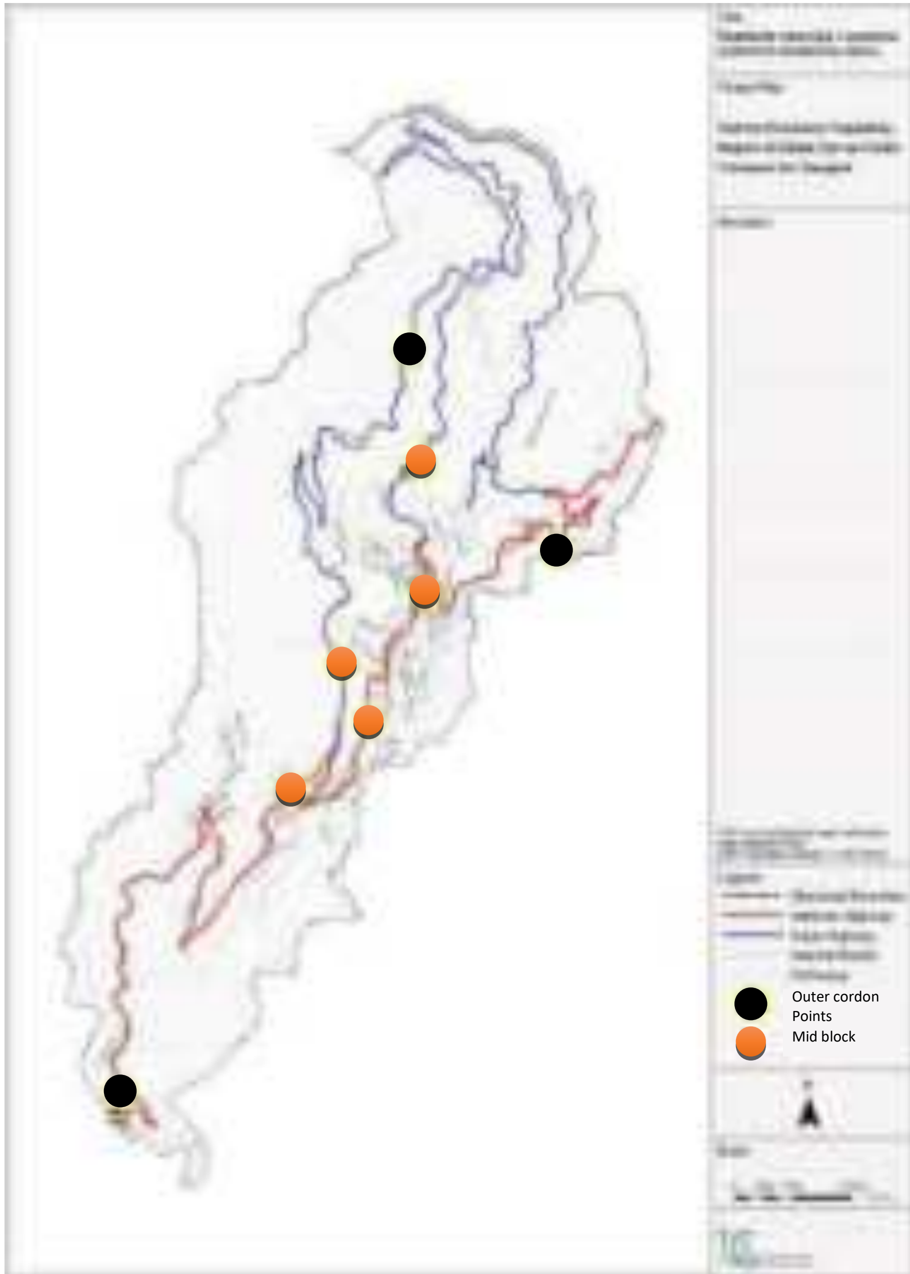


Figure 15-2: Road Side Interview locations

15.1.3. Occupancy Surveys – Outer Cordon/ Mid-block locations

Objective of the Survey: To assess the Occupancy of traffic flowing within and outside the study area from the adjoining areas/regions.

Scope of the Survey: Assessment of vehicle occupancy classified by the type of vehicle during the specified duration.

Conduct of the Survey: These surveys were conducted at outer cordon and Mid-block locations, Manual counts of occupancy were carried out on a typical working day

No. of Locations: List of outer cordon count locations are presented in Table 15.3

Table 15-3: Occupancy Surveys locations

Sno	Location Name	Lat Long (Approx.)	
	Outer Cordon Locations		
1	Ranipool Taxi Stand	27°17'44.1"N 88°35'20.1"E	27.295572, 88.588920
2	Lower Brutuk Road (Nr Helipad)	27°21'18.2"N 88°36'51.5"E	27.355044, 88.614314
3	Chandmari Shiv Mandir (on Chandmari road)	27°20'18.9"N 88°37'22.8"E	27.338578, 88.622985
	Mid block Locations		
1	Holy Cross School / saint Paul Chruch	27°18'52.8"N 88°35'43.2"E	27.314679, 88.595331
2	Sikkim continental	27°19'30.4"N 88°36'36.6"E	27.325096, 88.610170
3	Neat Holidays-Gangtok Rangpo Road	27°19'53.9"N 88°36'23.5"E	27.331636, 88.606524
4	SNT Bus Stand	27°20'03.9"N 88°36'55.0"E	27.334415, 88.615267
5	Taxi Stand North District	27°20'32.6"N 88°36'46.4"E	27.342383, 88.612875

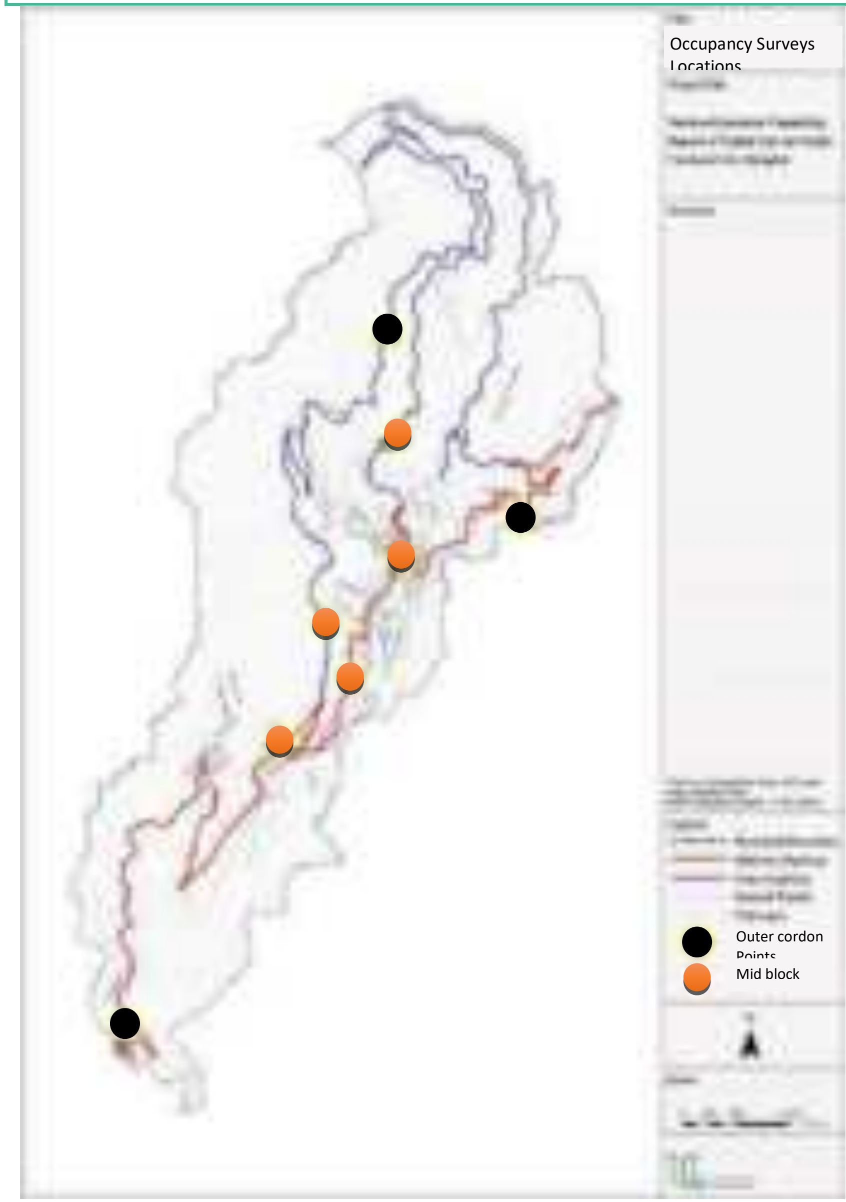


Figure 15-3: Occupancy Surveys locations

15.1.4. Household Survey

Objective of the Survey: The house hold survey was carried out to collect the socio economic and travel data assessing the travel patterns and preferences of city's residents.

Scope of the survey: Collection of data on socio-economic characteristics, household members and their travel diary covering a size of 5% sample.

Conduct of the Survey: The survey questionnaire comprises of two sections, a) Socio-economic datasheet and Household member characteristic datasheet, and b) the travel diary of each individual member of the household. The travel diary section requests information of all trips made by each person in the household on the previous day. This information includes the time of the trip, the trip purpose, the address of the trip starting, ending place and the mode of travel. This data was collected by visiting a fixed sample in each area of the city (zone). Each Household constitutes a sample.

Table 15-4: Household Survey TAZs

Taz Num	TAZ Name
1	Burtuk
2	Lower Sichey
3	Upper Sichey
4	Chandmari
5	Development Area
6	Diesel Power House
7	Arithang
8	Lower MG Marg
9	Upper MG Marg
10	Tibet Road
11	Deorali
12	Dara Goan
13	Tadong
14	Ranipool
15	Syari- tathangchen
16	Lower Burtuk
17	Lower Sichey

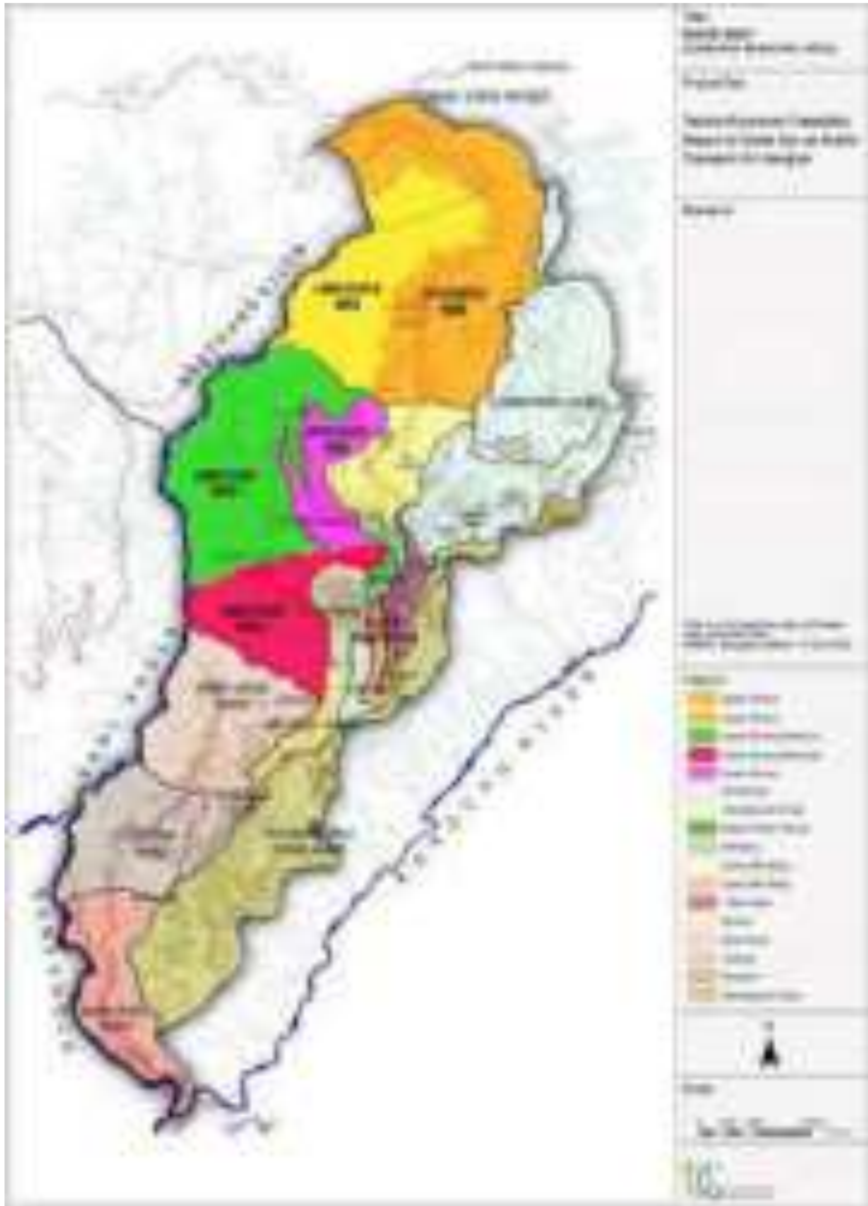


Figure 15-4: Household Survey TAZs

15.1.5. Establishment Survey

Objective of the Survey: The Establishment survey documents and measures the spatio temporal distribution and growth of the employment. It provides establishment typology, sub typology, ownership status, age of establishment, employment record, number of visitors and data regarding provision of transport facility etc. The primary objective of the data is to document and map the improvement and growth in employment in the area in the form of non-residential activities. However, the survey report can also be used for other purposes like future projections, demand calculation etc

Scope of the survey: Collection of data on establishment characteristics, covering a size of 20% samples.

Conduct of the Survey: The survey questionnaire comprises of basic establishment details, business typology (detailed), Establishment characteristics detailed. This data was collected by visiting a fixed sample in each area of the city (zone). Each establishment constitutes a sample.

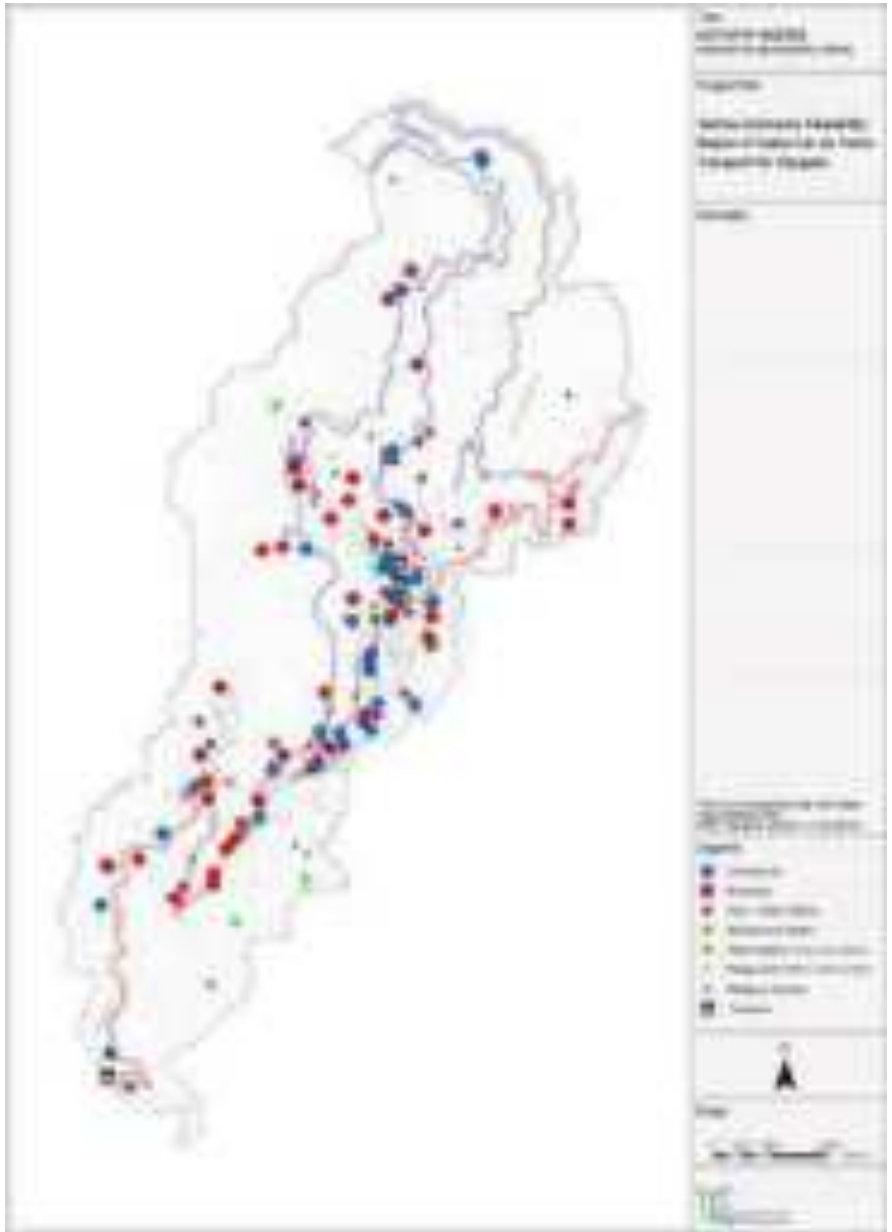


Figure 15-5: Establishment Survey locations

15.1.6. Willingness to Pay Survey

Objective of the Survey: To access the current trip characteristics and willingness to shift towards proposed public transport system.

Scope of the Survey: The survey captured the data regarding socio economic profile, travel preferences, stated choice and preference for willingness to shift to new transit mode.

Conduct of the Survey: These surveys were conducted at 10 major locations in normal working day. At each identified location, trip characteristics and stated preference of the commuters was recorded.

No. of Locations: The 'Willingness to Pay' Survey was conducted on seven major locations i.e. Ranipool, Sikkim Manipal Hospital, Gangtok Municipal Corporation, SNT bus stand/MG Marg, Taxi stand for North district, Helipad and Burtuk Ward.

Figure 15-6: Willingness to Pay Survey locations

15.1.7. Speed and Delay Survey

Survey Objective: The principle objective of the study is to find out the journey speed, running speed and types of delay such as stopped delay and operational delay to evaluate the level of service or quality of traffic flow of a road or entire road network system.

Scope of Work

- The surveys were carried out during peak and off-peak periods in both directions.
- Collection of delay information on different road stretches and at intersections/level crossings in the study area.
- Identification of bottlenecks.

Conduct of the Survey: The survey was conducted using moving car observer method. The enumerators travelled along the stream by noting down the starting time, end time, travelled and the time of stop of the vehicle on the road stretches, at intersections and the reasons for the same.

Key Outputs.

- Travel speed and journey speed
- Delays along each of the selected corridors by type/reason
- Intersection delays

Figure 15-7: Speed and Delay Survey network

15.1.8. Tourist Survey

Survey Objective: to access the travel Characteristics (Assessment of Origin Destination) of tourists entering /leaving city.

Scope of Work

The tourist's travel and general characteristics are derived from assessment of primary data collected from major tourist attraction points. The characteristics provides information on group size, origin area, stay duration, major tourist attraction sites, Mode used etc.

Conduct of the Survey: These surveys were conducted major tourist attraction sites during weekdays and weekends. At each identified location, the aforementioned information was collected.

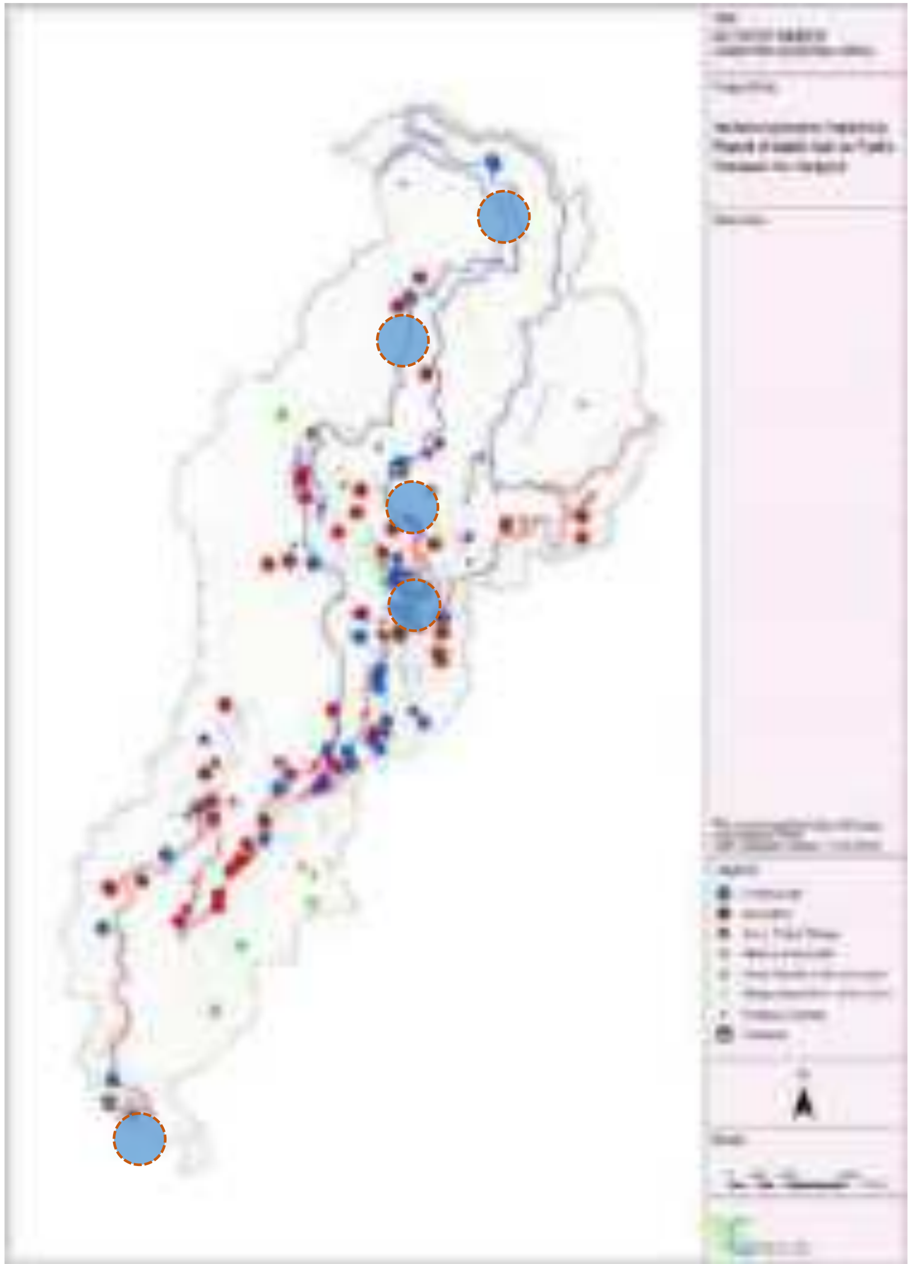


Figure 15-8: Tourist Survey locations

15.1.9. Stakeholders Consultation

Multiple stakeholders meetings/consultation were conducted after presentation of Draft Report-1 submission. The minutes of the meeting are given below:

Minutes of the meeting of the stakeholder consultation for draft final report on "Techno-economic feasibility of cable car as public transport in Gangtok" and workshop on finding short and long term solutions to traffic problems in Gangtok held on 30th November 2018 is given below:


URBAN DEVELOPMENT & HOUSING DEPARTMENT
GOVERNMENT OF SIKKIM
GANGTOK

OFFICE MEMORANDUM

ANNEXURE 2

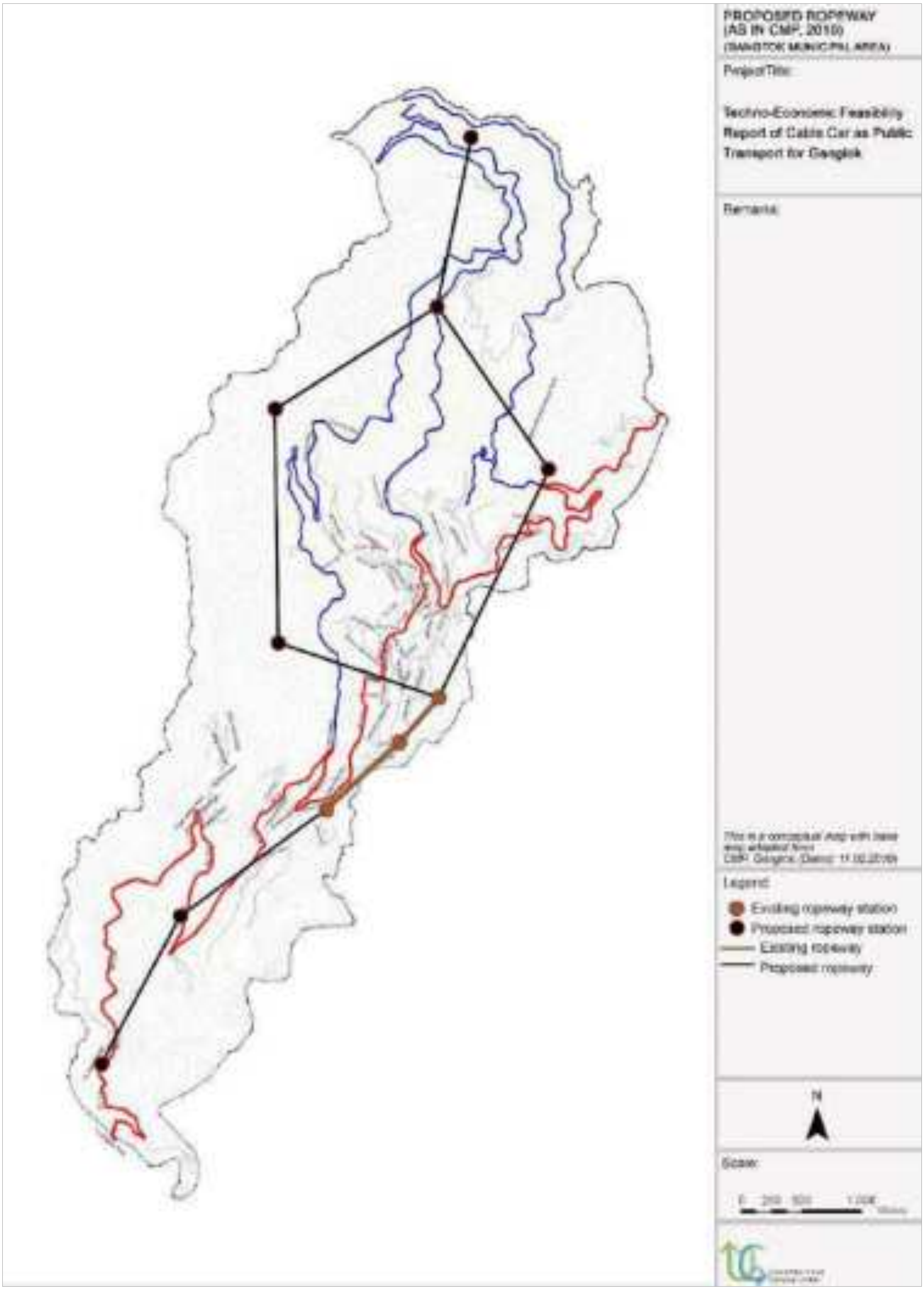


Figure 15-9: Cable Car Proposal as per CMP, 2010

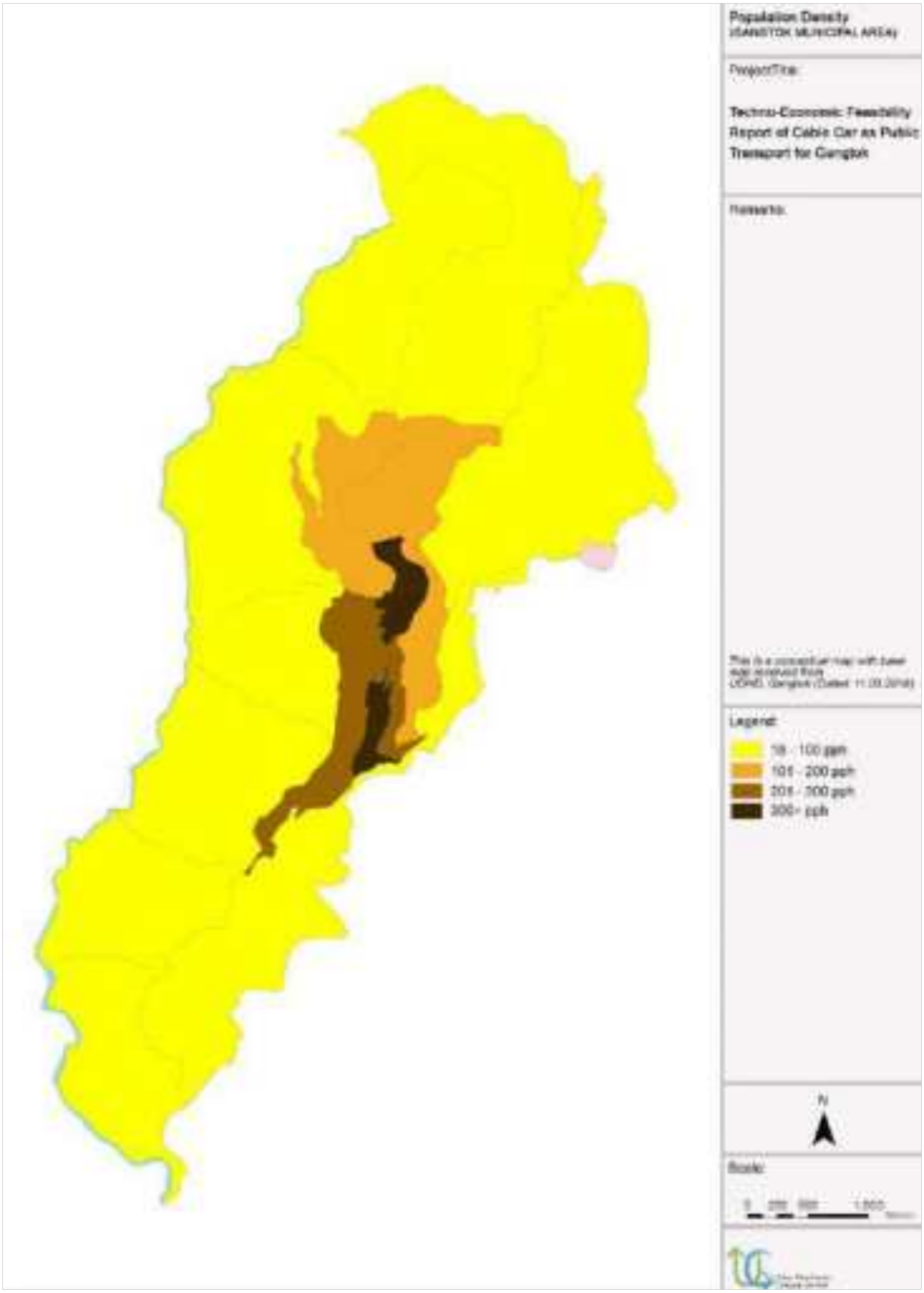


Figure 15-10: Population Density Distribution of Gangtok City

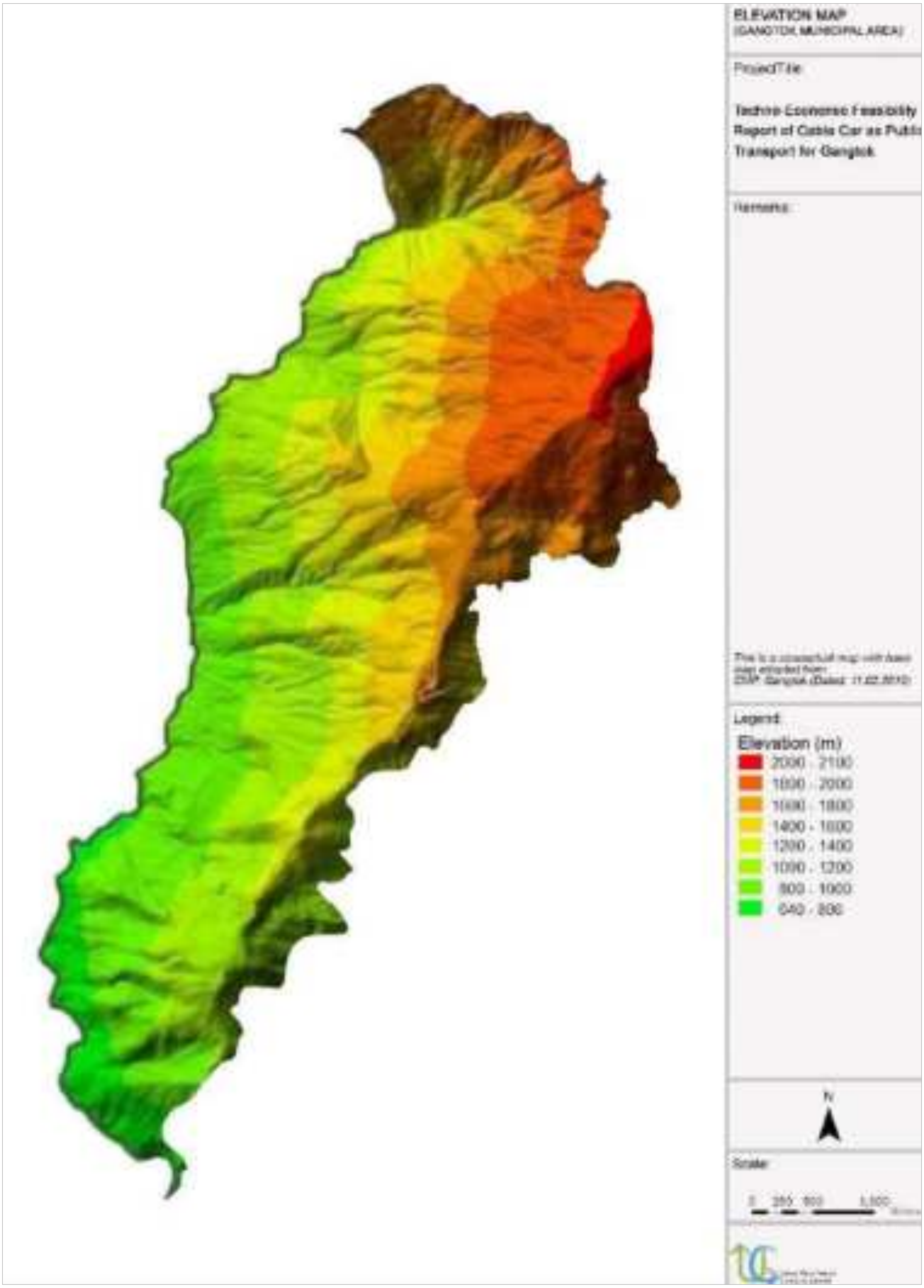


Figure 15-11: Physiographic Map of Gangtok

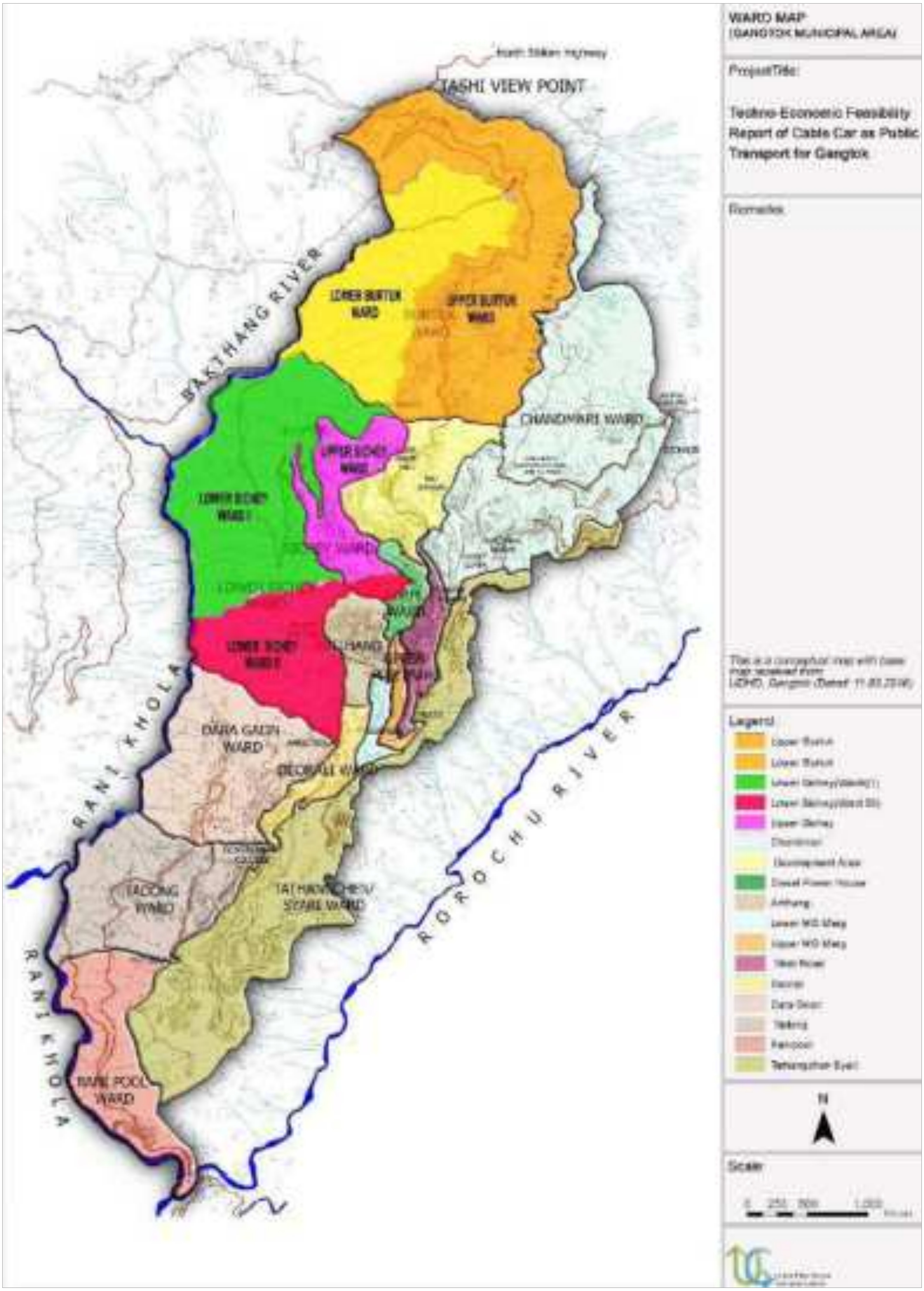


Figure 15-12: Gangtok Municipal Corporation Ward Map

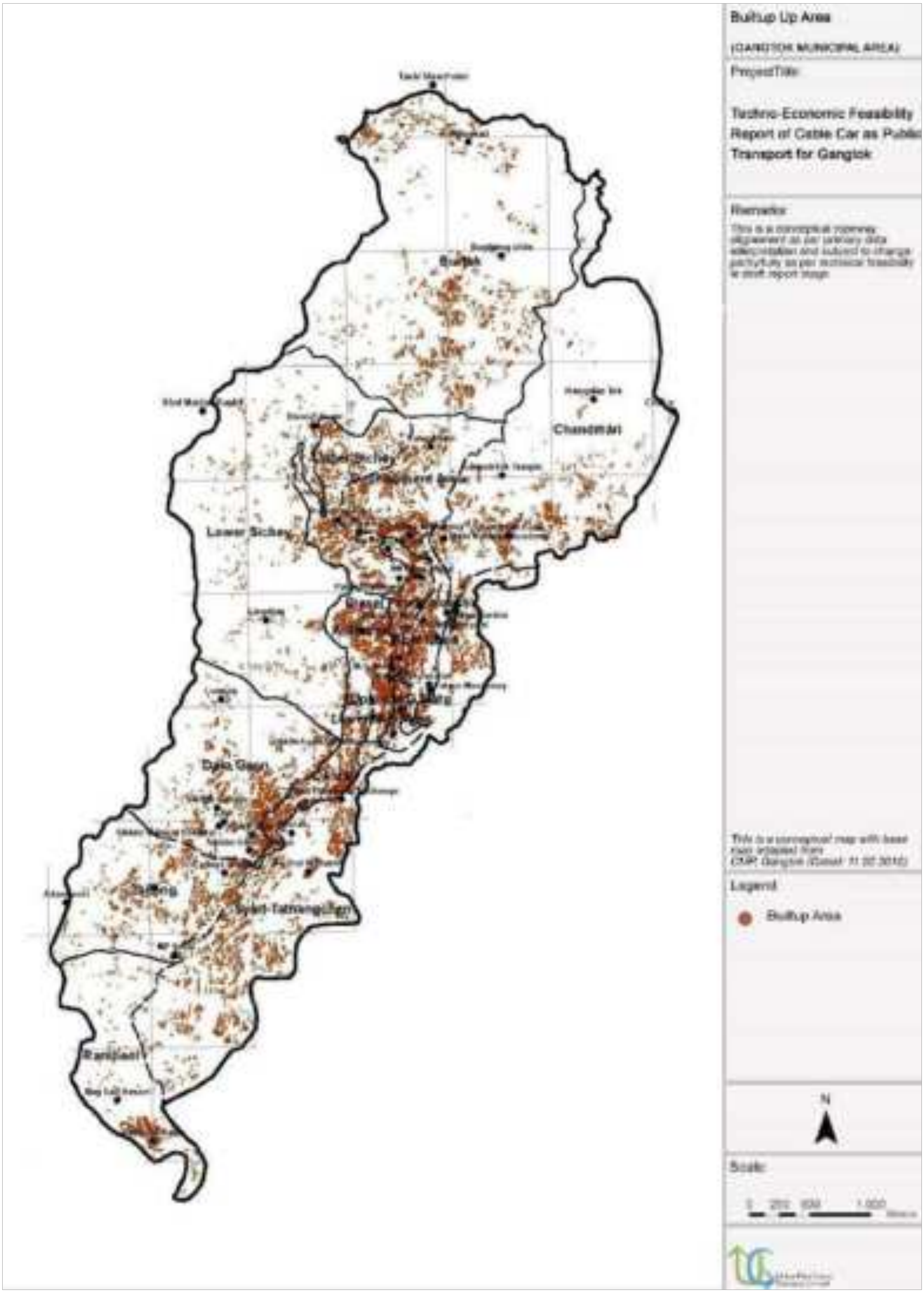


Figure 15-13: Built-up in Gangtok Municipal Corporation Area

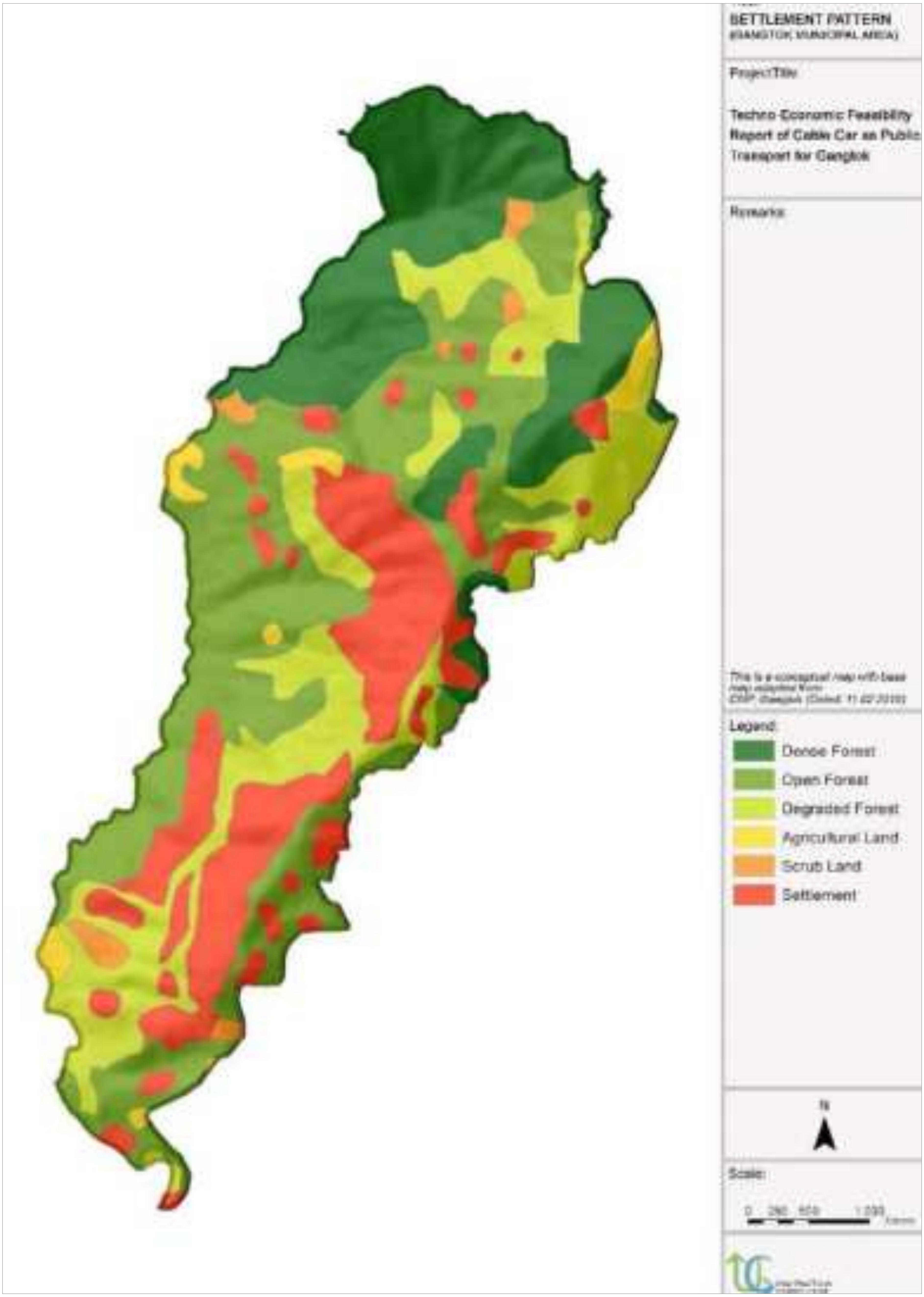


Figure 15-14: Settlement Pattern in Gangtok

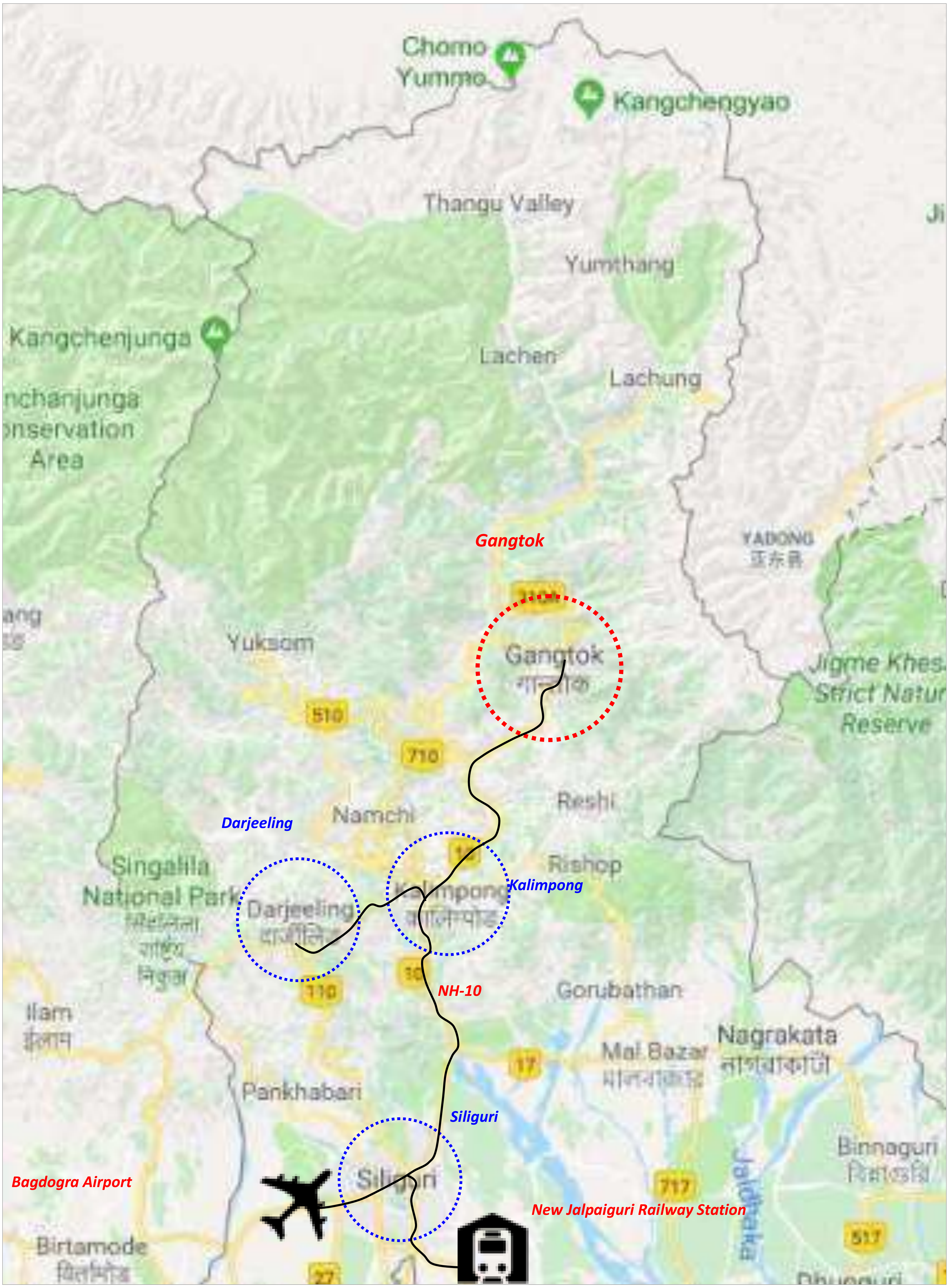


Figure 15-15: Regional Connectivity to Gangtok

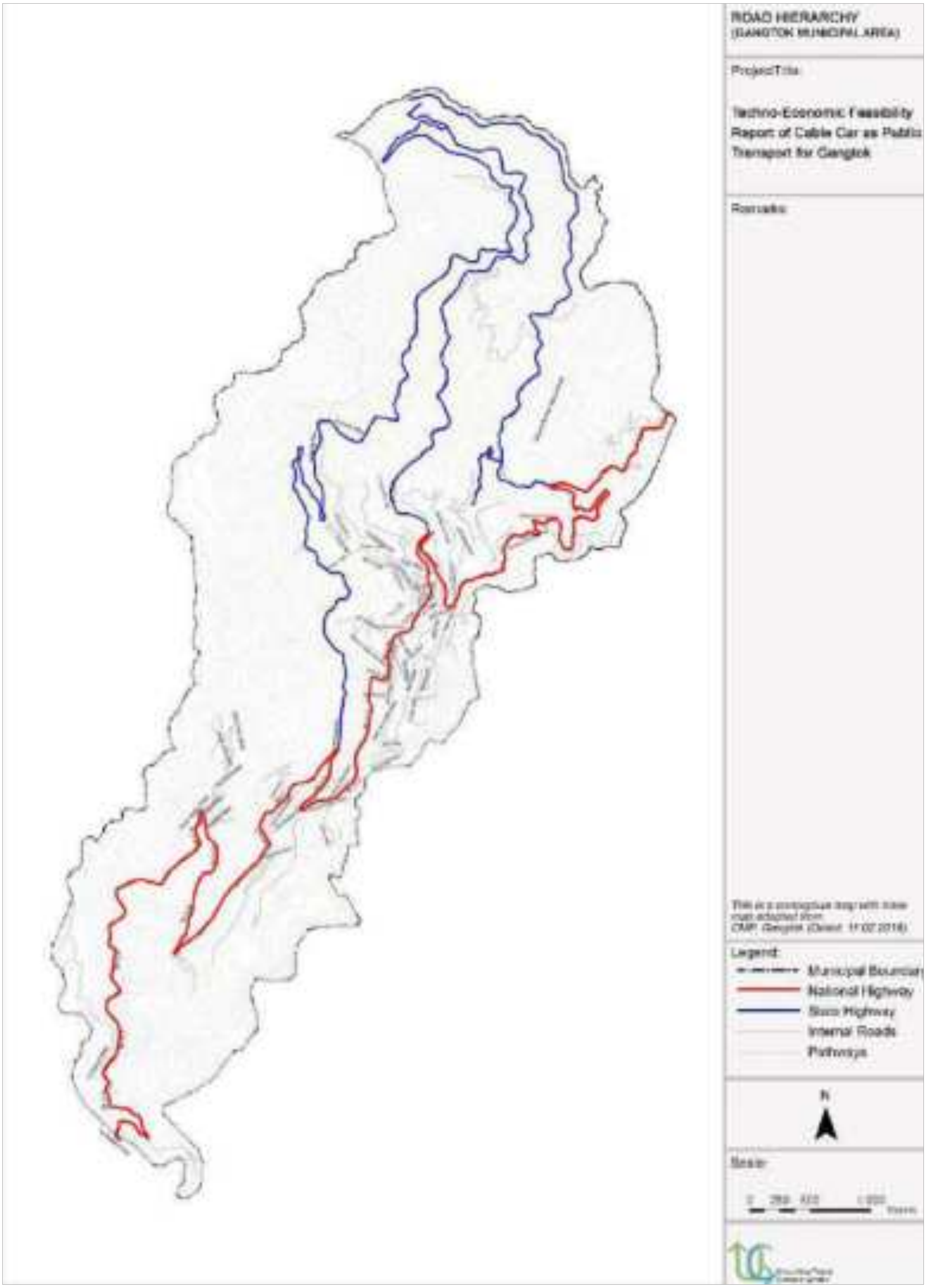


Figure 15-16: Road Network in Gangtok

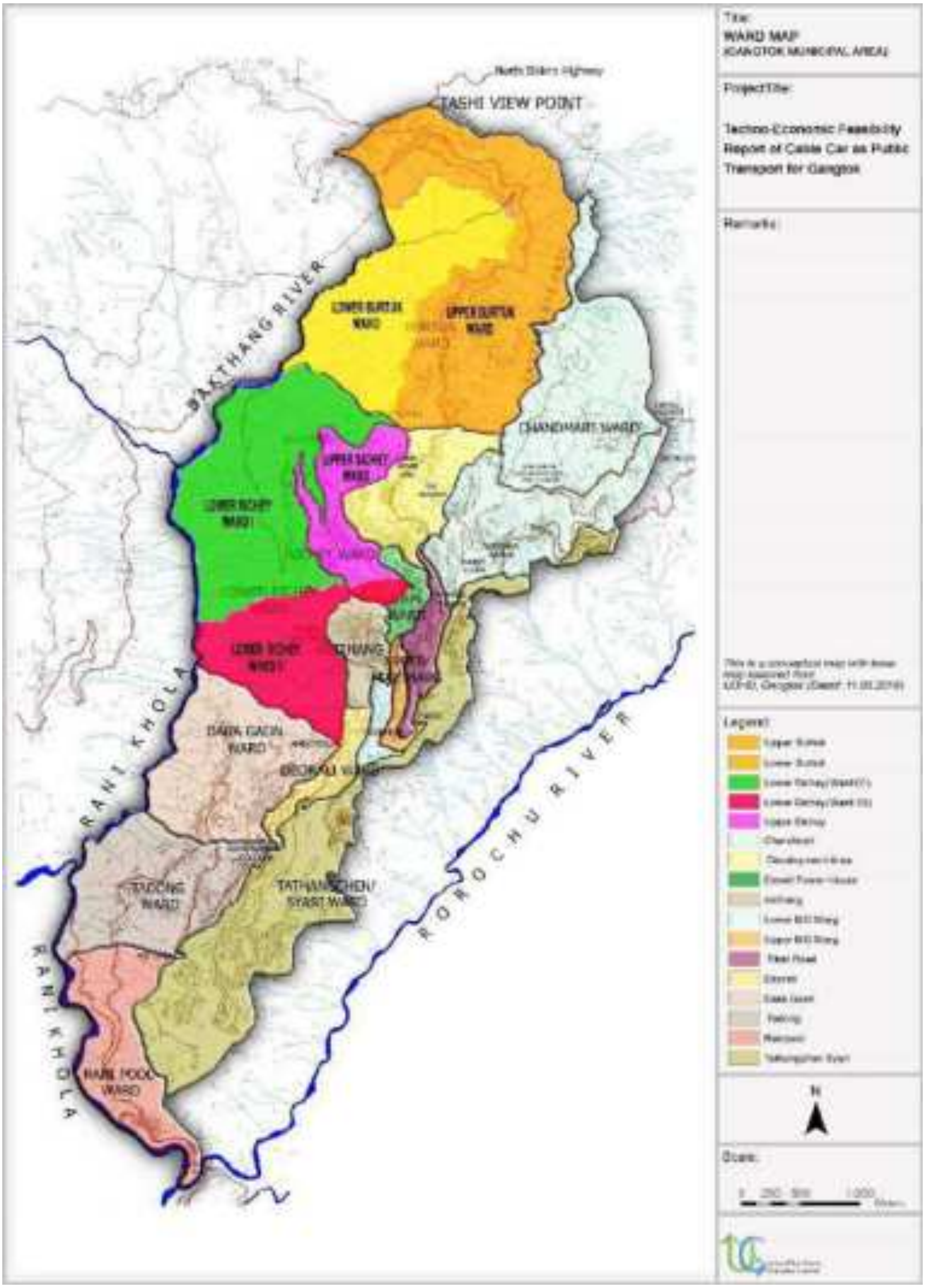


Figure 15-17: Traffic Analysis zones in study area

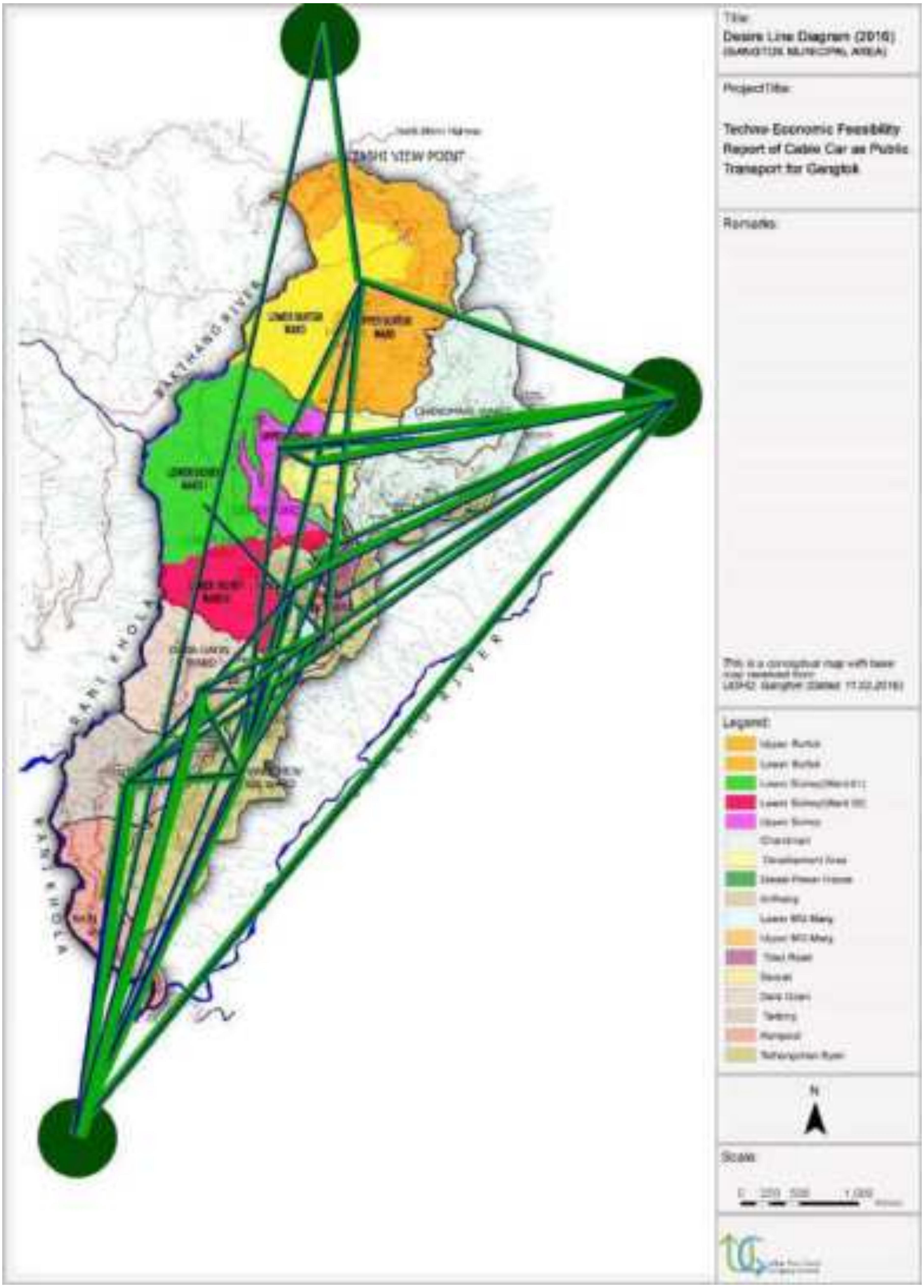


Figure 15-18: Desire Line Diagram (Do Nothing 2016)

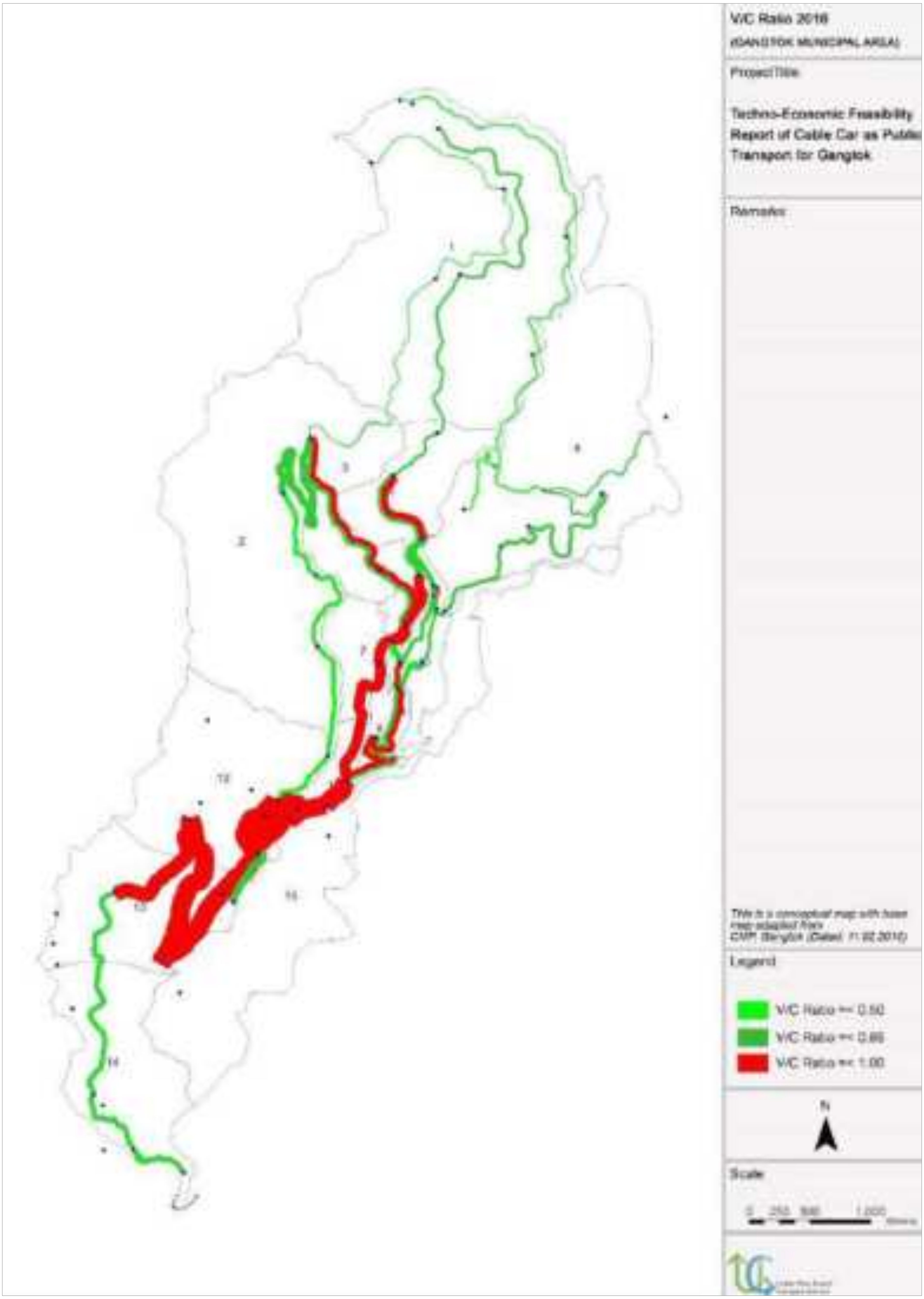


Figure 15-19: V/C Ratio Plotted on Base Year Network (2016)

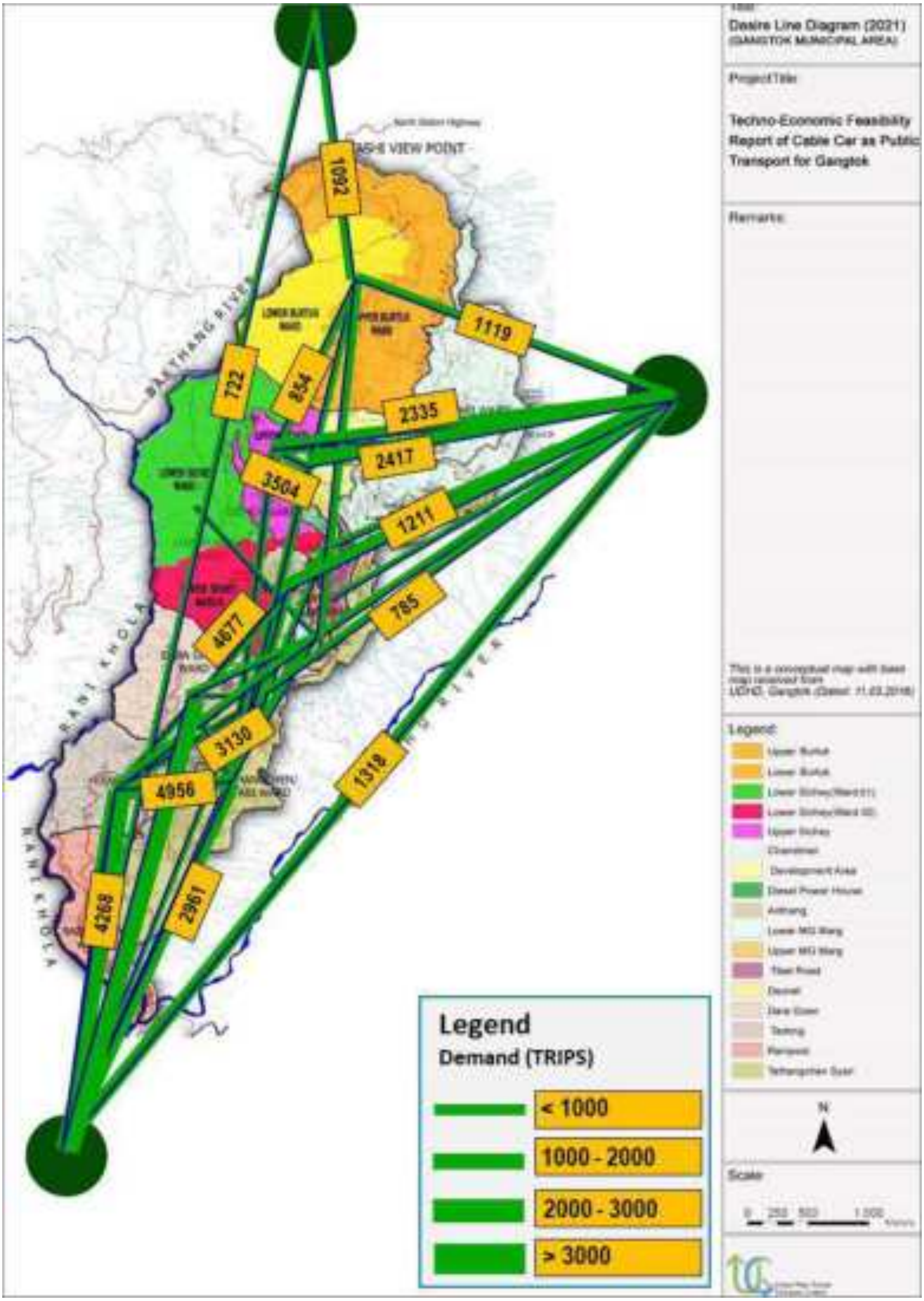


Figure 15-20: Desire Line Diagram (Do Nothing 2021)

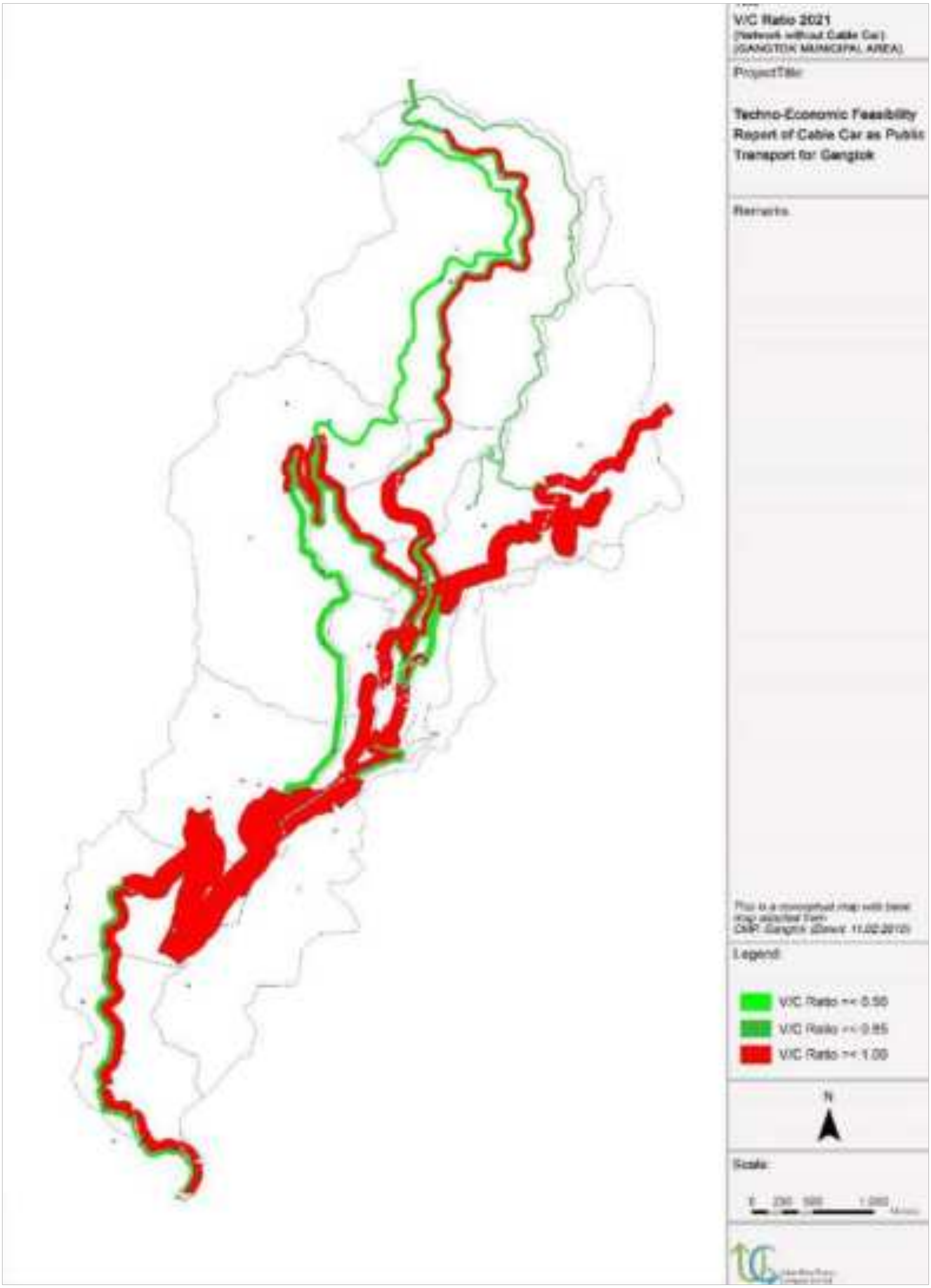


Figure 15-21: V/C Ratio in Do Nothing Scenario for Year 2021

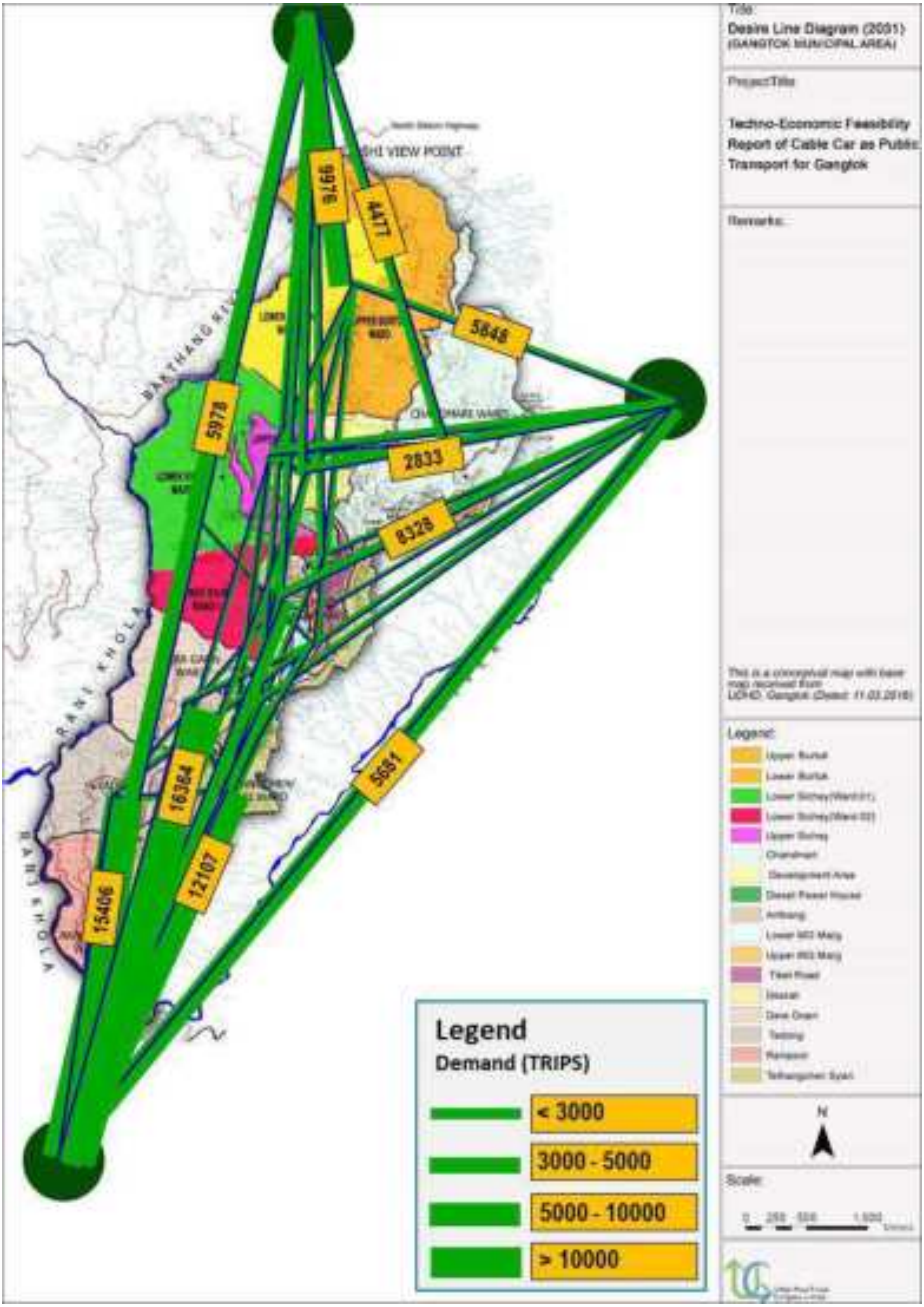


Figure 15-22: Desire Line Diagram (Do Nothing 2031)

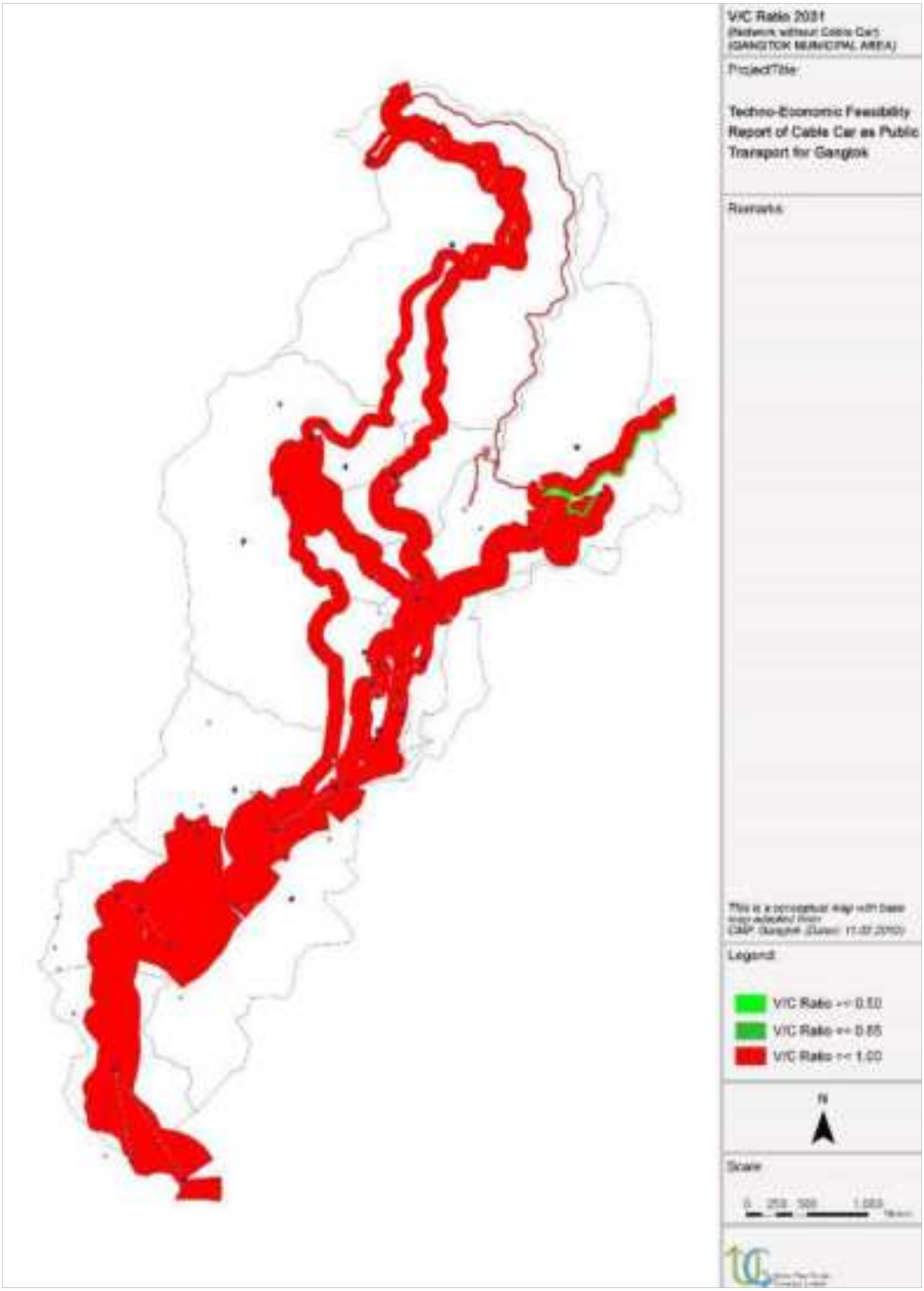


Figure 15-23: V/C Ratio in Do Nothing Scenario for Year 2031

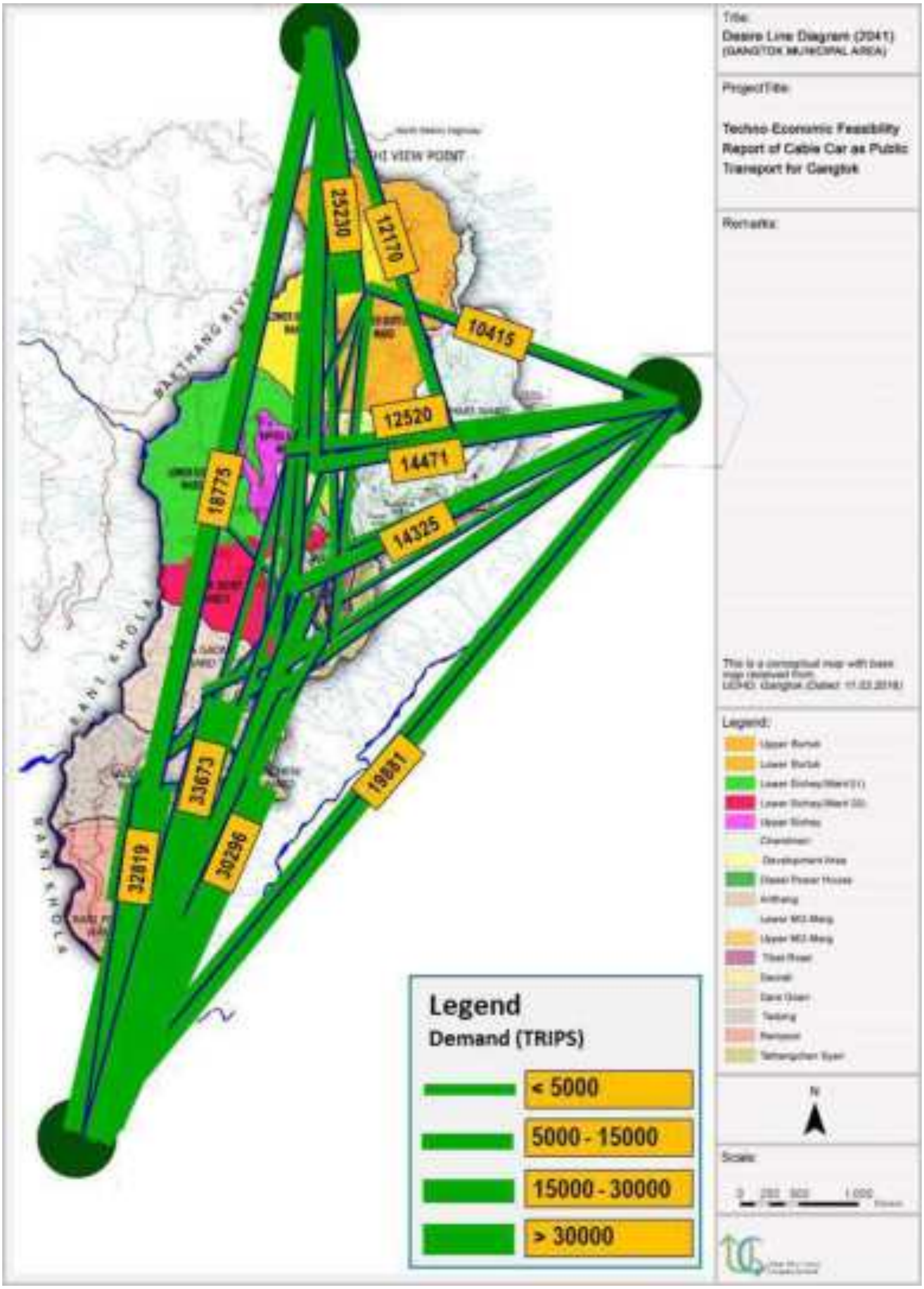


Figure 15-24: Desire Line Diagram (Do Nothing 2041)

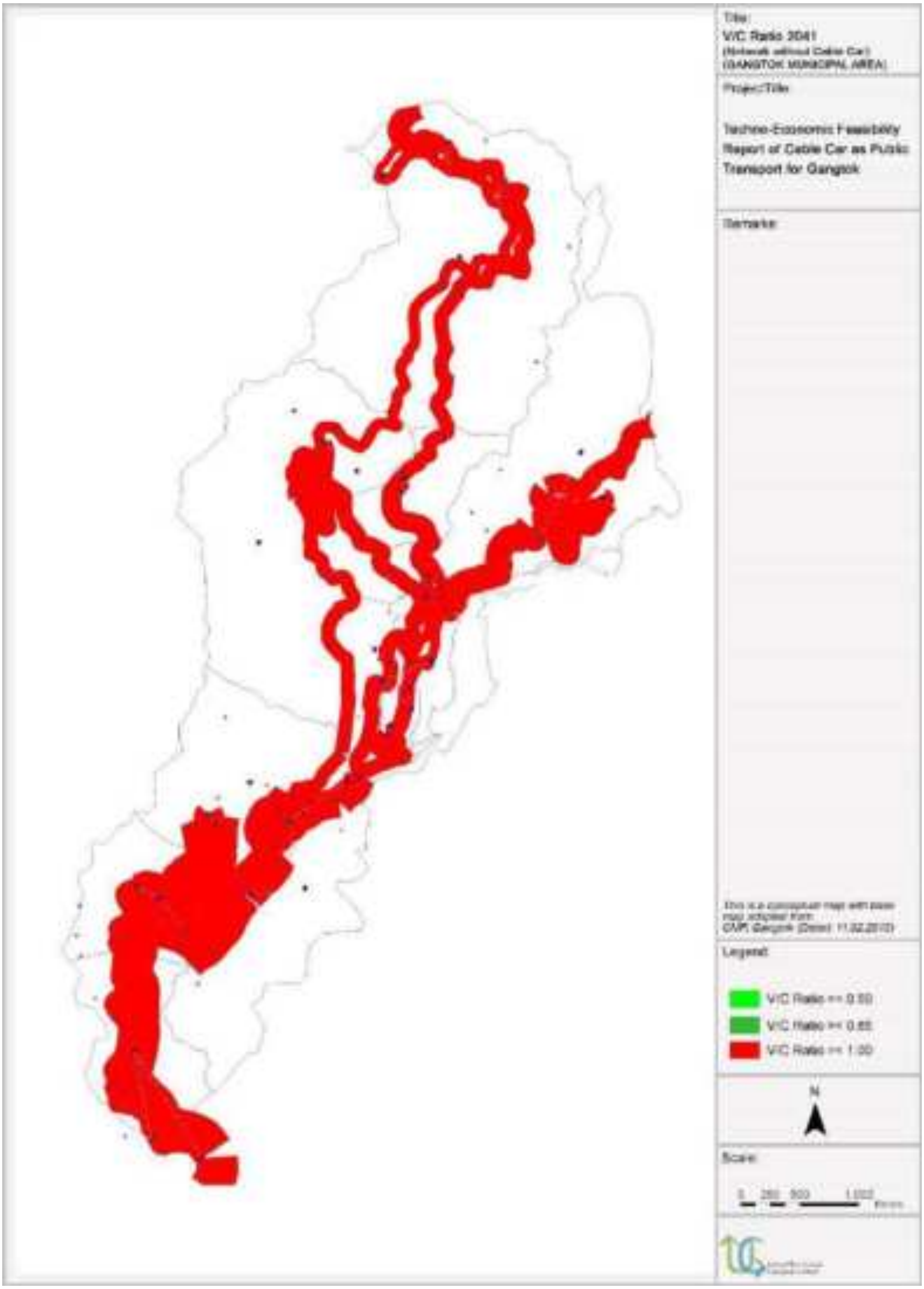


Figure 15-25: V/C Ratio in Do Nothing Scenario for Year 2041

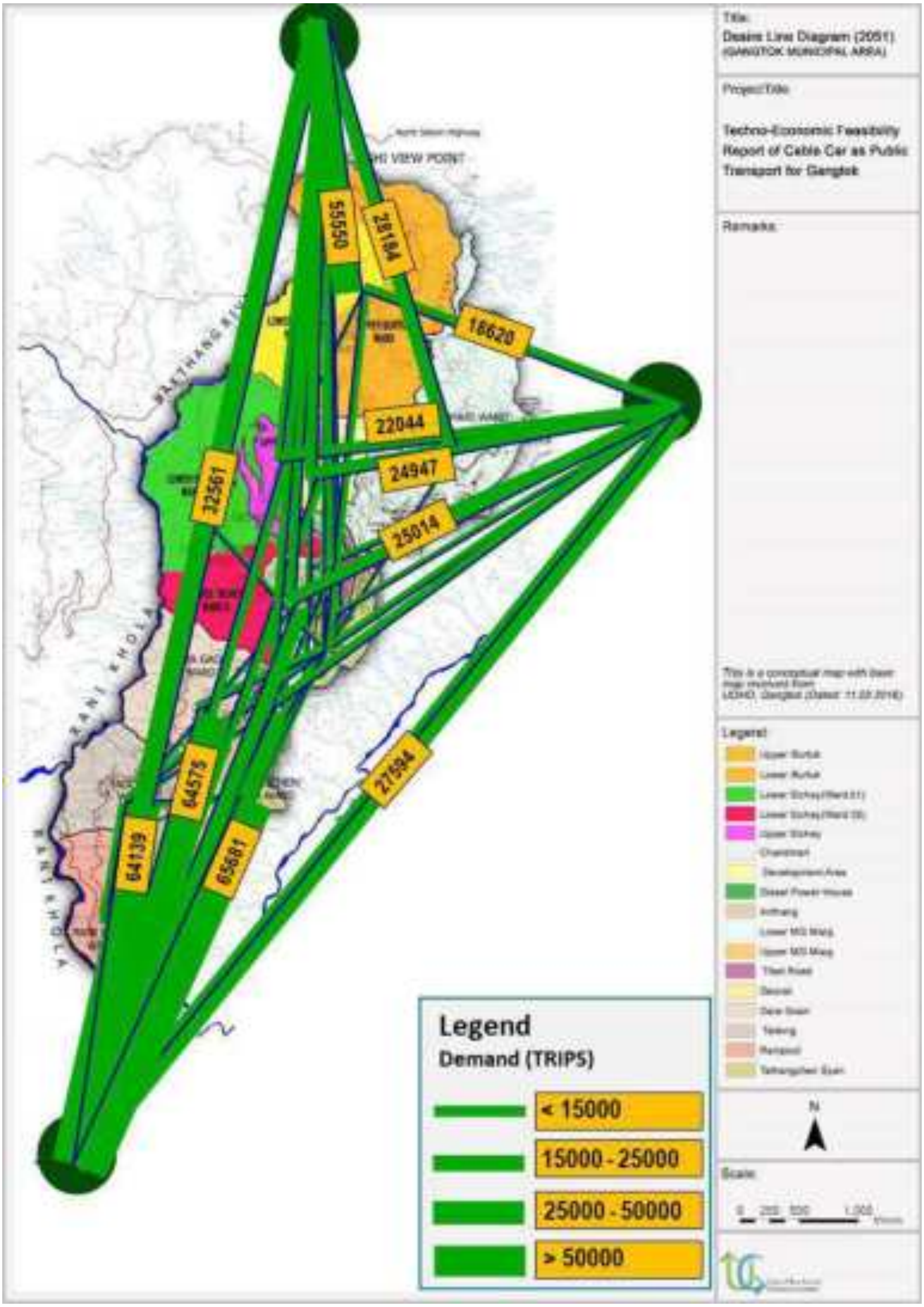


Figure 15-26: Desire line diagram in 2051

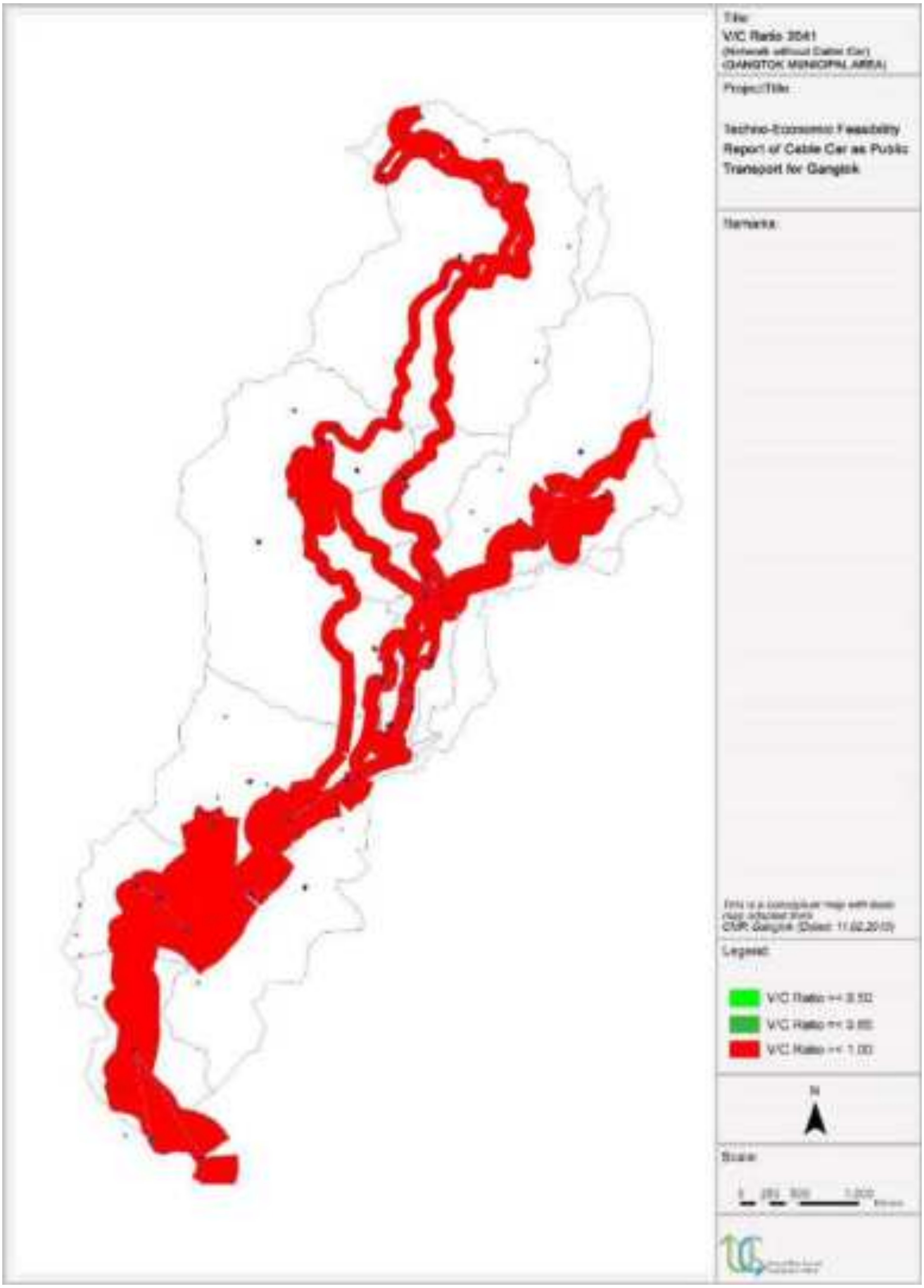


Figure 15-27: V/C Ratio in Do Nothing Scenario for Year 2051

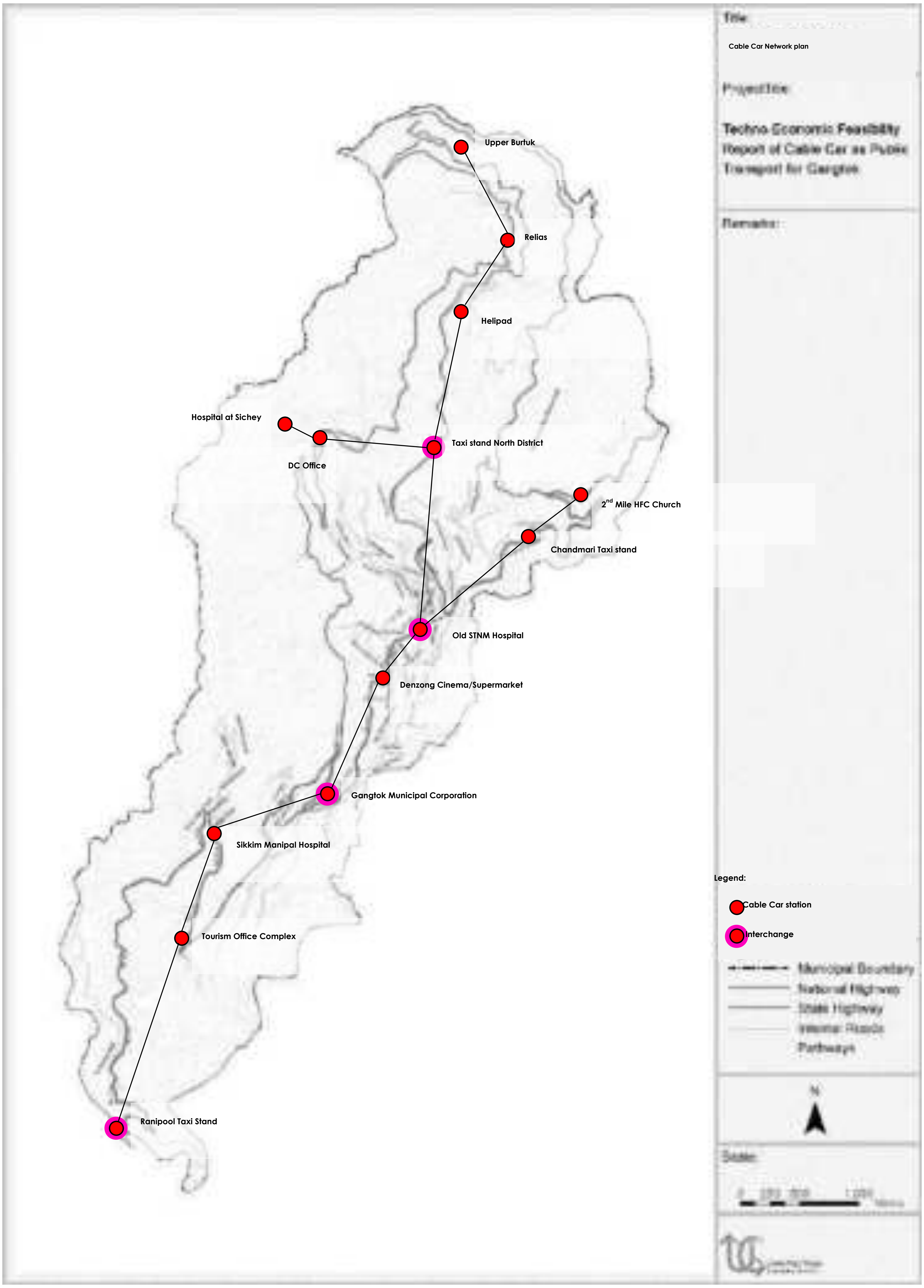


Figure 15-28: Conceptual Cable Car Alignment for Gangtok

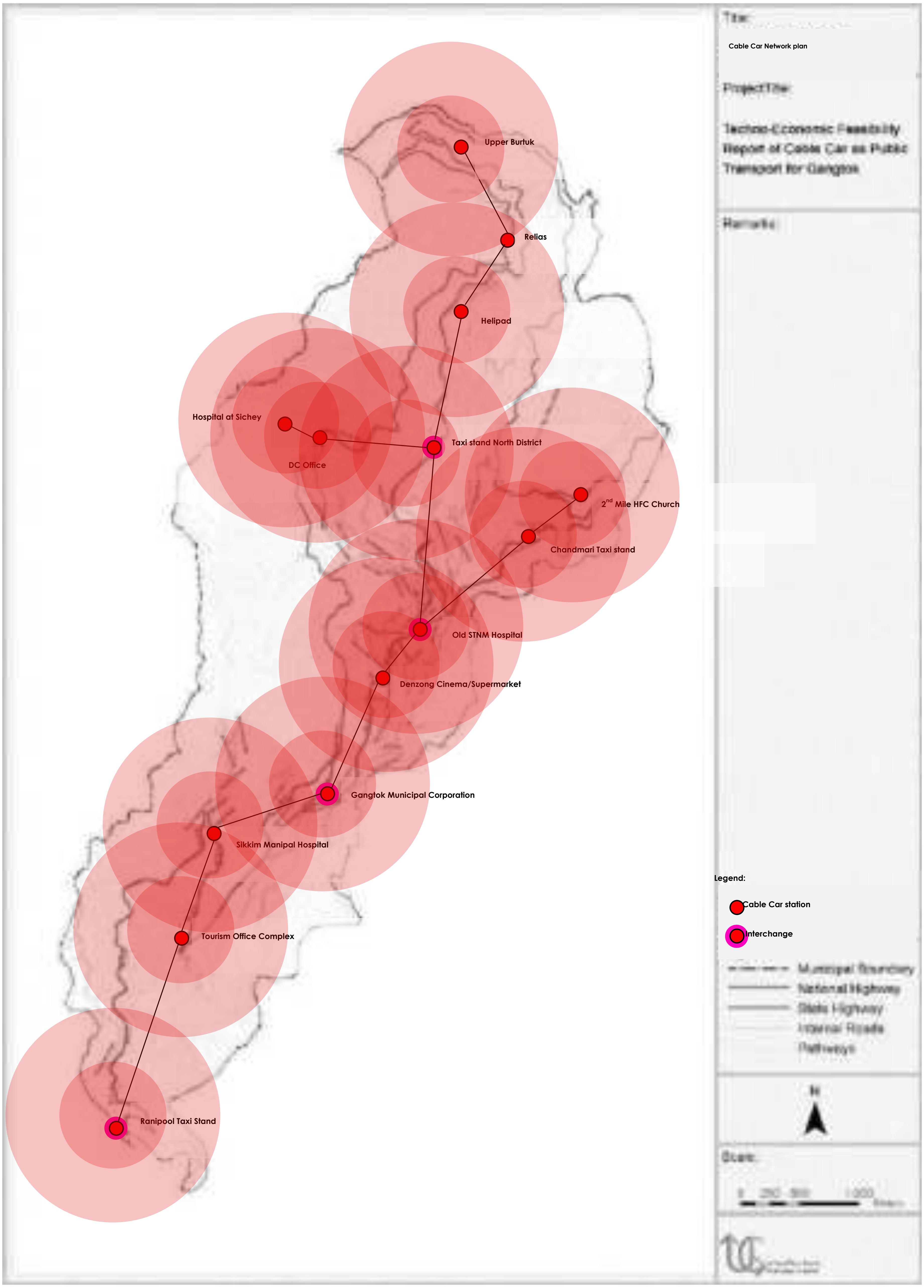


Figure 15-29: Conceptual Cable Car Alignment Catchment Area

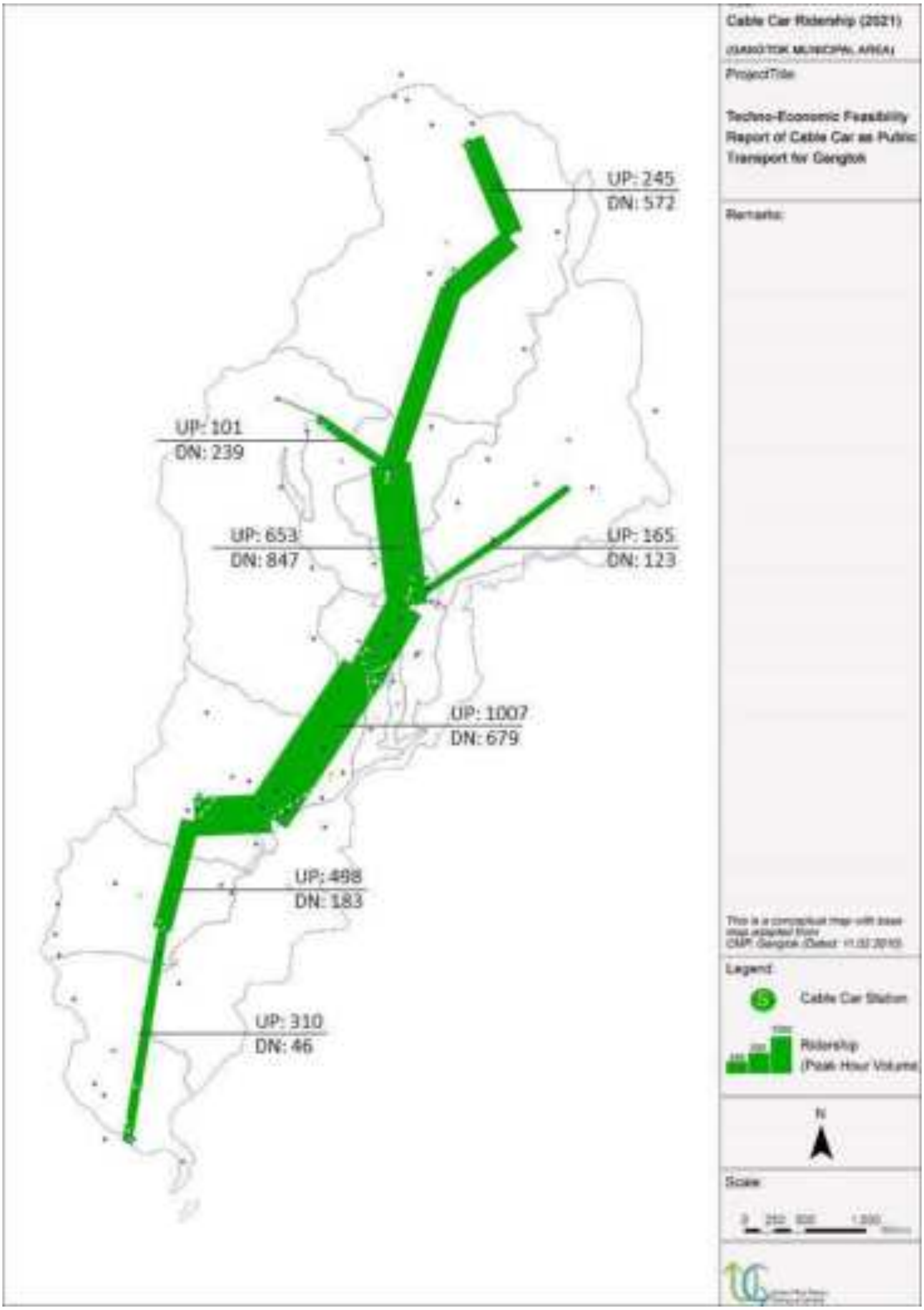


Figure 15-30: Cable Car System Ridership in the Year 2021

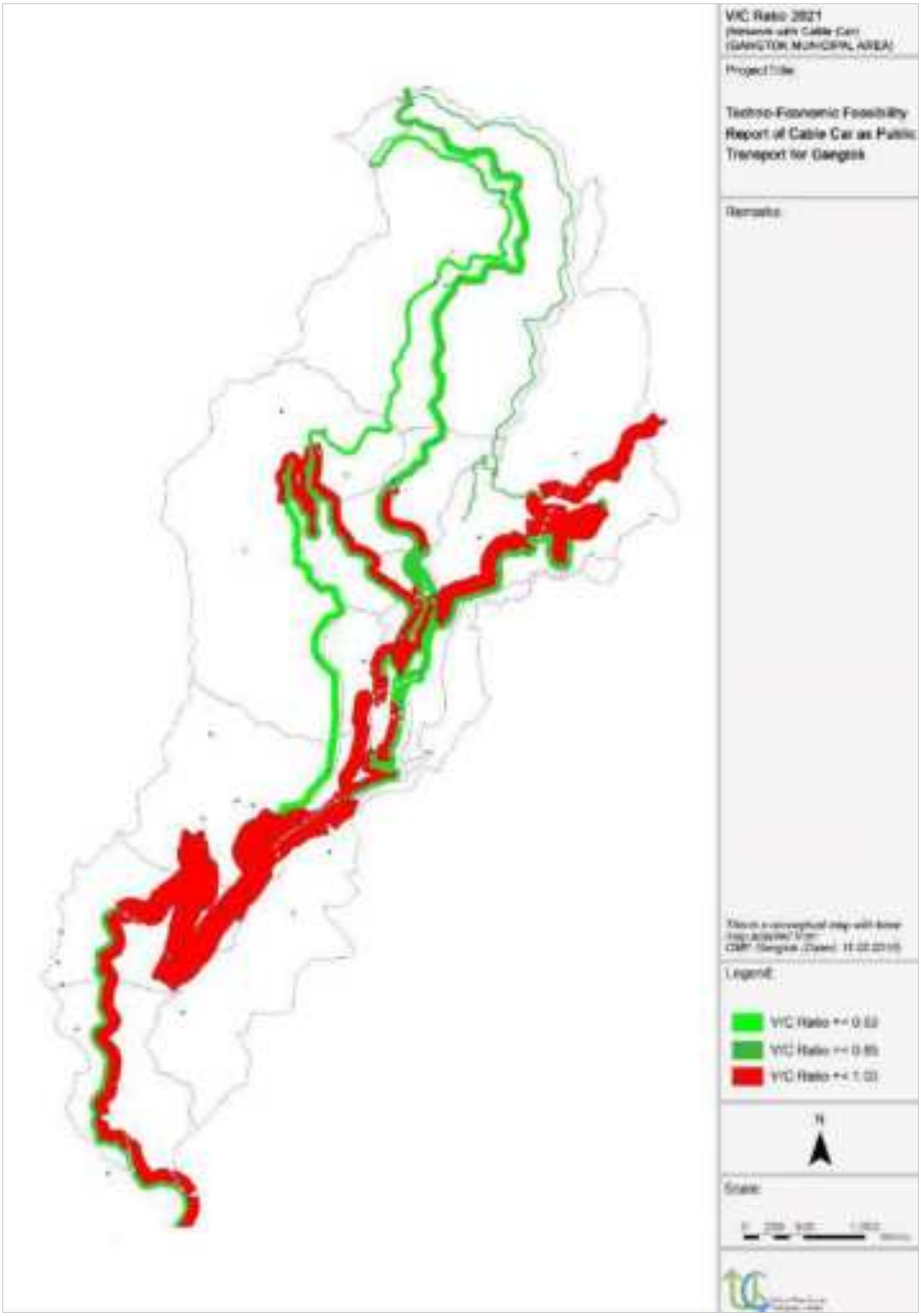


Figure 15-31: V/C Ratio in Project Scenario for the Year 2021

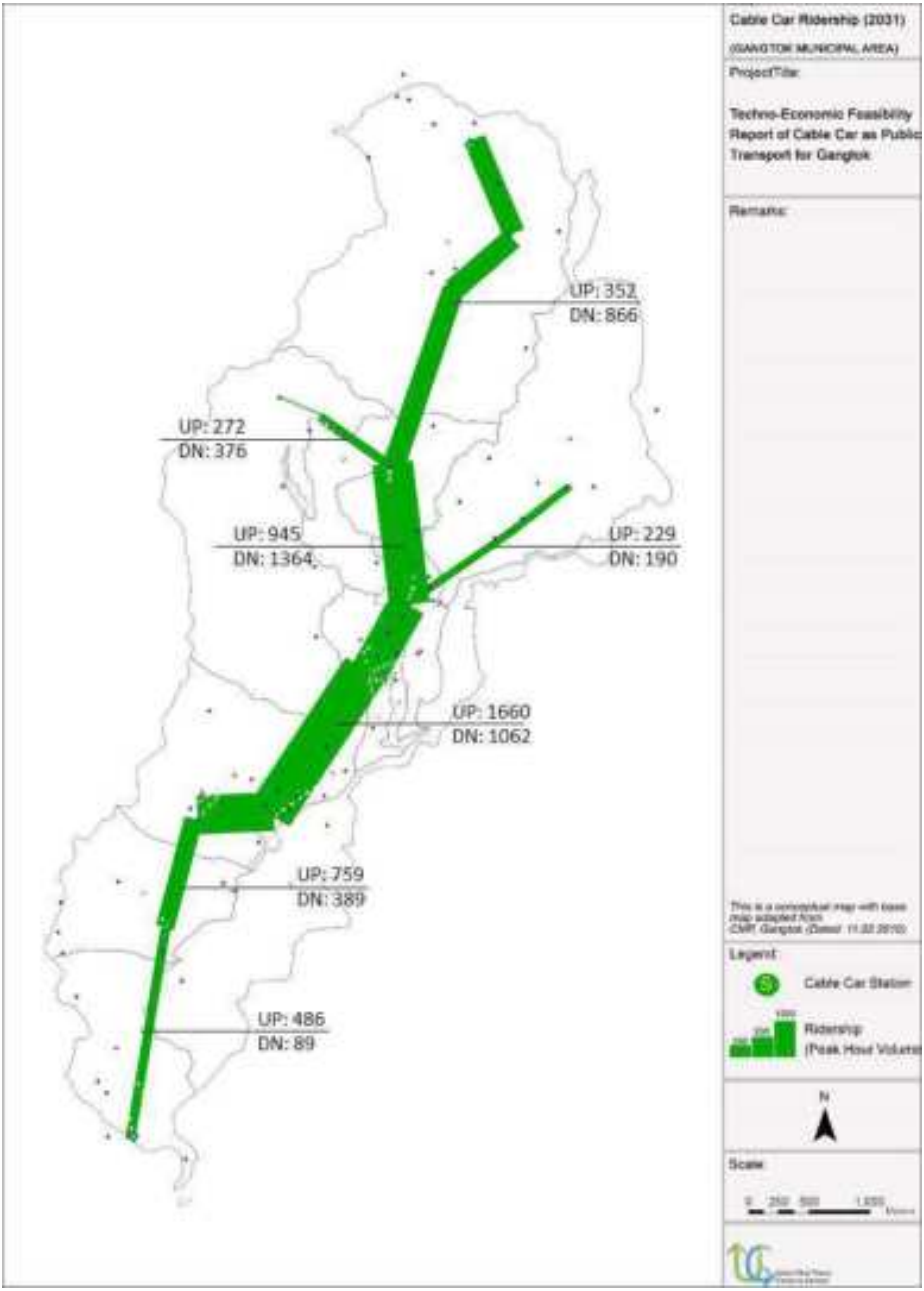


Figure 15-32: Cable Car System Ridership in the Year 2031

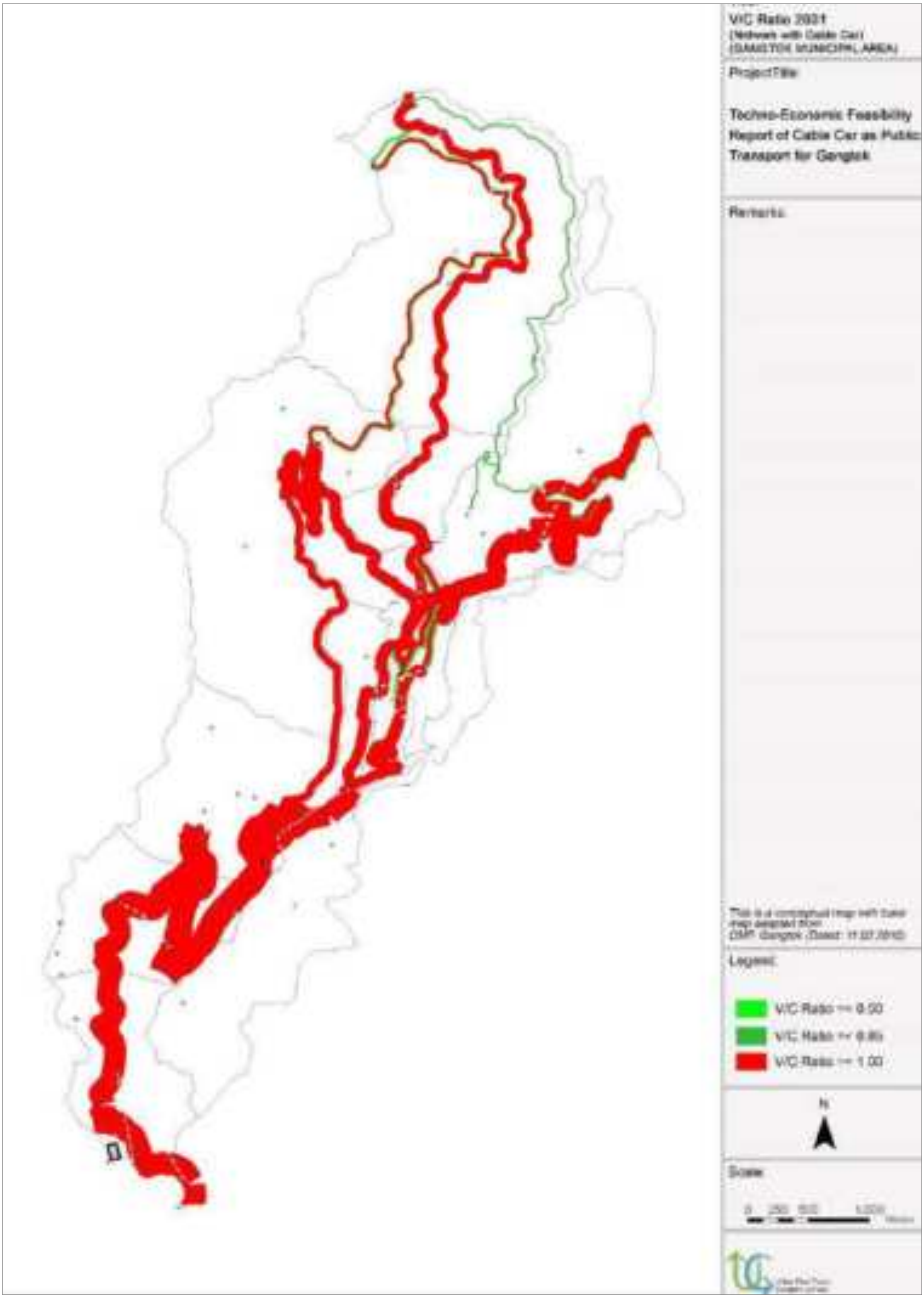


Figure 15-33: V/C Ratio in Project Scenario for the Year 2031

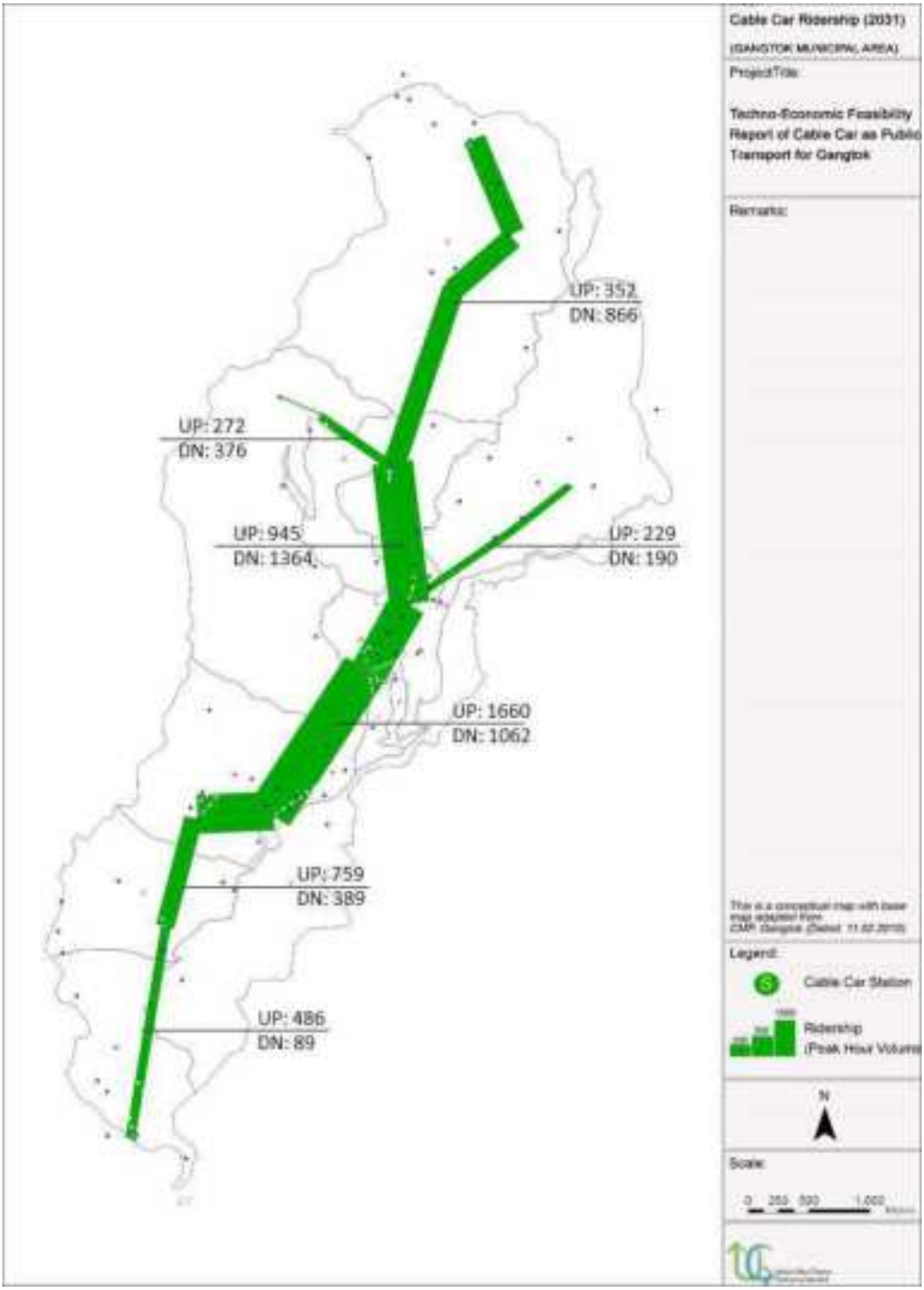


Figure 15-34: Cable Car System Ridership in the Year 2031

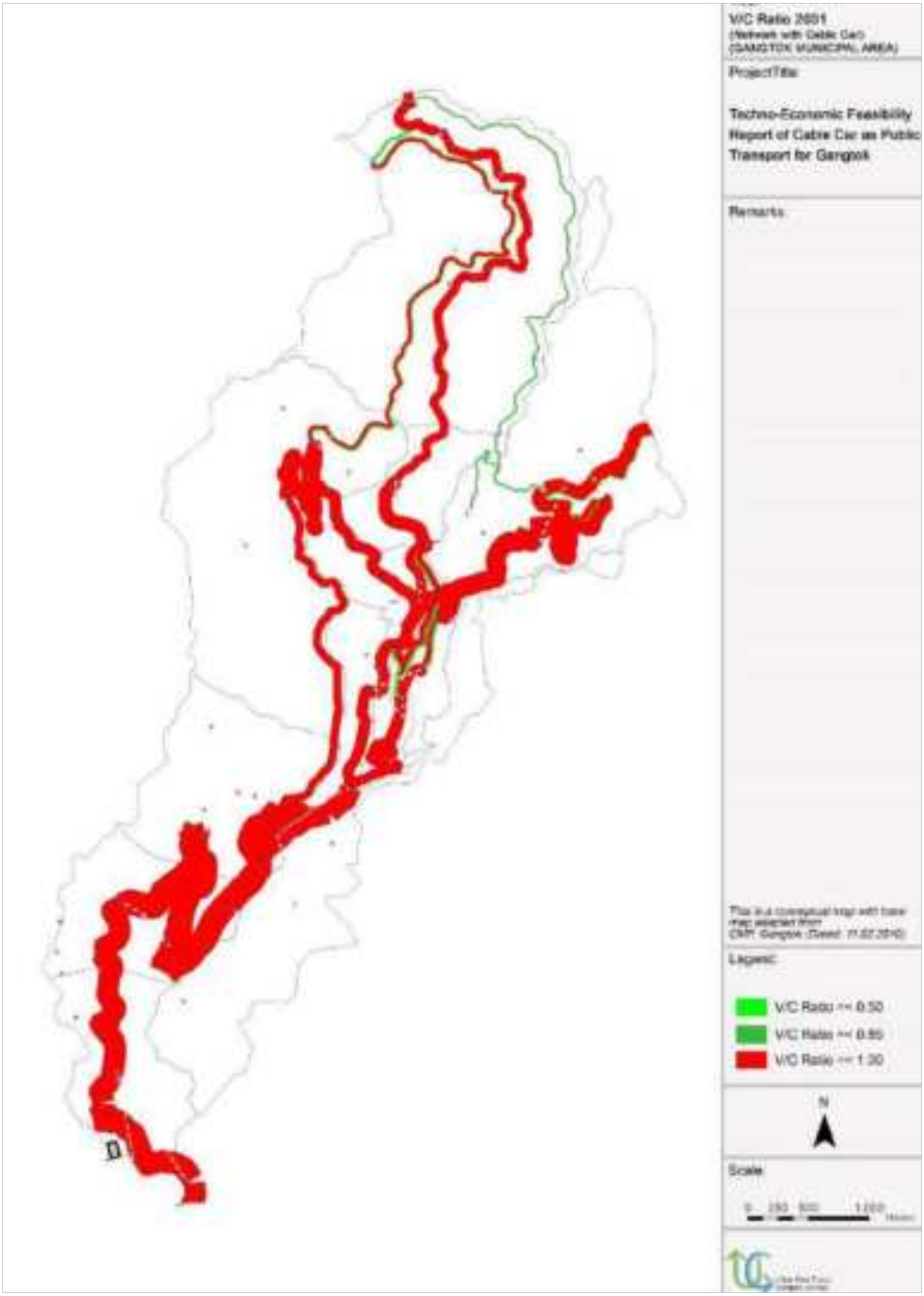


Figure 15-35: V/C Ratio in Project Scenario for the Year 2031

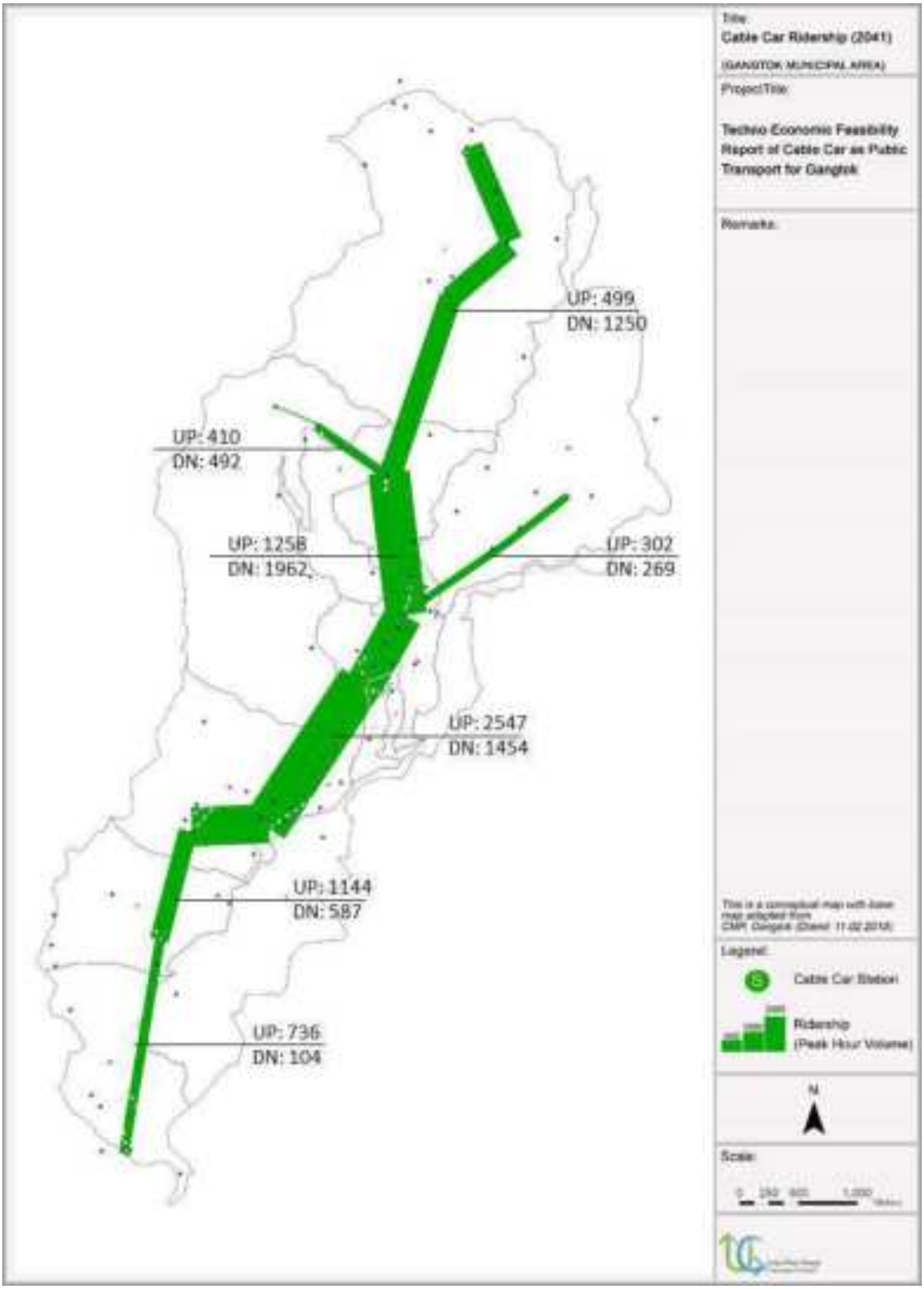


Figure 15-36: Cable Car System Ridership in the Year 2041

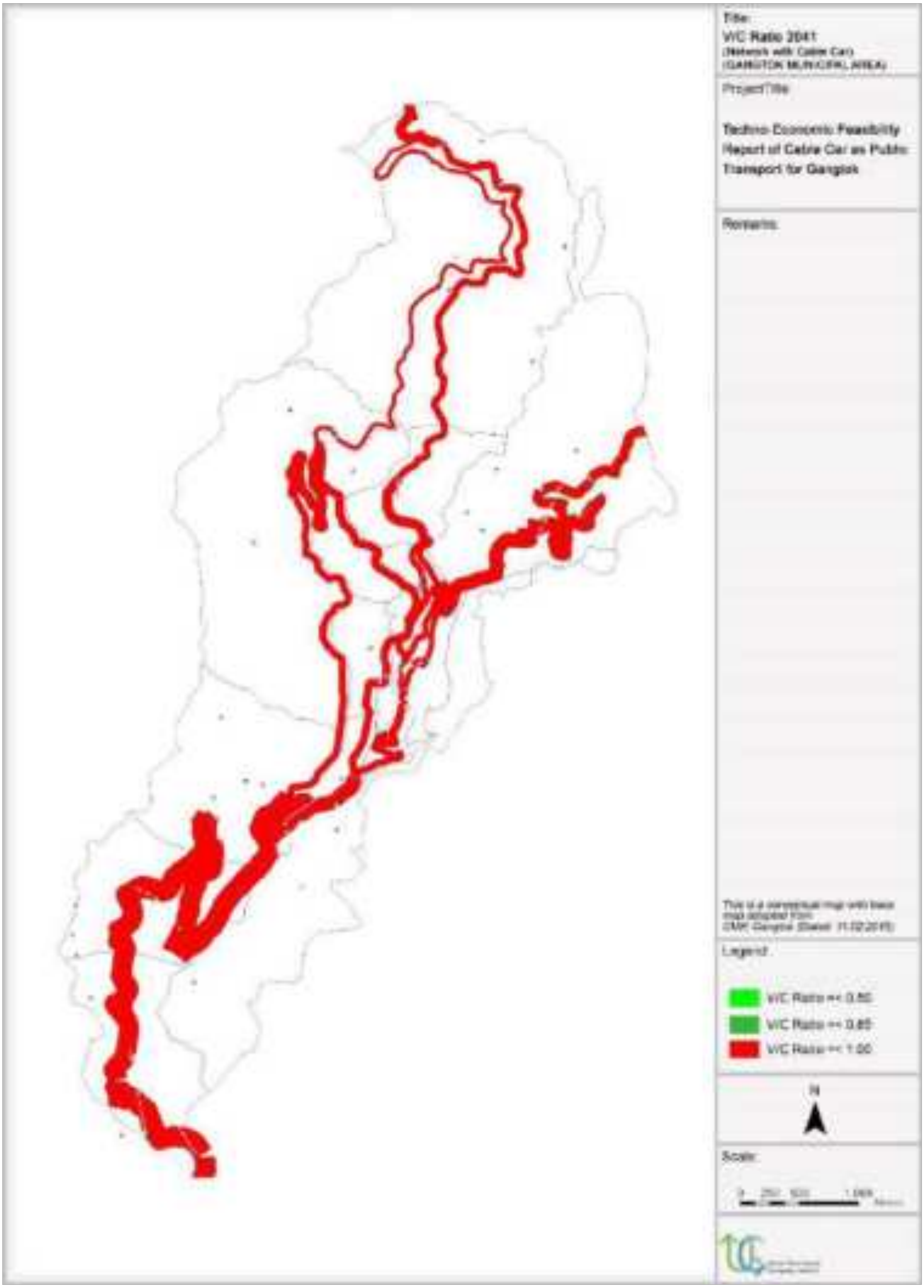


Figure 15-37: V/C Ratio in Project Scenario for the Year 2041

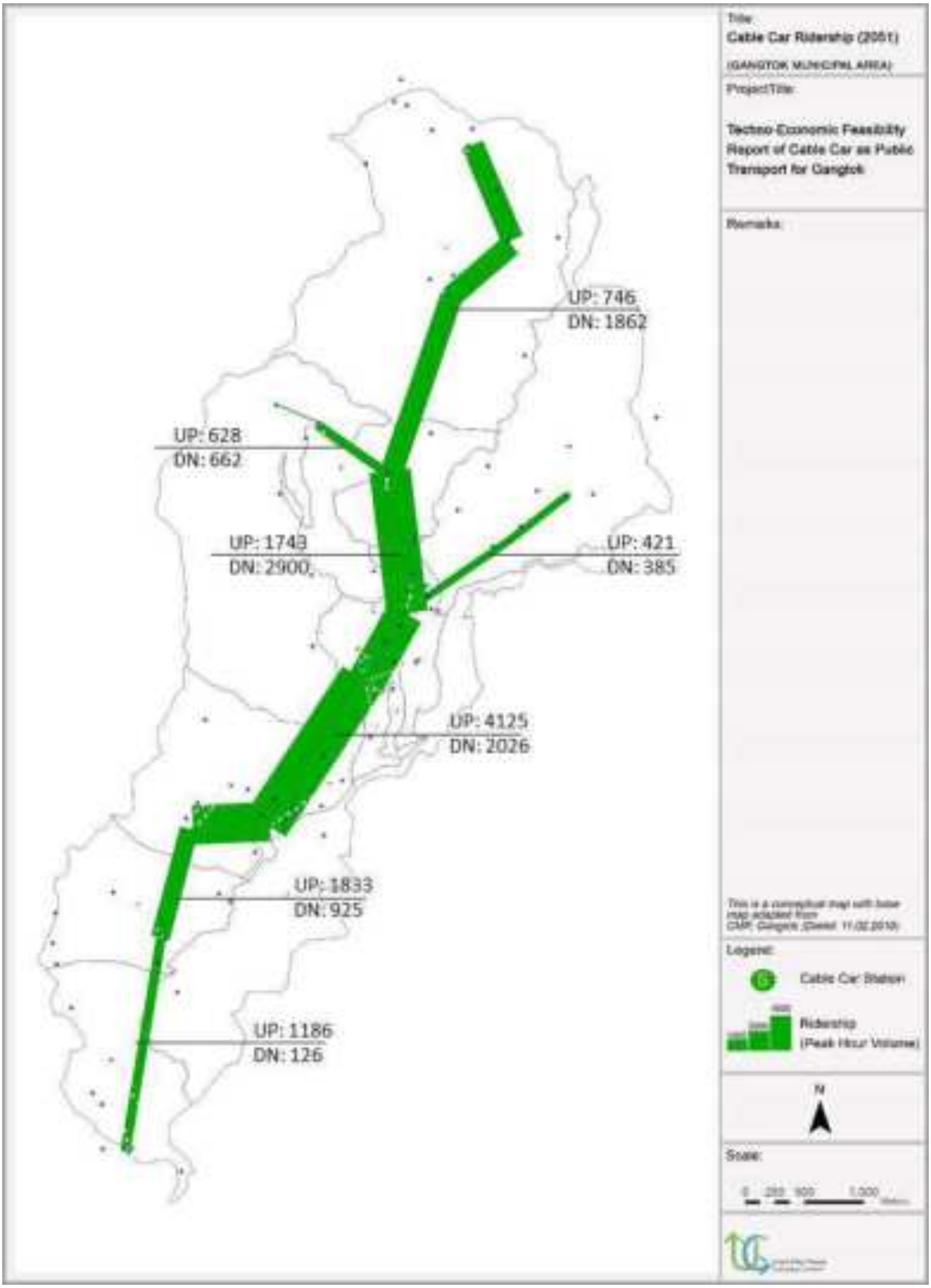


Figure 15-38: Cable Car System Ridership in the Year 2051

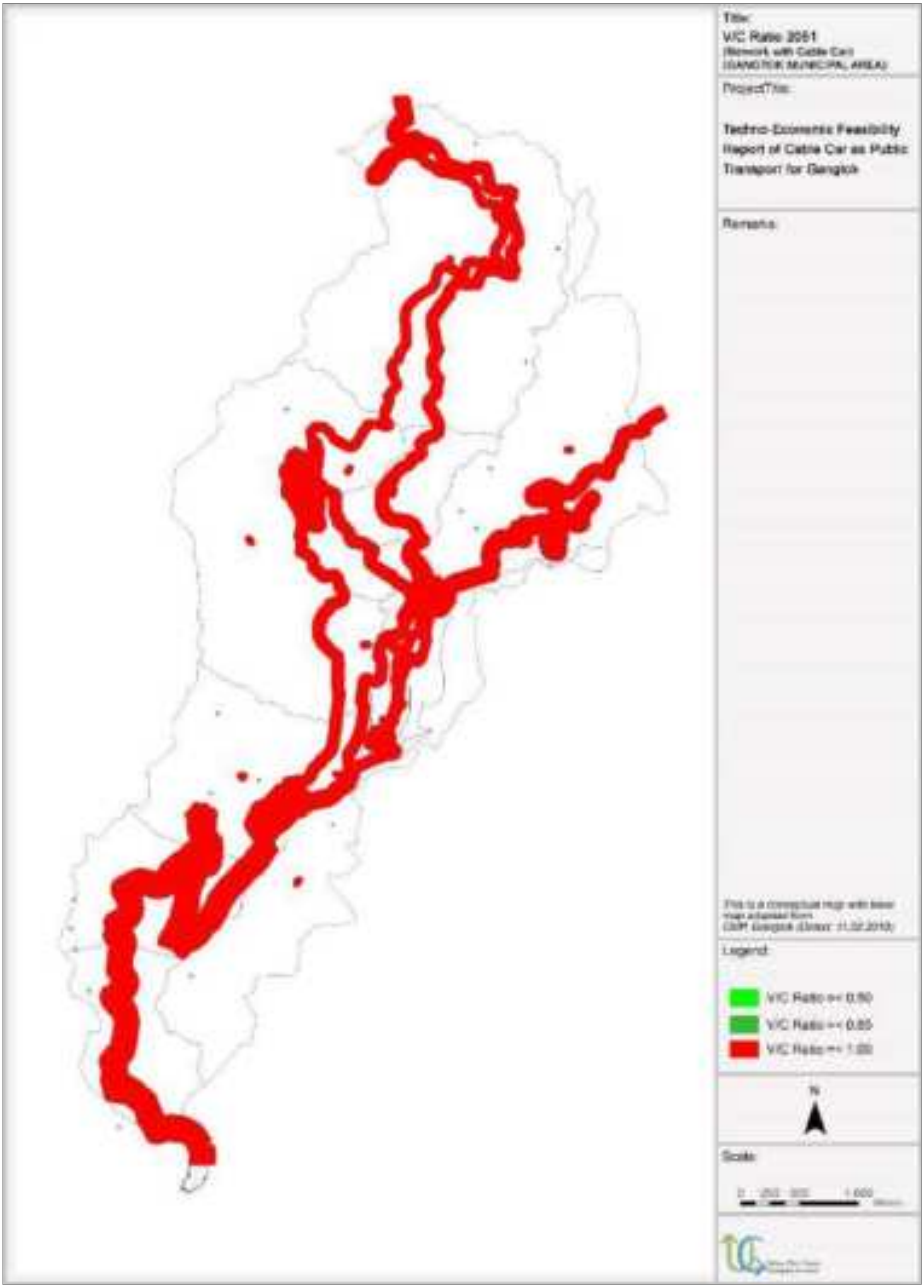


Figure 15-39: V/C Ratio in Project Scenario for the Year 2051

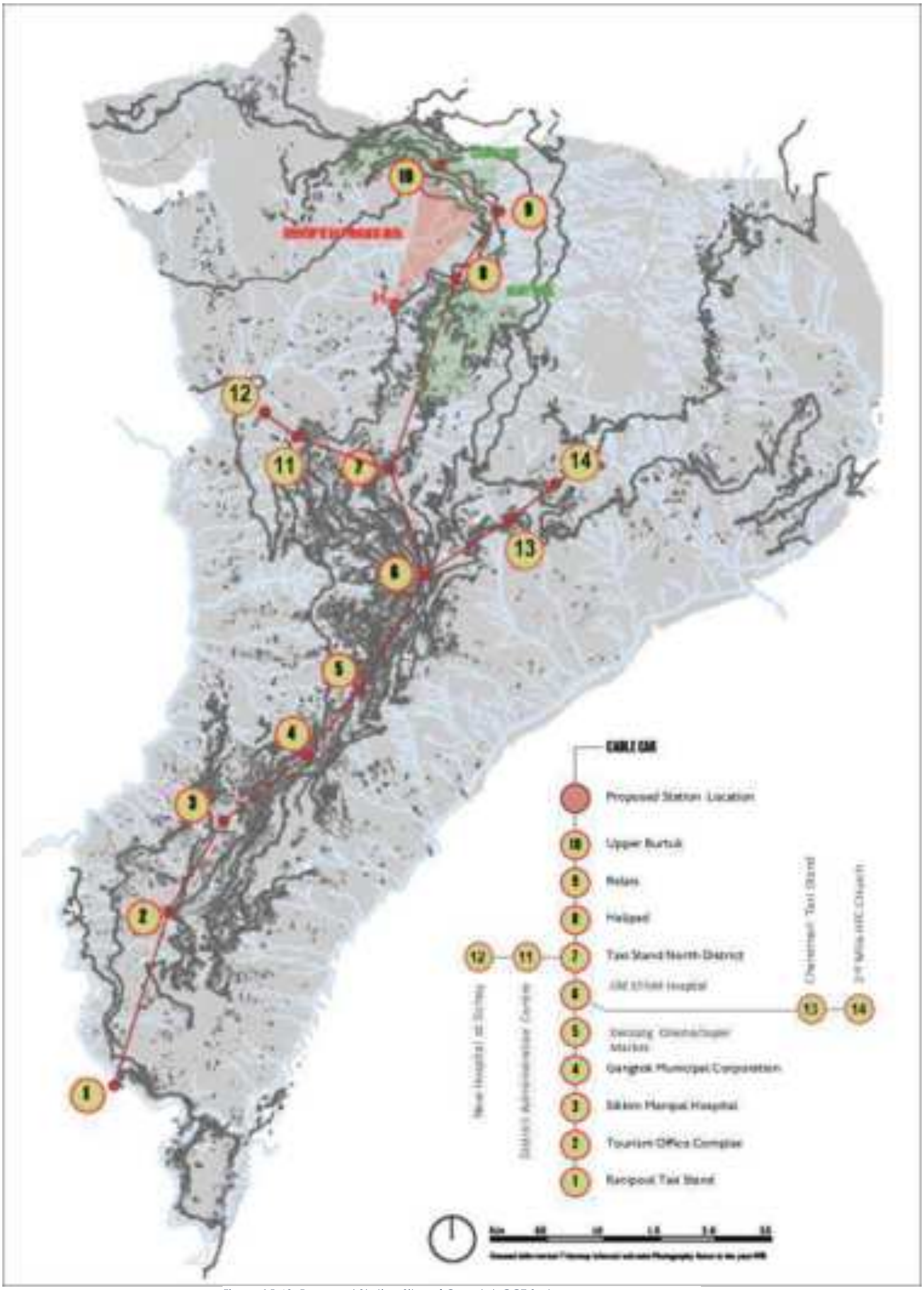


Figure 15-40: Proposed Station Sites of Gangtok CCT System

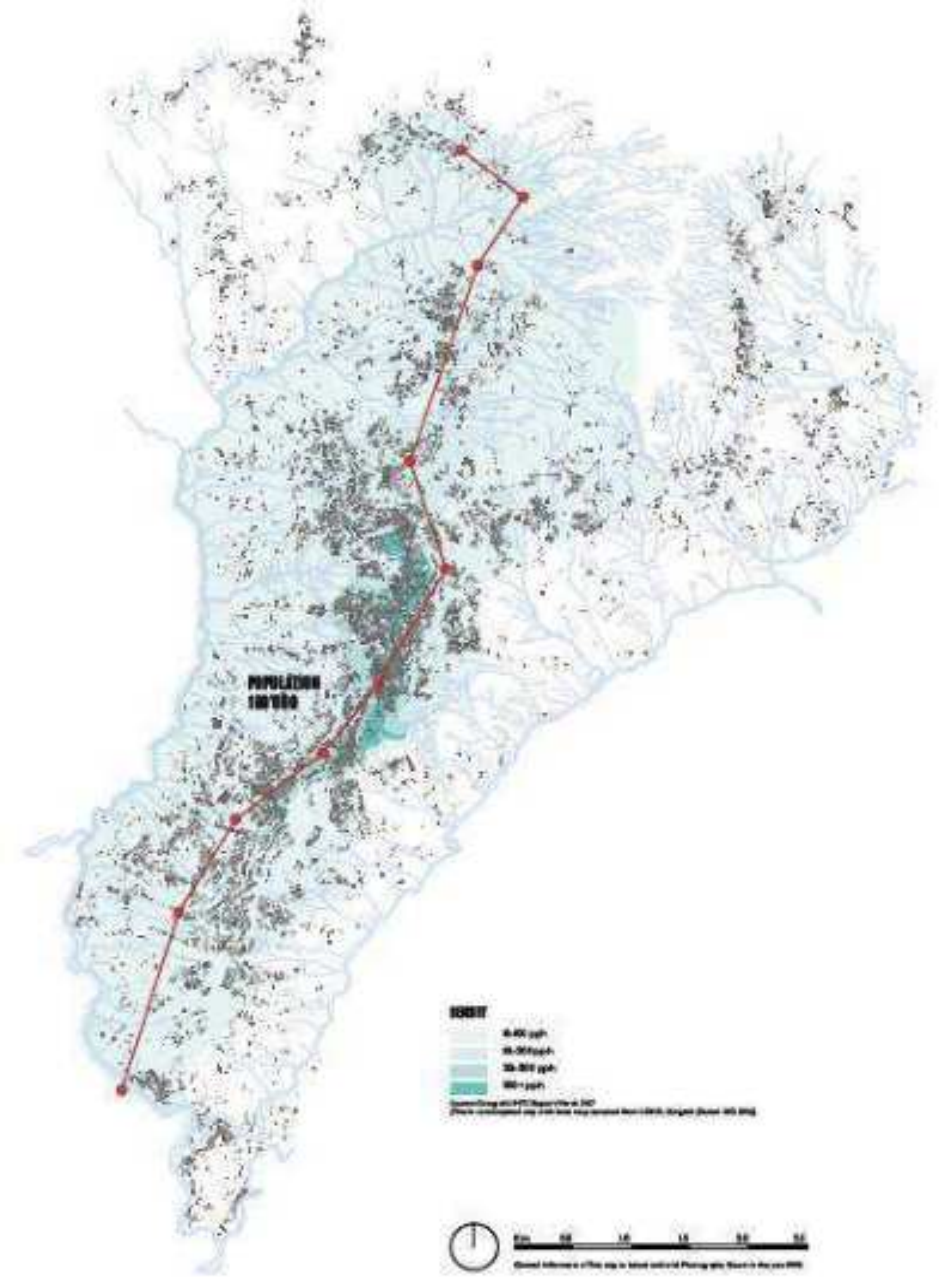


Figure 15-41: Population Density along Proposed CCT System Alignment

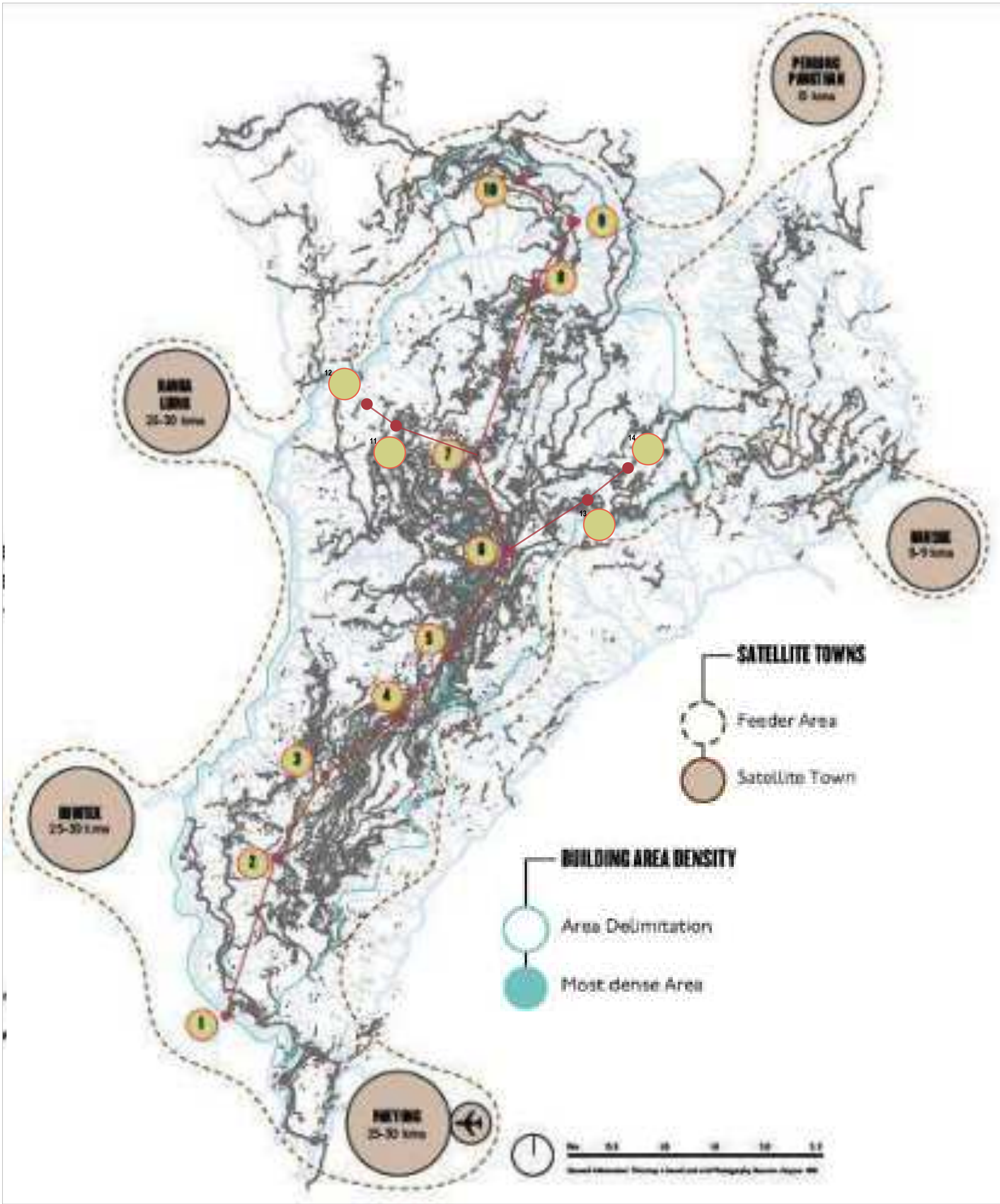
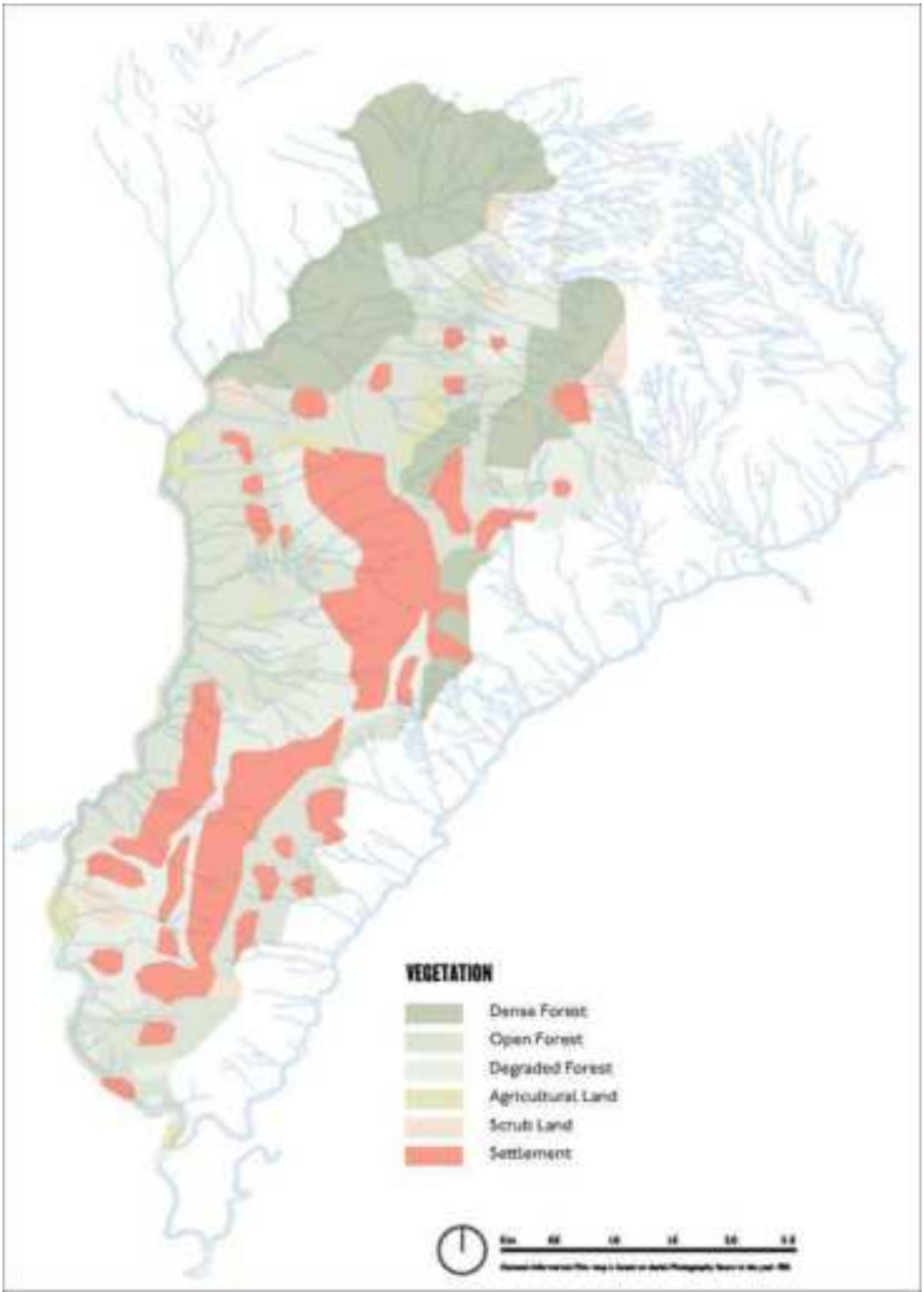


Figure 15-42: Building Density and Satellite Towns

Figure 15-43:



Schematic Representation of Vegetation Across Gangtok

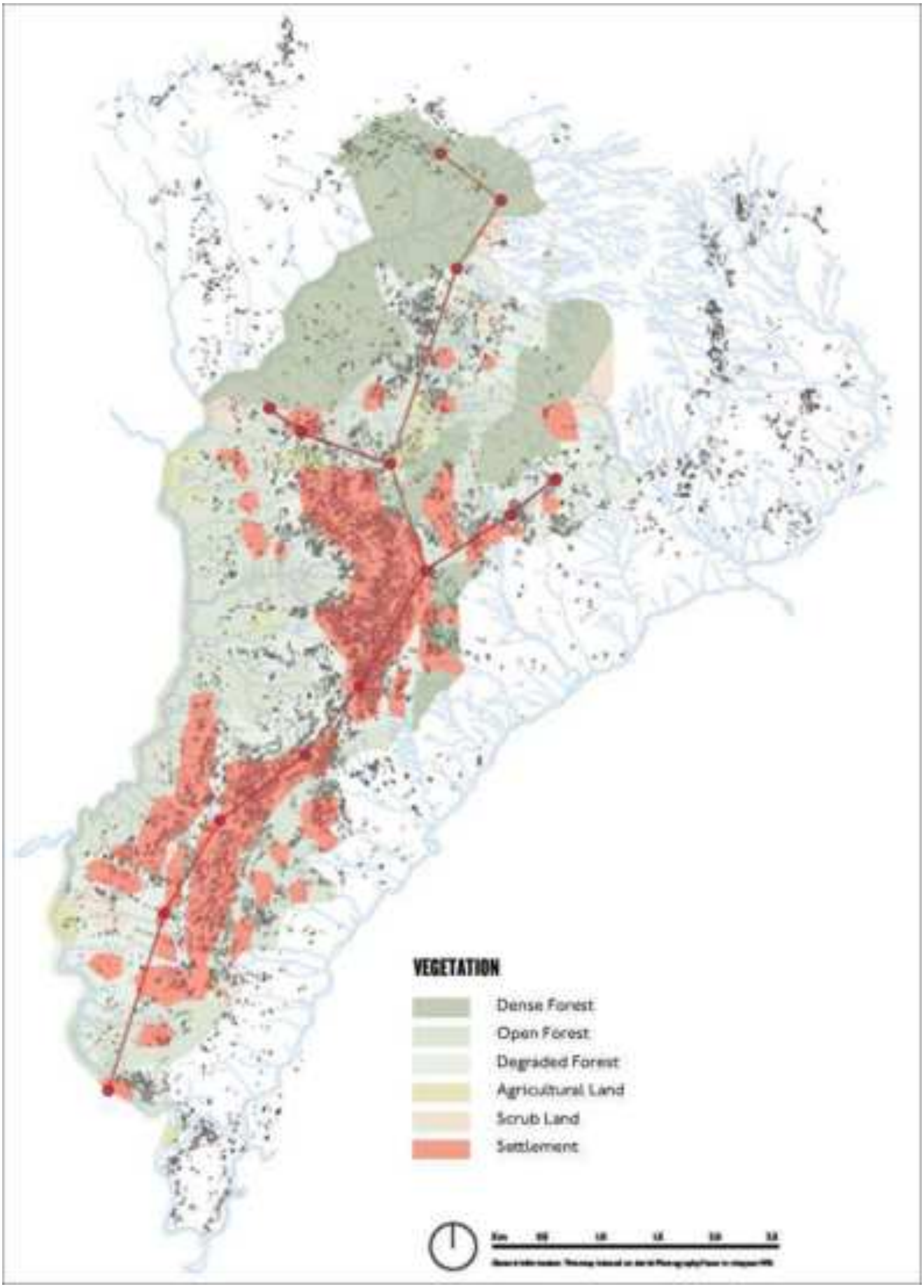


Figure 15-44: Schematic Representation of Vegetation, Settlements and CCT Line

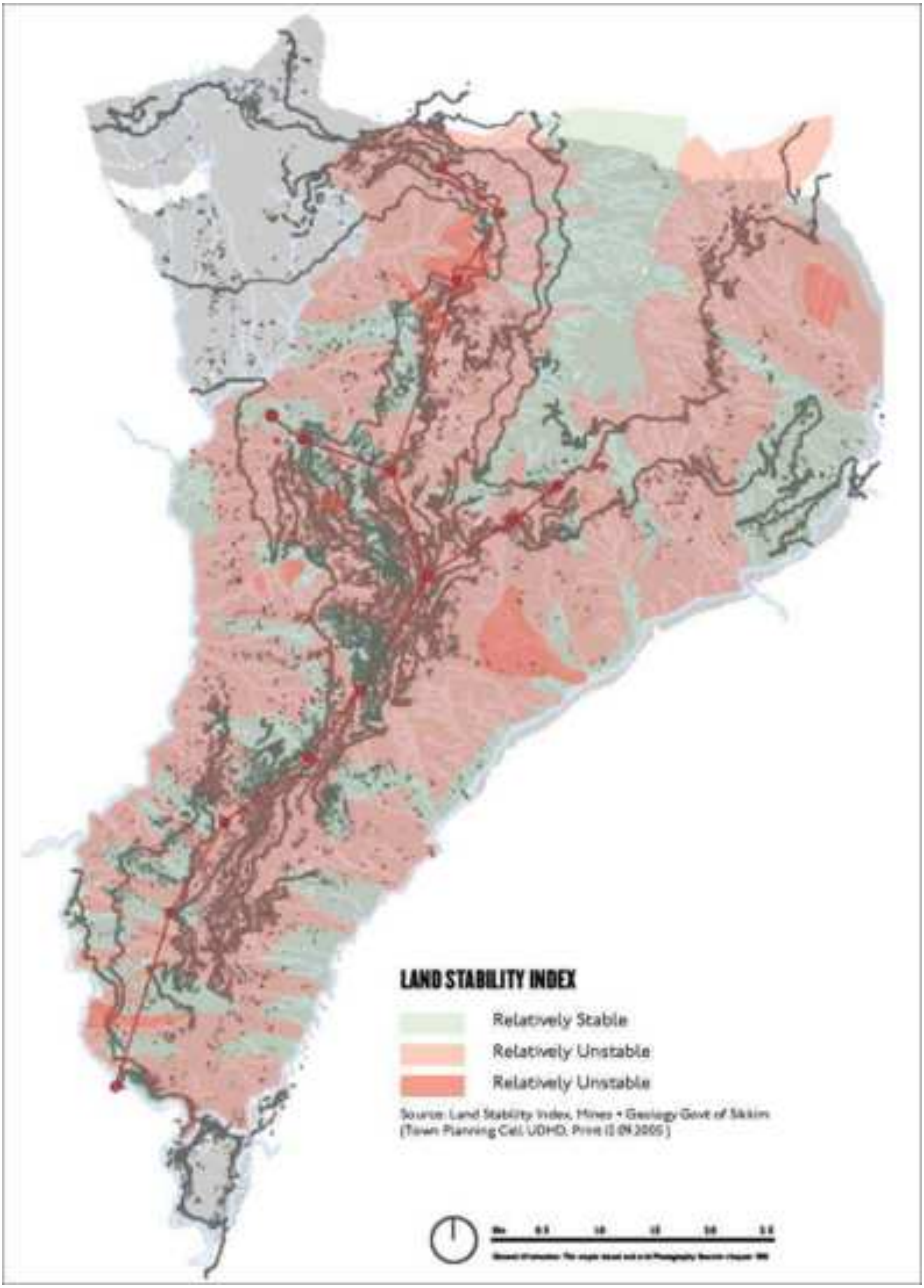


Figure 15-45: Schematic Representation of Land Stability Across Gangtok

Figure 15-46: Location of Local Taxi Stops/Stands Across Gangtok

Figure 15-47: Location of Regional Taxi Stands Across Gangtok

Figure 15-48: Location of Regional Bus Stands Across Gangtok

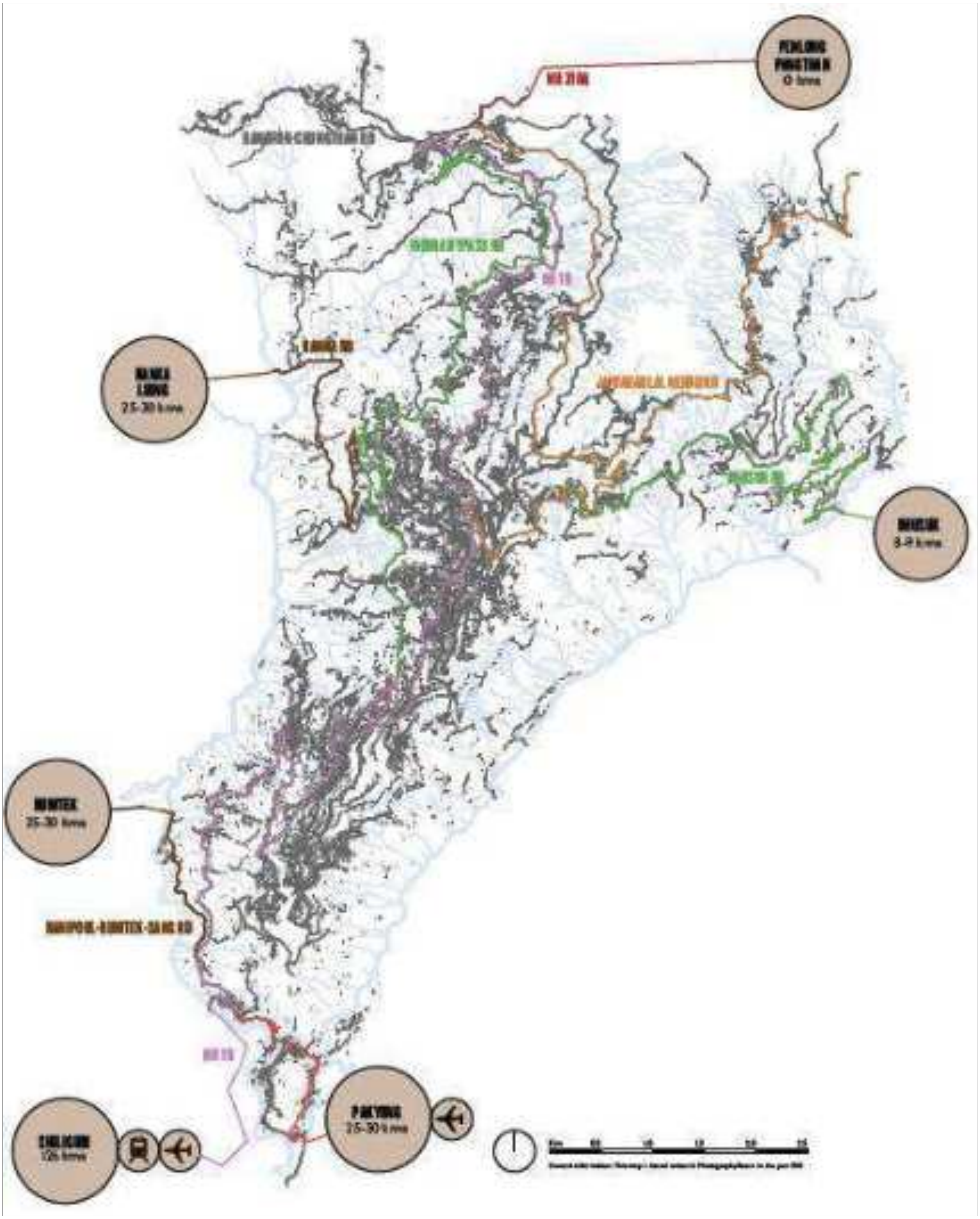


Figure 15-49: Major Roads in Gangtok

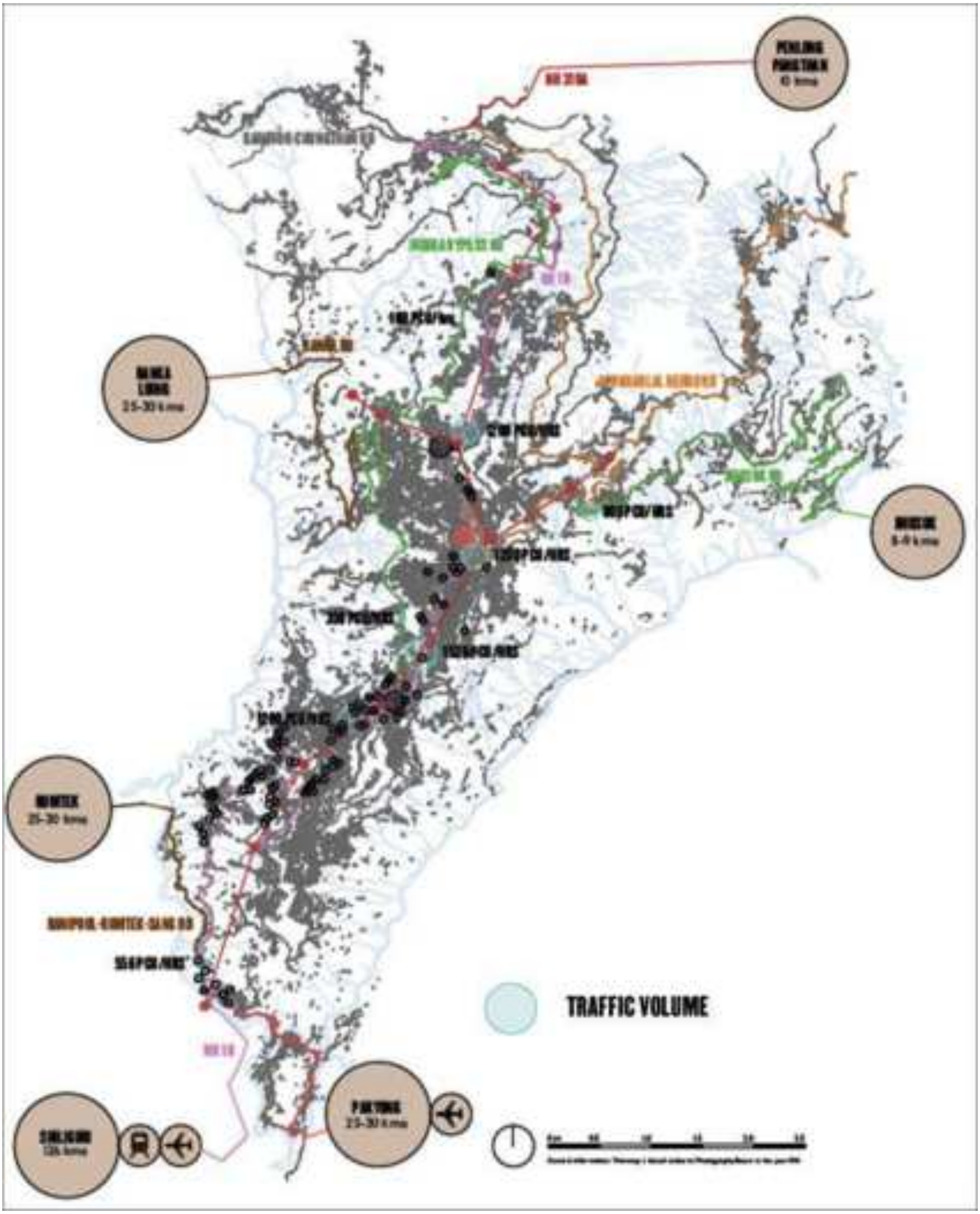


Figure 15-50: Traffic Volumes an Major Roads in Gangtok

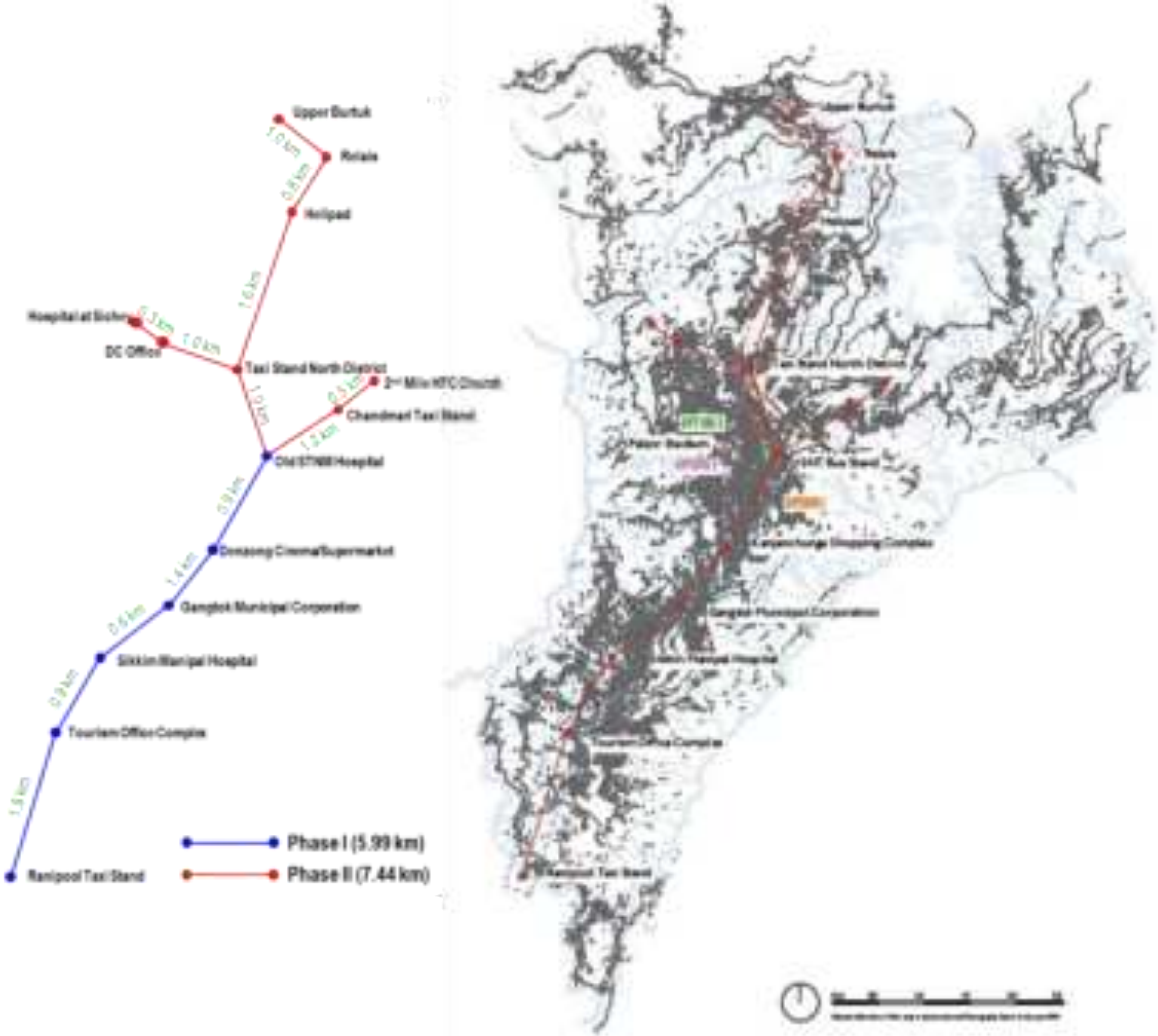


Figure 15-51: Gangtok Cable Car System Alignment and Phasing

Figure 15-52: Schematic Placement of Proposed MDG System at Identified Site at Taxi Stand Ranipool Station Location

Figure 15-53: Aerial View of Proposed Taxi Stand Ranipool MDG Station and Surrounding Area

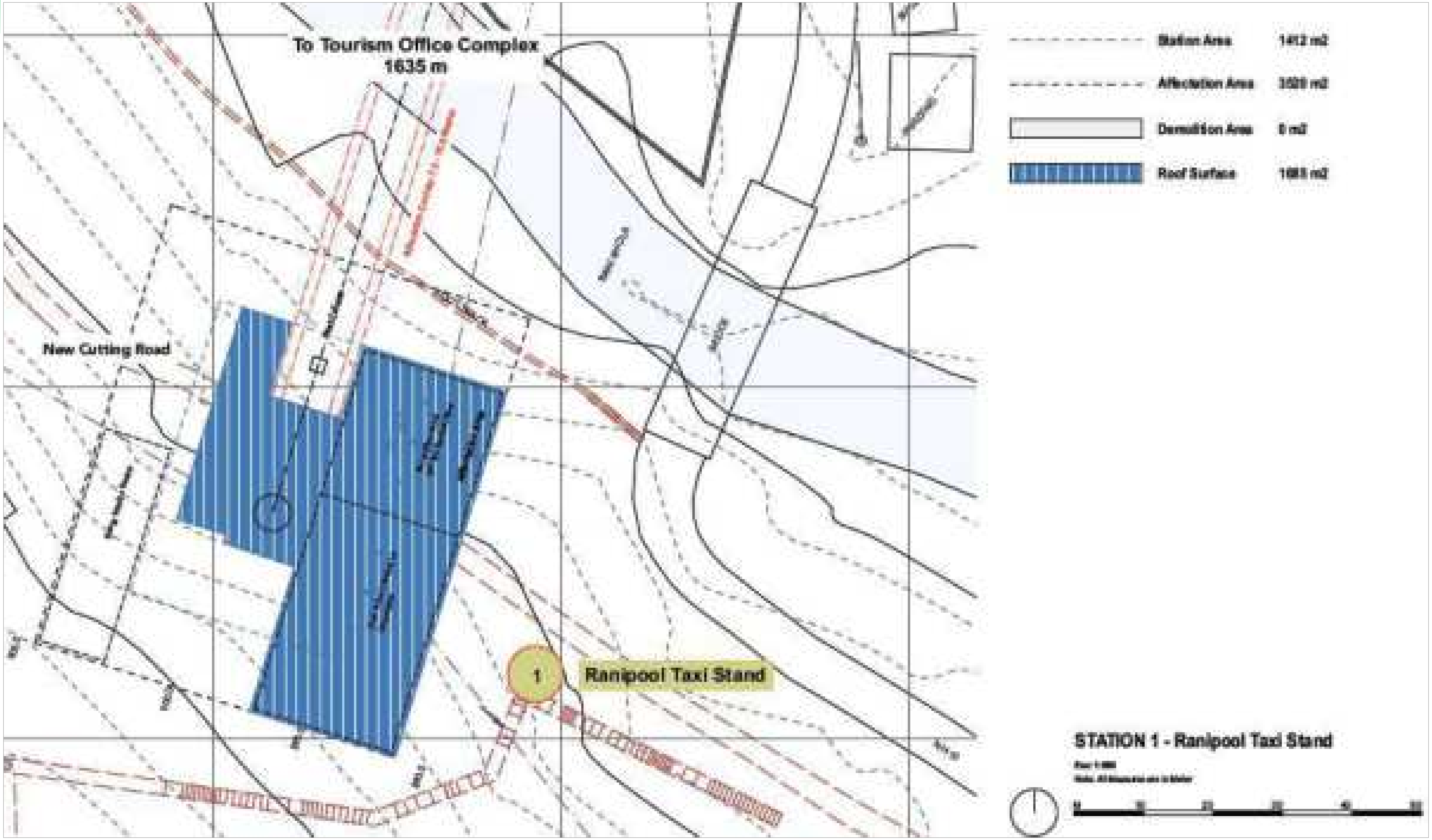


Figure 15-54: Schematic Placement of Proposed Taxi Stand Ranipool MDG Station on Topographical Survey Map of 2017

Figure 15-55: Schematic Placement of Proposed MDG System at Identified Site at Tourism Office Complex Station Location

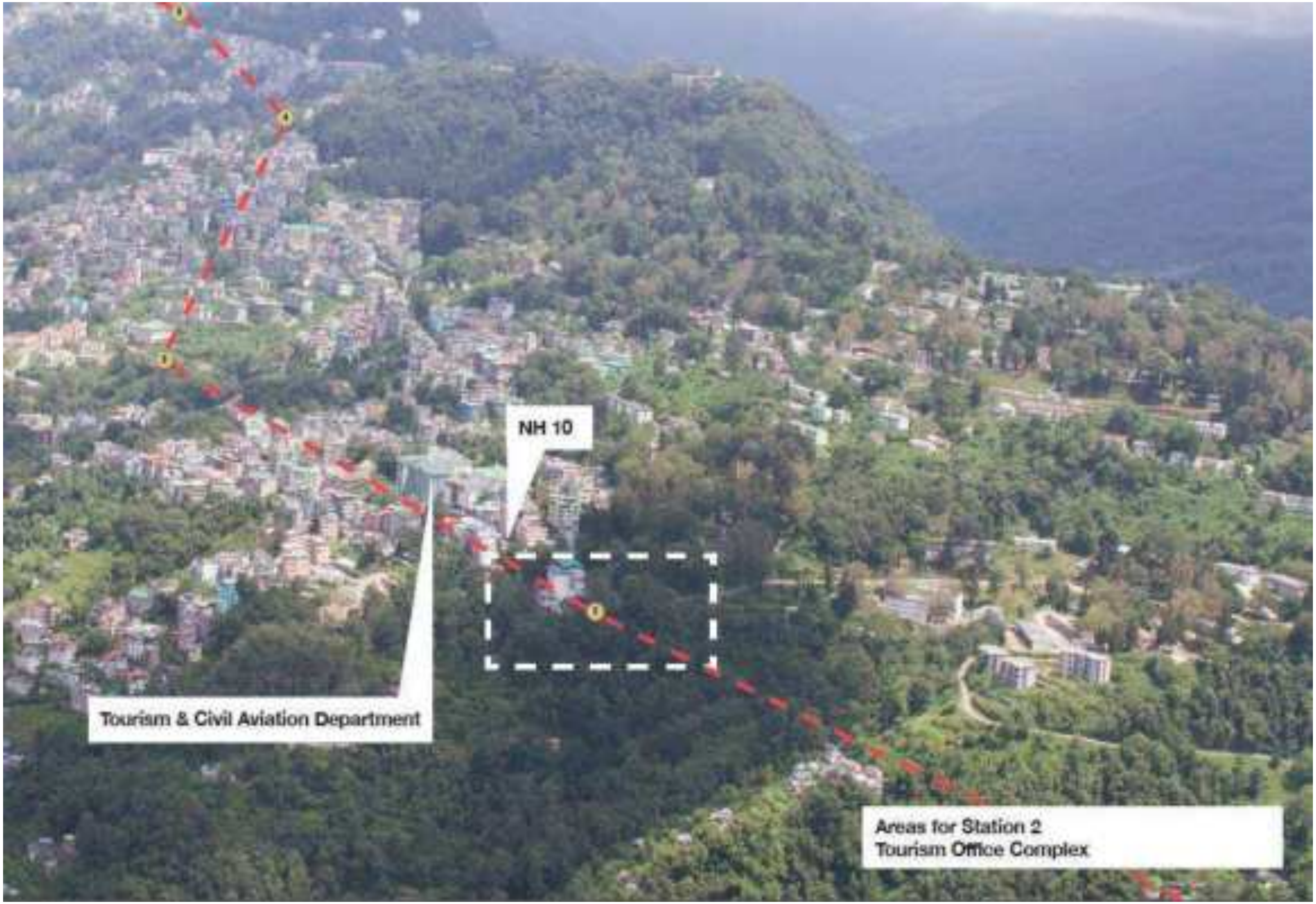


Figure 15-56: Aerial View of Proposed Tourism Office Complex MDG Station and Surrounding Areas

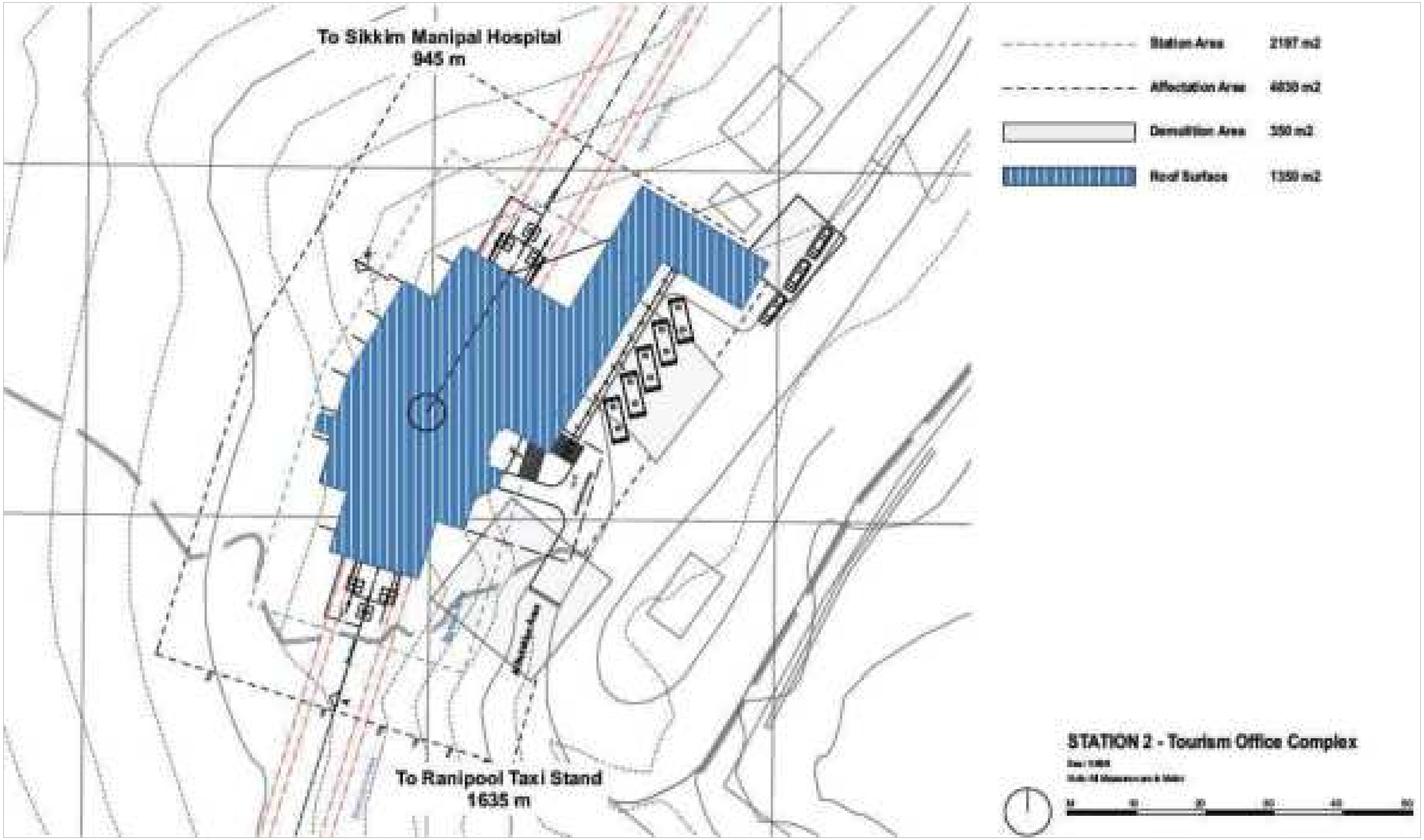


Figure 15-57: Schematic Placement of Proposed Tourism Office Complex MDG Station on Topographical Survey Map of 2017

Figure 15-58: Schematic Placement of Proposed MDG System at Identified Site at Sikkim Manipal Hospital Station Location

Figure 15-59: Aerial View of Proposed Sikkim Manipal Hospital MDG Station and Surrounding Areas

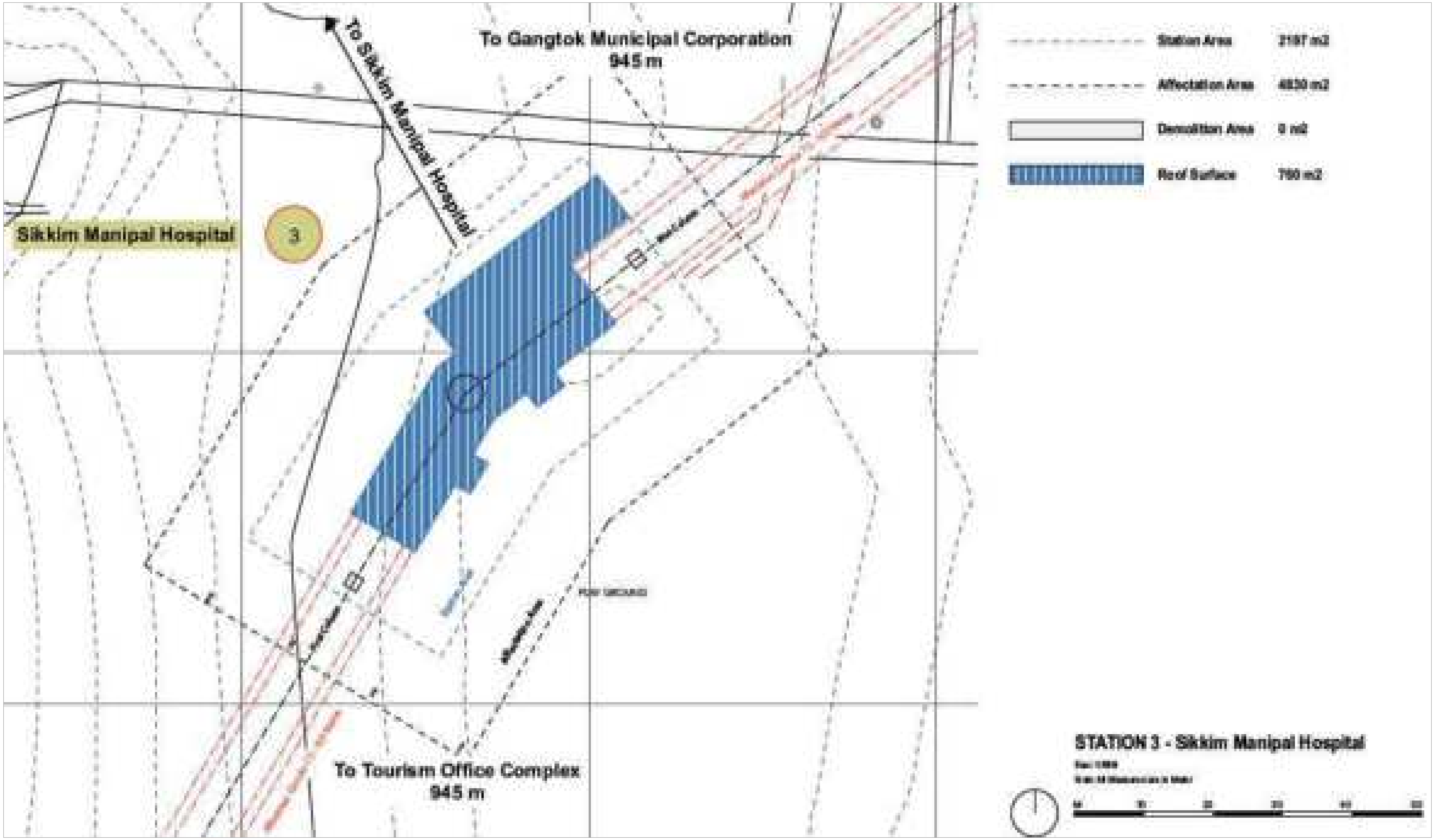


Figure 15-60: Schematic Placement of Proposed Sikkim Manipal Hospital MDG Station on Topographical Survey Map of 2017

Figure 15-61: Schematic Placement of Proposed MDG System at Identified Site at Gangtok Municipal Corporation Station Location

Figure 15-62: Aerial View of Proposed Gangtok Municipal Corporation MDG Station and Surrounding Areas

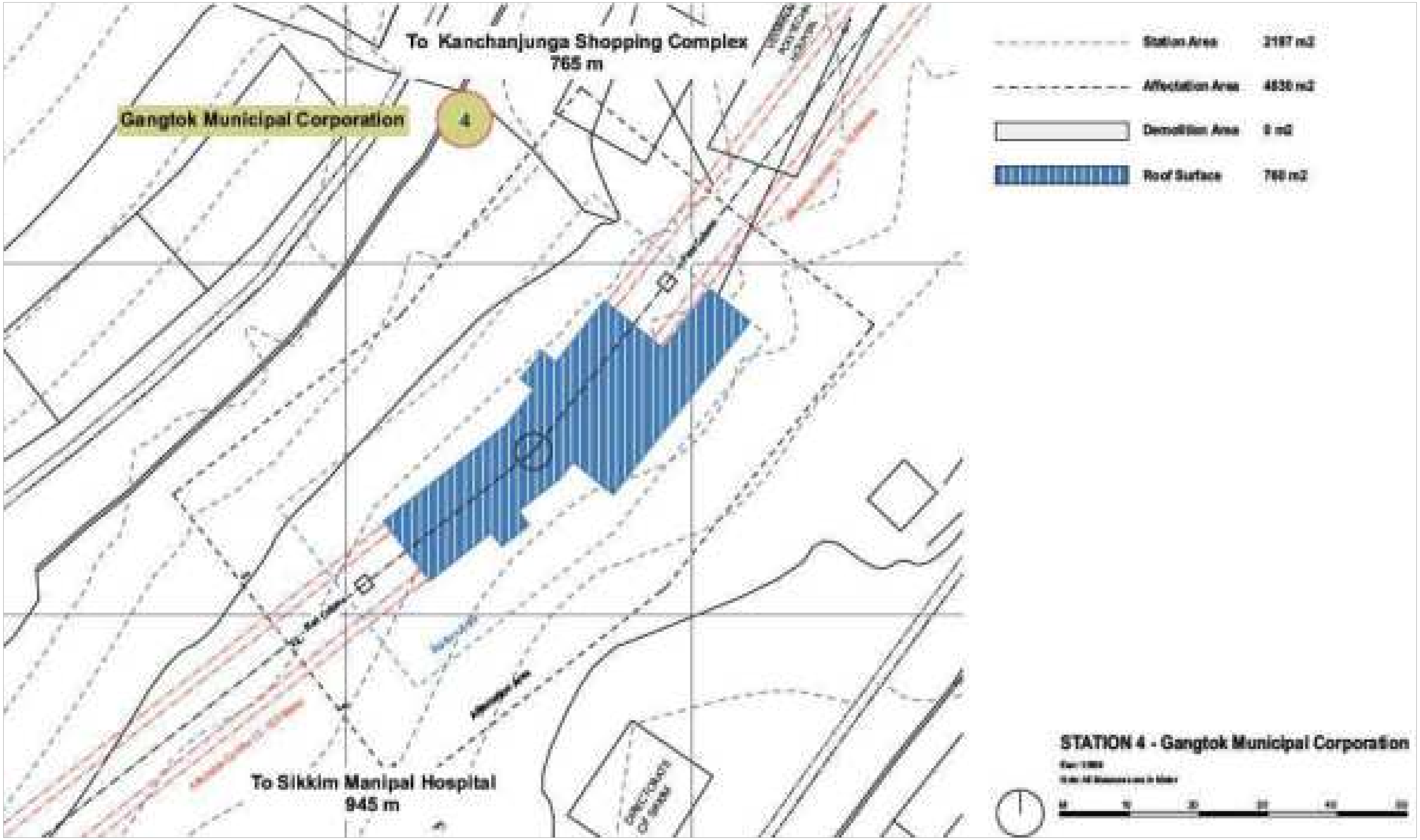


Figure 15-63: Schematic Placement of Proposed Gangtok Municipal Corporation MDG Station on Topographical Survey Map of 2017

Figure 15-64: Schematic Placement of Proposed MDG System at Identified Site at Denzong Cinema/Supermarket Station Location

Figure 15-65: Aerial View of Proposed Denzong Cinema/Supermarket MDG Station and Surrounding Areas

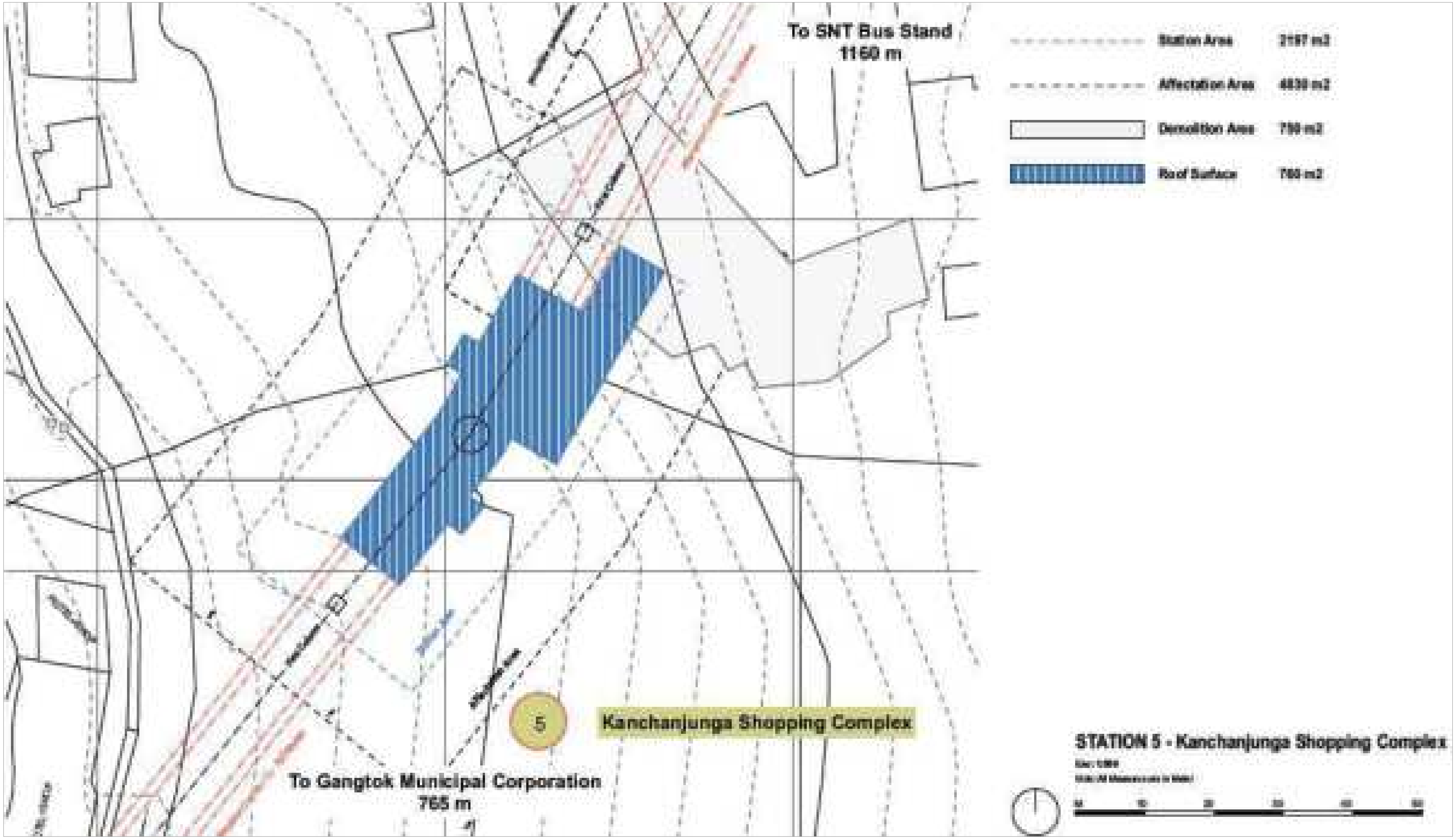


Figure 15-66: Schematic Placement of Proposed Kanchanjunga Shopping Complex MDG Station on Topographical Survey Map of 2017

Figure 15-67: Schematic Placement of Proposed MDG System at Identified Site at 'STNM Hospital' Station Location

Figure 15-68: Aerial View of Proposed 'Old STNM Hospital Station' and Surrounding Areas

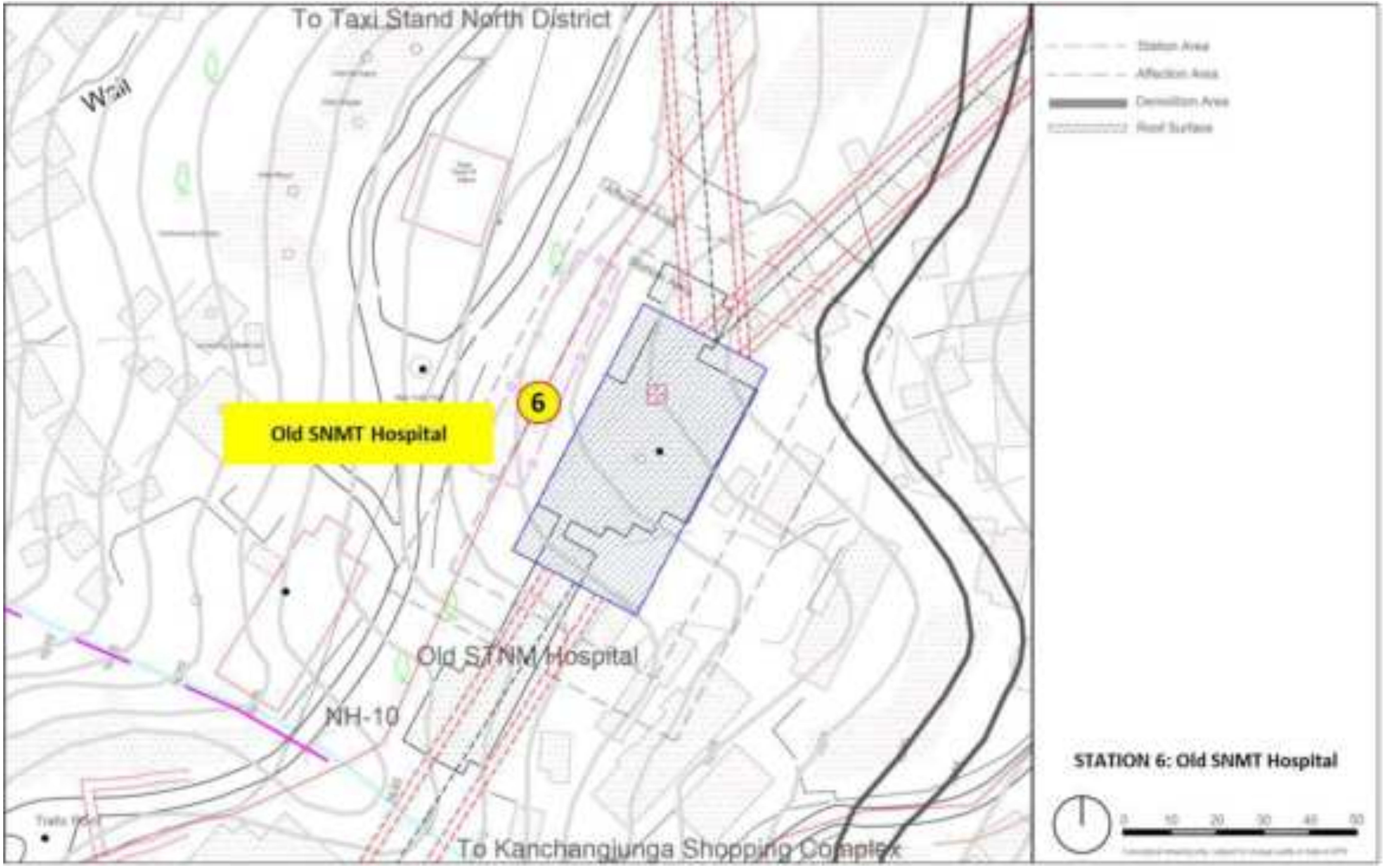


Figure 15-69: Schematic Placement of Proposed 'Old STNM Hospital Station' on Topographical Survey Map of 2017

Figure 15-70: Schematic Placement of Proposed MDG System at Identified Site at Taxi Stand North District Station Location

Figure 15-71: Aerial View of Proposed Taxi Stand North District MDG Station and Surrounding Areas

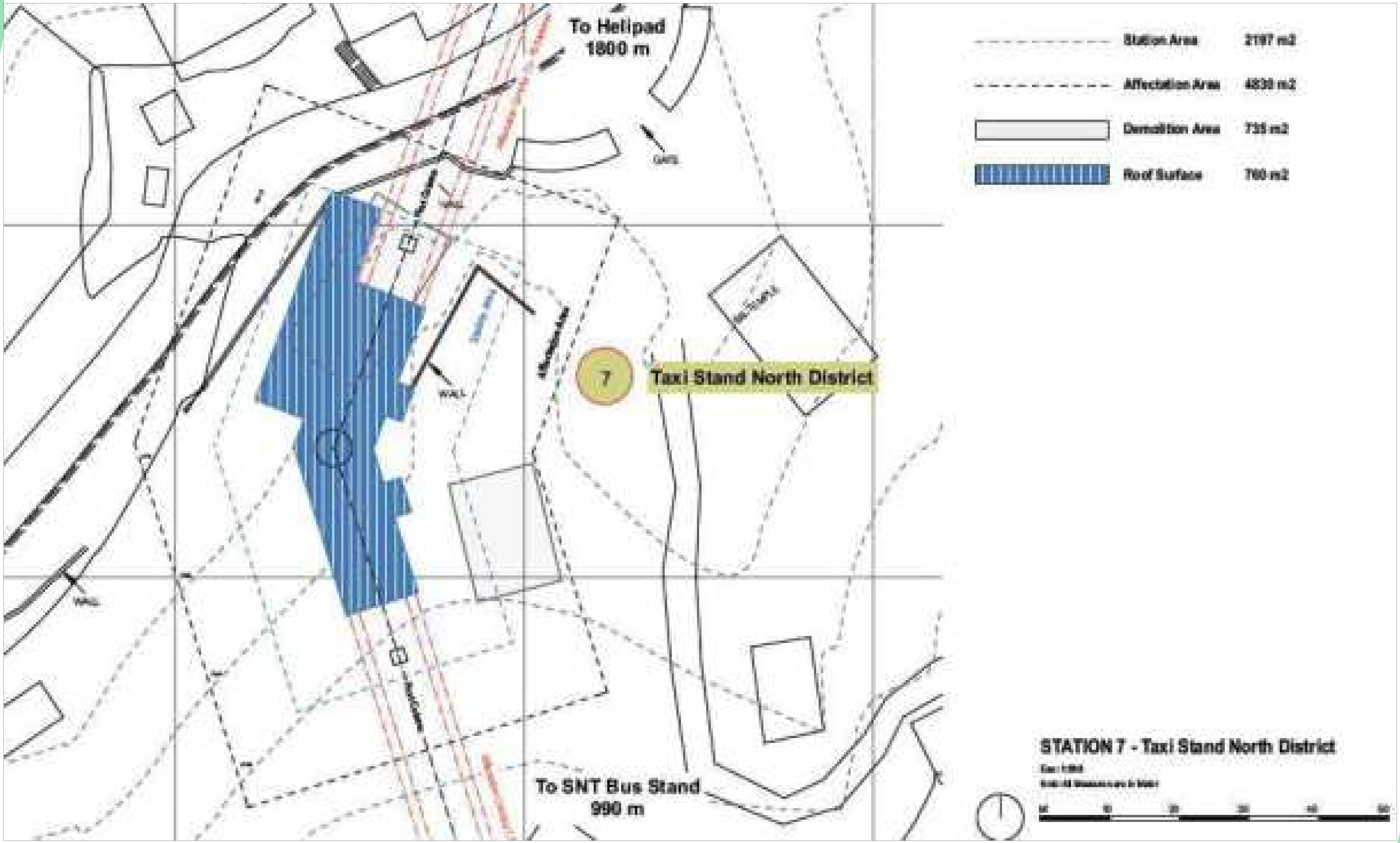


Figure 15-72: Schematic Placement of Proposed Taxi Stand North District MDG Station on Topographical Survey Map of 2017

Figure 15-73: Schematic Placement of Proposed MDG System at Identified Site at Helipad Station Location

Figure 15-74: Aerial View of Proposed Helipad MDG Station and Surrounding Areas

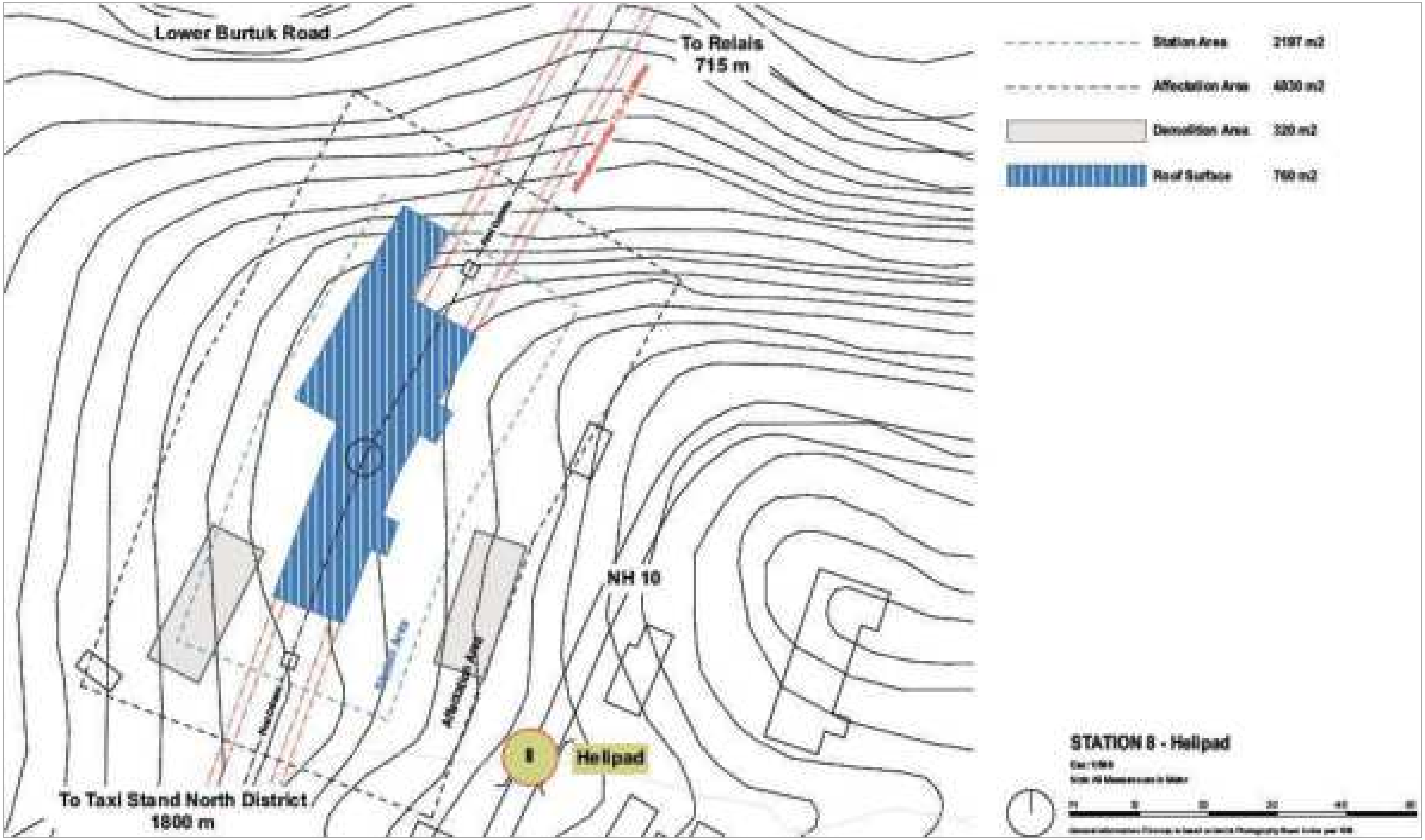


Figure 15-75: Schematic Placement of Proposed Helipad MDG Station on Topographical Survey Map of 2017

Figure 15-76: Schematic Placement of Proposed MDG System at Identified Site at Relias Station Location

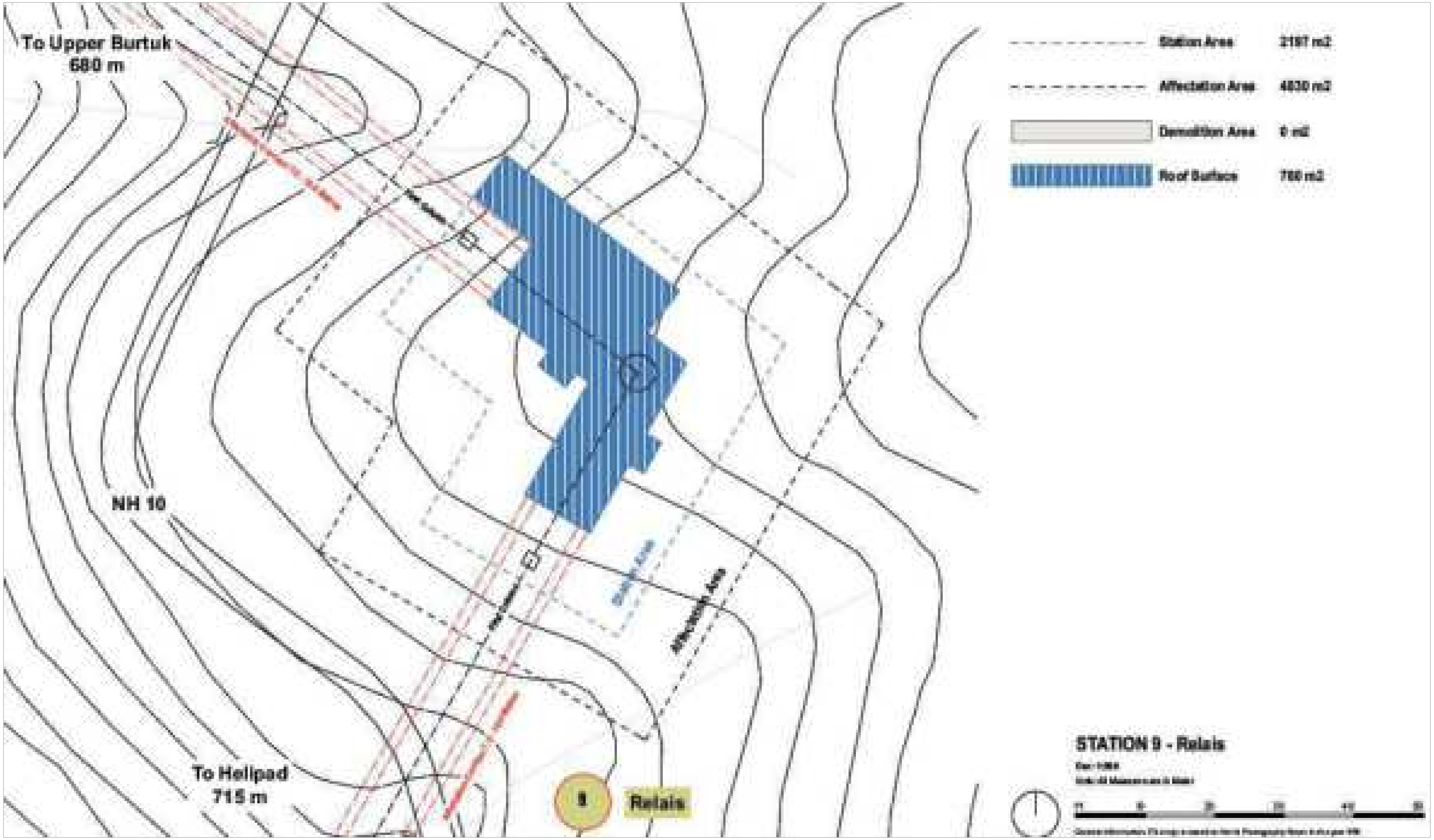


Figure 15-77: Schematic Placement of Proposed Relias MDG Station on Topographical Survey Map of 2017

Figure 15-78: Schematic Placement of Proposed MDG System at Identified Site at Upper Burtuk Station Location

Figure 15-79: Aerial View of Proposed Upper Burtuk MDG Station and Surrounding Areas

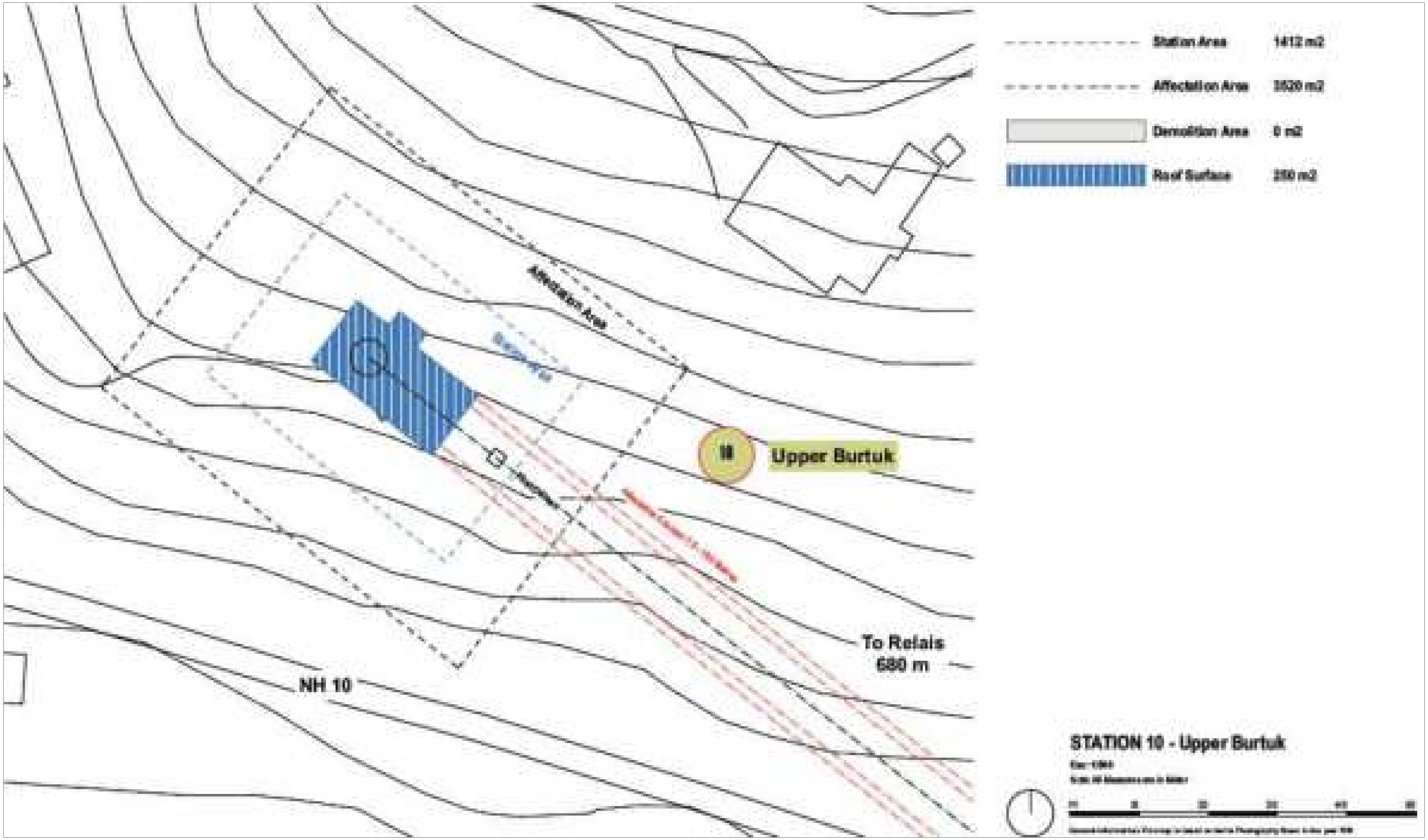


Figure 15-80: Schematic Placement of Proposed Upper Burtuk MDG Station on Topographical Survey Map of 2017

Figure 15-81: Schematic Placement of Proposed District Administrative Center station

Figure 15-82: Aerial View of Proposed DAC Station and Surrounding Areas

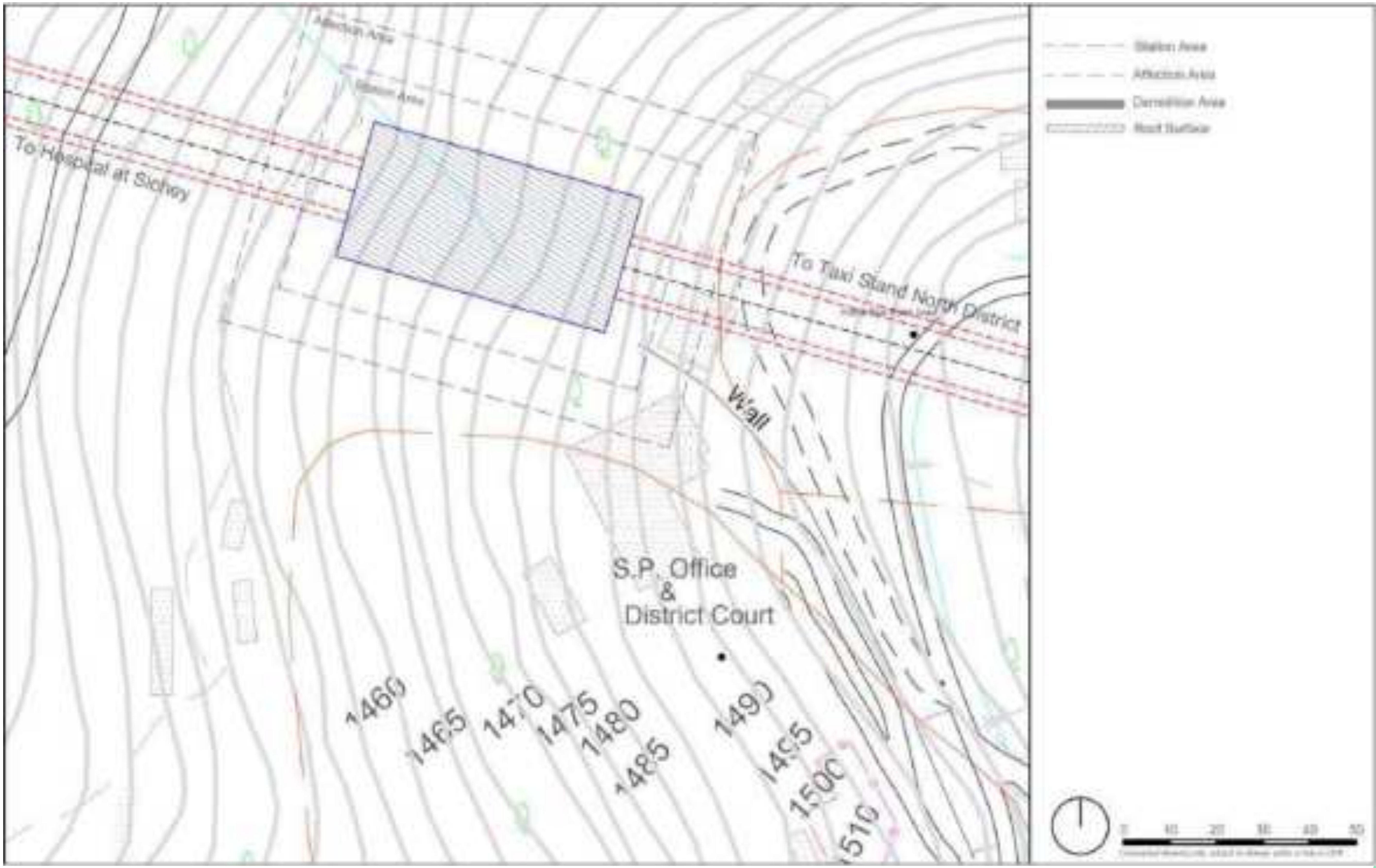


Figure 15-83: Schematic Placement of Proposed DAC Station on Topographical Survey Map of 2017

Figure 15-84: Schematic Placement of Proposed 'Hospital at Sichey' station

Figure 15-85: Aerial View of Proposed 'Hospital at Sichey' and Surrounding Areas

Figure 15-86: Schematic Placement of Proposed 'Hospital at Sichey- Station' on Topographical Survey Map of 2017

Figure 15-87: Schematic Placement of Proposed 'Chandmari Taxi Stand' station

Figure 15-88: Aerial View of Proposed 'Chandmari Taxi Stand' and Surrounding Areas

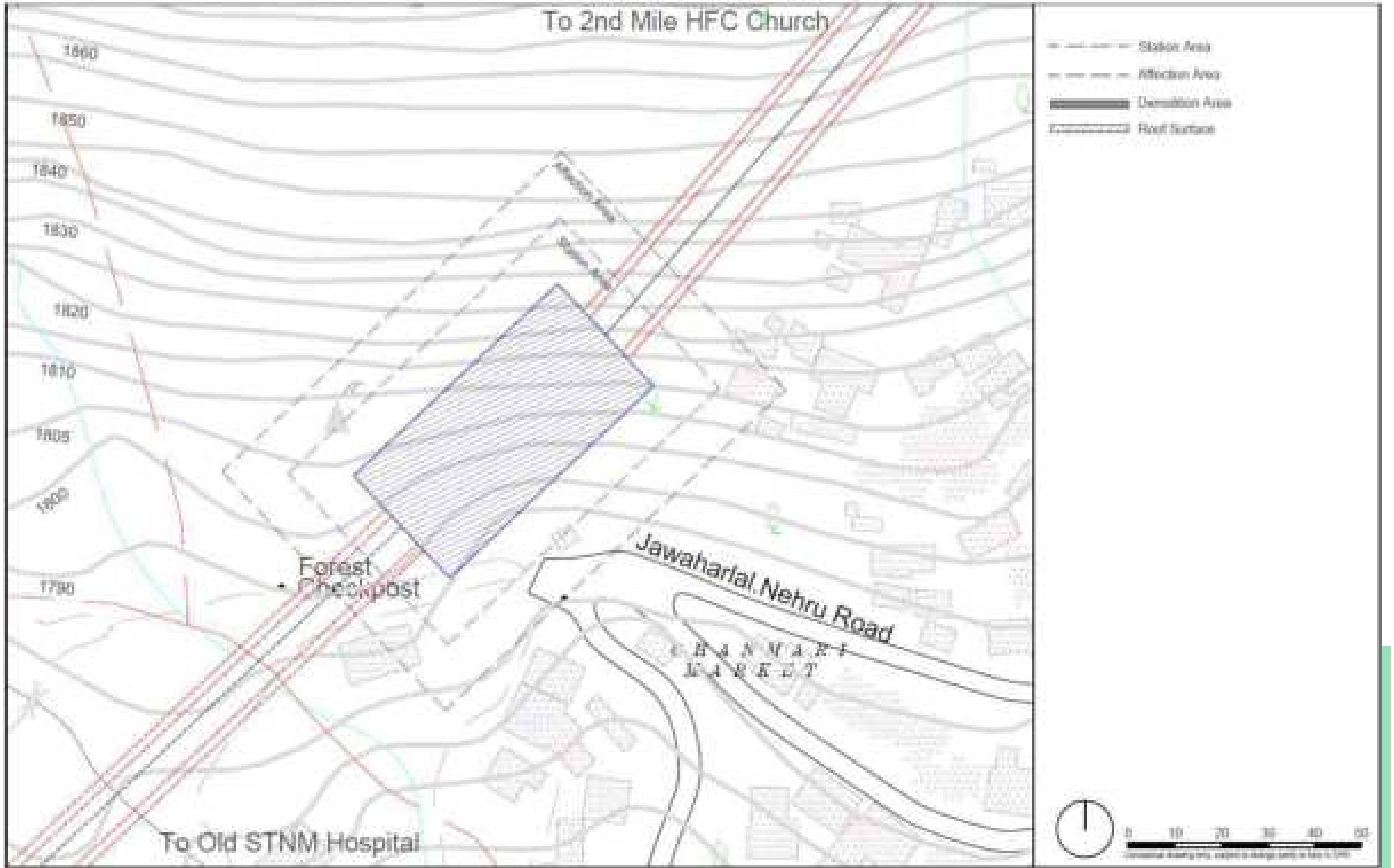


Figure 15-89: Schematic Placement of Proposed 'Chandmari Taxi Stand Station' on Topographical Survey Map of 2017

Figure 15-90: Schematic Placement of Proposed '2nd Mile HFC Church' station

Figure 15-91: Aerial View of Proposed '2nd Mile HFC Church' and Surrounding Areas

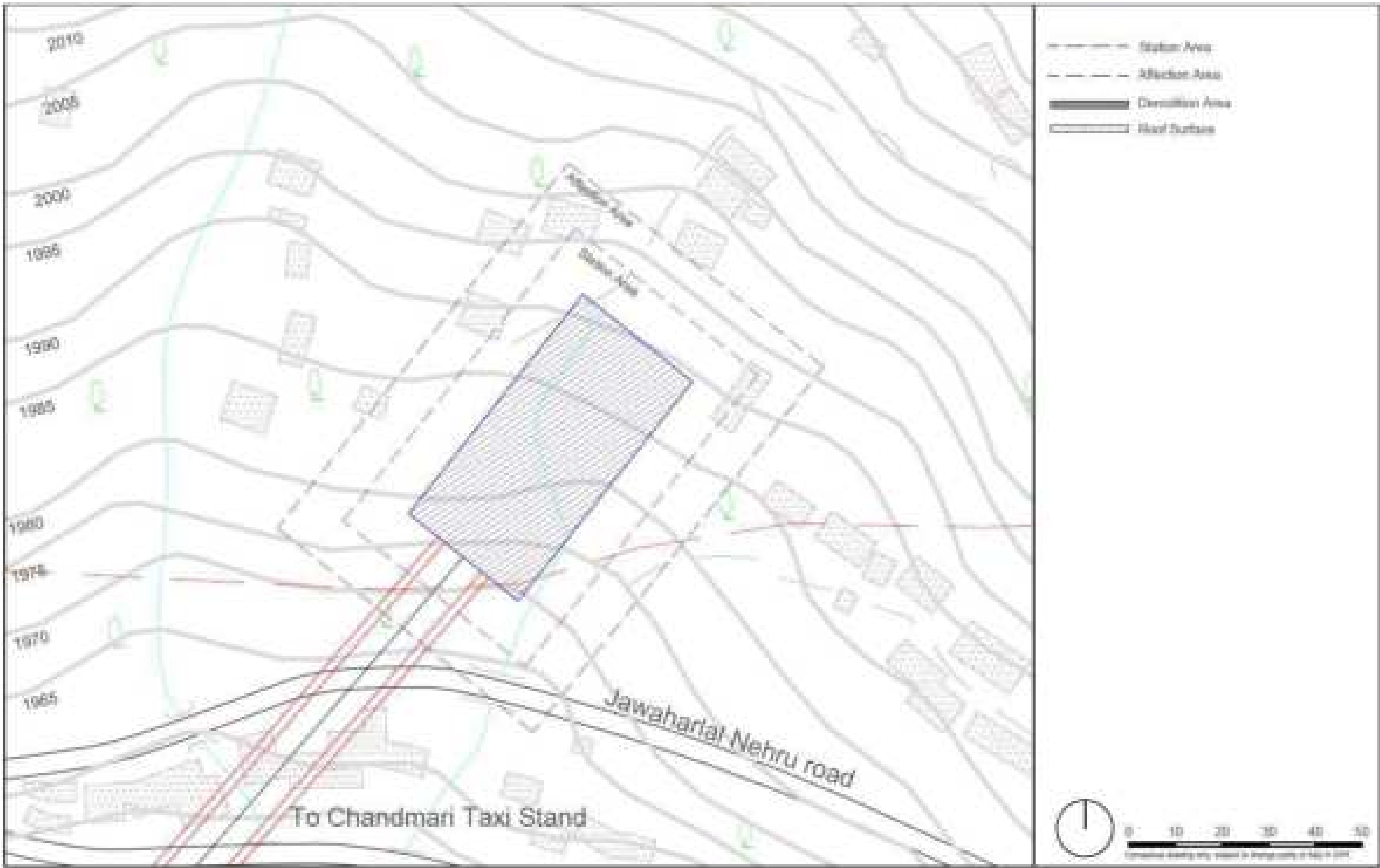


Figure 15-92: Schematic Placement of Proposed '2nd Mile HFC Church Station' on Topographical Survey Map of 2017

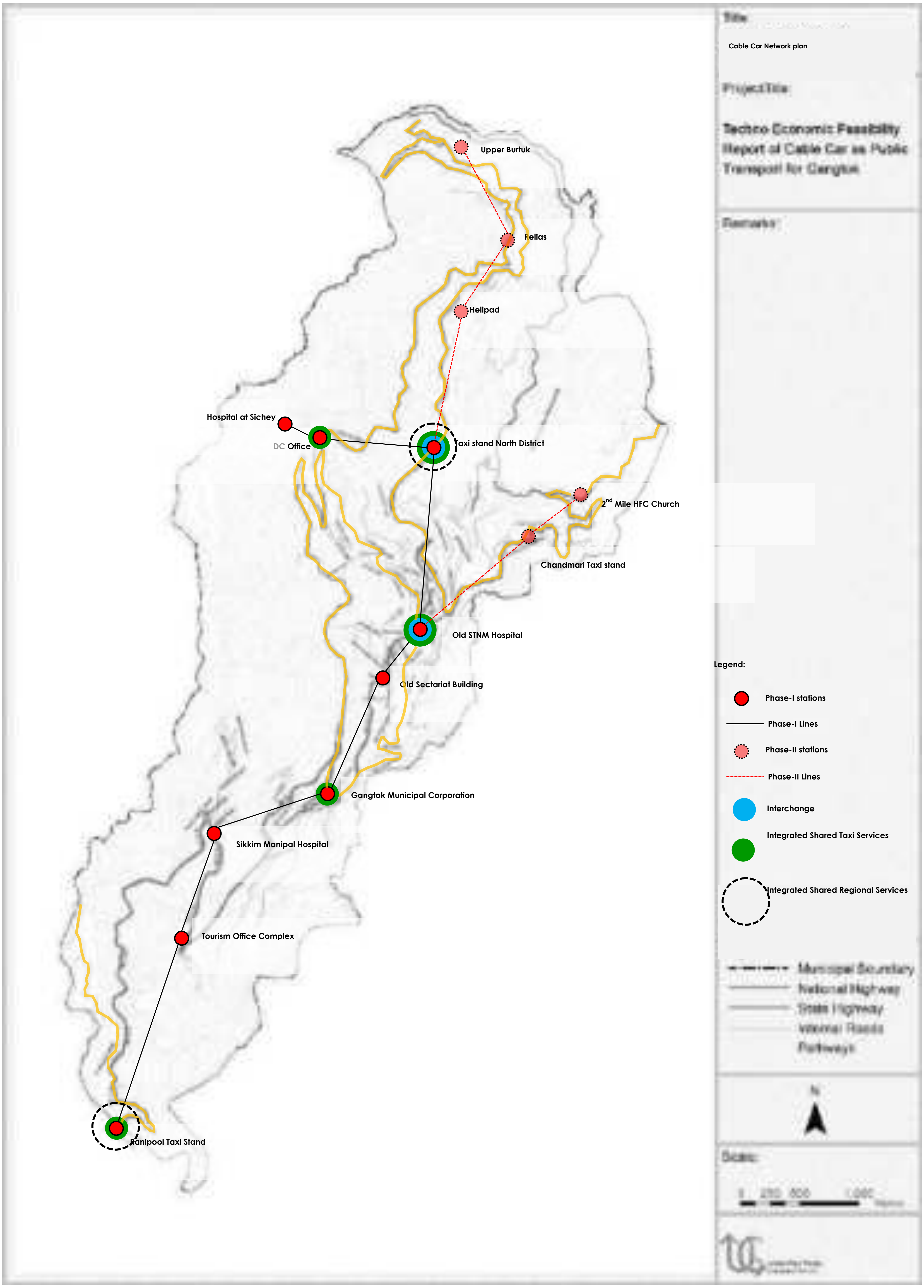


Figure 15-93: Schematic Representation of Multi-Modal Integration Plan