INDO–NORWAY Project - CLIMATRANS

Technical Article

Sustainability Analysis of the Proposed Elevated Road Corridors in Bengaluru City – A Comparative Scenario Analysis With Metro Rail System

by

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The article aims to give scientific outlook on the proposed elevated road corridor project in Bengaluru city, by Government of Karnataka (through KRDCL), from the point of view of Transportation Engineering and Planning. The Government of Karnataka has proposed to construct the elevated corridor for 92.2 km with 53 entry/exit ramps connecting North-South and East-West of the Bengaluru city. The article details the quantitative evaluation of travel behaviour in terms of trip length, mode share, Vehicle Kilometres Travelled (VKTs), Volume by Capacity ratio (V/C), exhaust emissions (CO, HC, NO_x and PM) and greenhouse gas emissions (CO_2). The technical analysis is carried out for Business as Usual (BAU) scenario and elevated corridor scenario for the base year (2017) and the future years 2020 and 2030. The study is executed with the assumption that the proposed elevated corridor project will be completed in 2020. The article highlights the demerits of the proposed elevated road corridor in respect of increased traffic congestion, VKTs and emissions. The evaluation also highlights the merits of the elevated Metro Rail corridor along the same corridor in terms of reduced traffic congestion, reduced emissions and also increase in modal shift to public transport. The detailed technical analysis of the various scenarios is explained in the following sections.

The above mentioned transportation system problems can be modelled using microscopic and macroscopic models. While the microscopic models analyse the transportation system at a very closer level macroscopic models analyse at a large scale considering the aggregated estimates. Various types of scenarios which can be potential transportation problem solving methods can be modelled using these methods. Figure 1 shows a flow chart about the transportation sector mitigation to reduce GHG emissions, local pollutants and traffic congestion for the Bangalore Metropolitan Region. The flow chart focuses on evaluating various alternative transport mitigation scenarios and compare the results with the Business As usual Scenario (BAU) to come up with a best policy scenario to reduce the transportation problems. A detailed explanation of the flow chart is out of scope for this article but the full details about the flow chart are available in the report by Verma A., Harsha V., Hemanthini AR. (2018), “Sustainable Transport Measures for Liveable Bengaluru”, Project Sub Report, IISc Bangalore, India.

The technical details of the proposed elevated corridor are obtained from the ‘*Detailed Feasibility Report (DFR) for the Construction of Proposed Elevated Corridors within Bengaluru Metropolitan Region, Bengaluru by Karnataka Road Development Corporation Limited*’ which is then digitised and added to the existing road network for further analysis. It is also mentioned in the DFR that only two-wheelers, cars and buses are allowed to ply on the elevated corridor and the same had been incorporated in this study. The Bangalore Metropolitan Region (BMR) covering an area about 8005 sq. km. is considered for the current study. The conventional macro-simulation framework in terms of four-stage Travel Demand Modelling (TDM) is adopted for the transportation forecasts and scenario evaluation. The trip end equation utilized for forecasting is obtained from the report ‘*Sustainable Transport Measures for Liveable Bengaluru by Verma et. al. Indian Institute of Science, Bangalore*’.

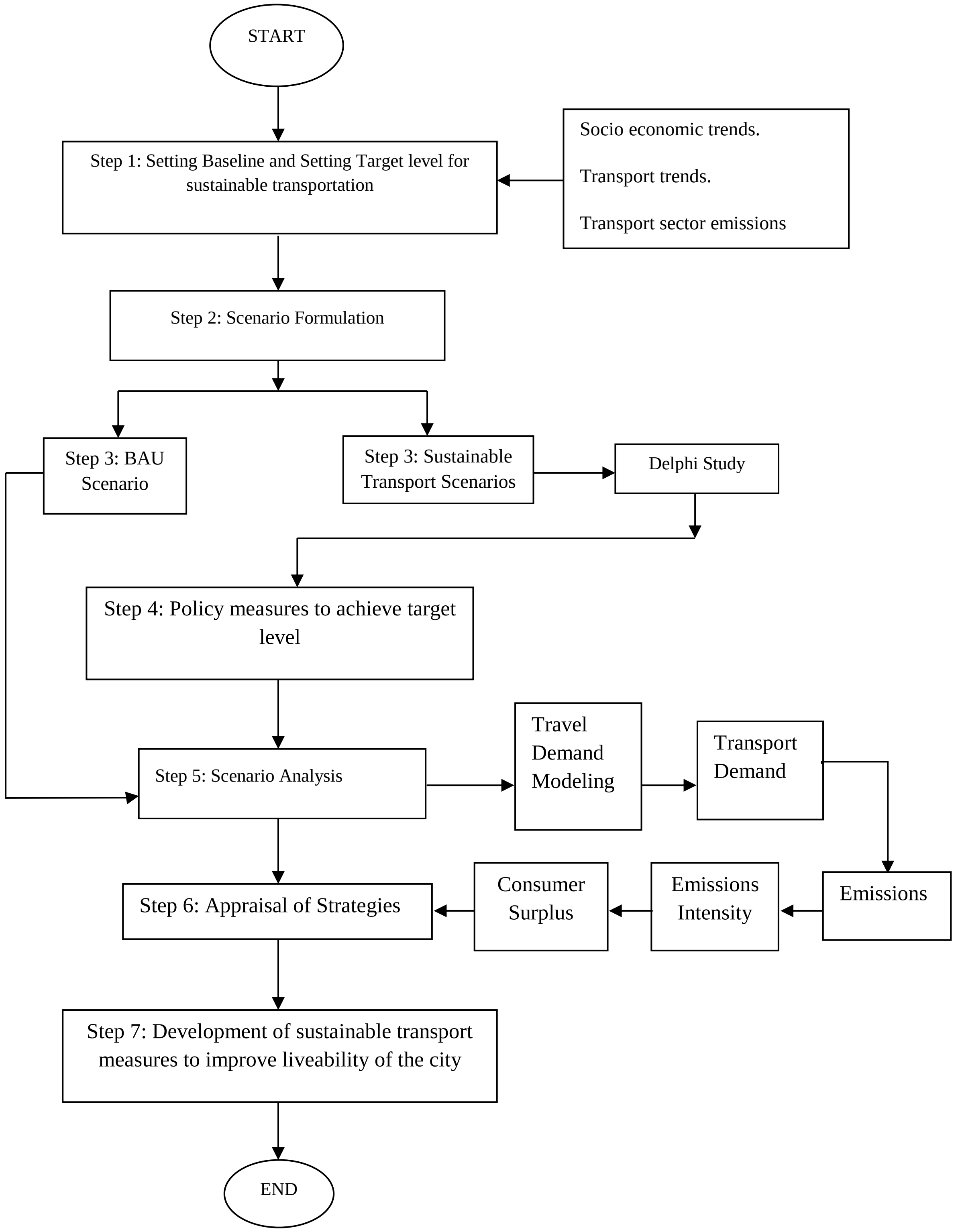


Fig.1: Macro-Simulation based CLIMATRANS methodology for scenario evaluation of different transport policies

The trip end equations used for forecasting the future year trip productions and attractions separately for private and public transport were taken from the CLIMATRANS study of authors.

Population from Base Year (Verma et. al. 2018) is projected to 2017, 2020 and 2030 using the trip end equations. The base year model is used to forecast the travel demand for 2020 and 2030 respectively. The three scenarios considered for the analysis are described below:

- **Business as Usual Scenario (BAU)** – Scenario without Elevated Corridor construction.
- **Scenario 1 (S1)** – Scenario where Elevated Corridor is constructed.
- **Scenario 2 (S2)** – Scenario where Metro Rail is constructed instead of Elevated Corridor along the same proposed corridor.

The impact in the travel behaviour with reference to the above mentioned scenarios is explained in the following sections. The trip length distribution for private and public transport for the scenarios is presented in Figure 2.

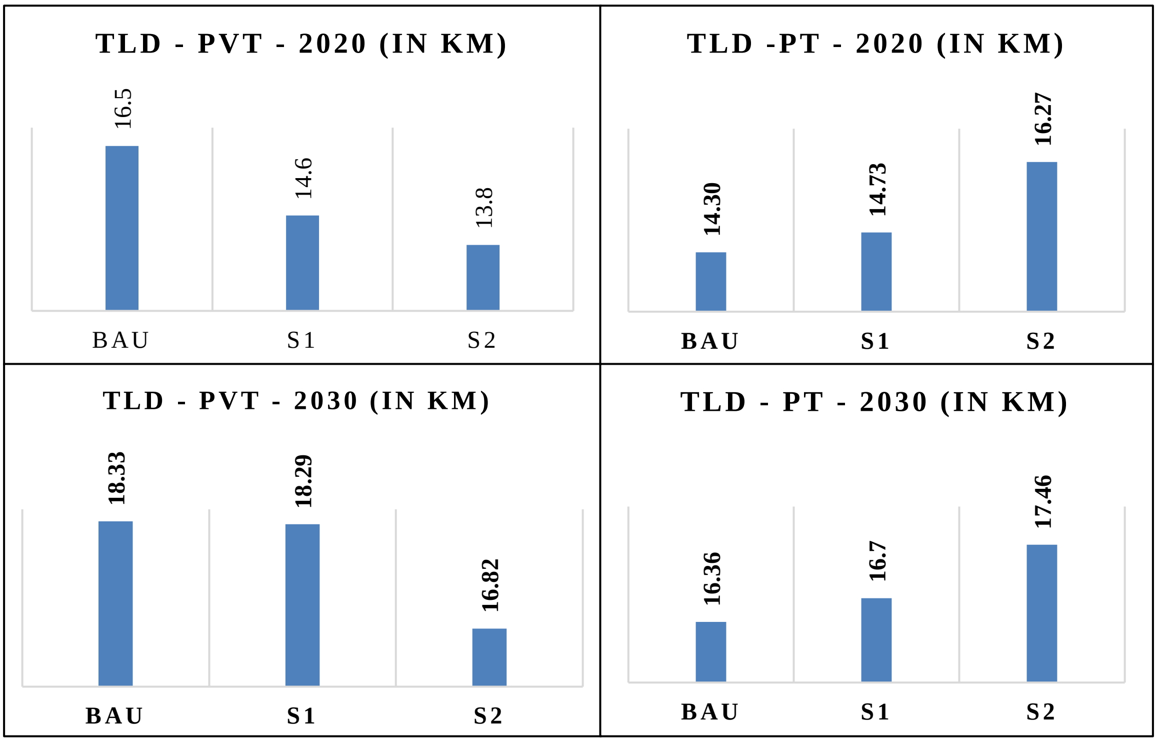


Figure 2. Estimated Trip Length Distribution for Private and Public Transport for the years 2020 and 2030

The average trip length for private transport is decreasing with the construction of elevated road corridor or Metro Rail corridor whereas in case of public transport the average trip length increases with the construction of elevated road corridor or Metro Rail corridor due to completion of remaining phase 2 work of Metro Rail. The modal share estimation for the years 2020 and 2030 for the given scenarios is represented in Figure 2.

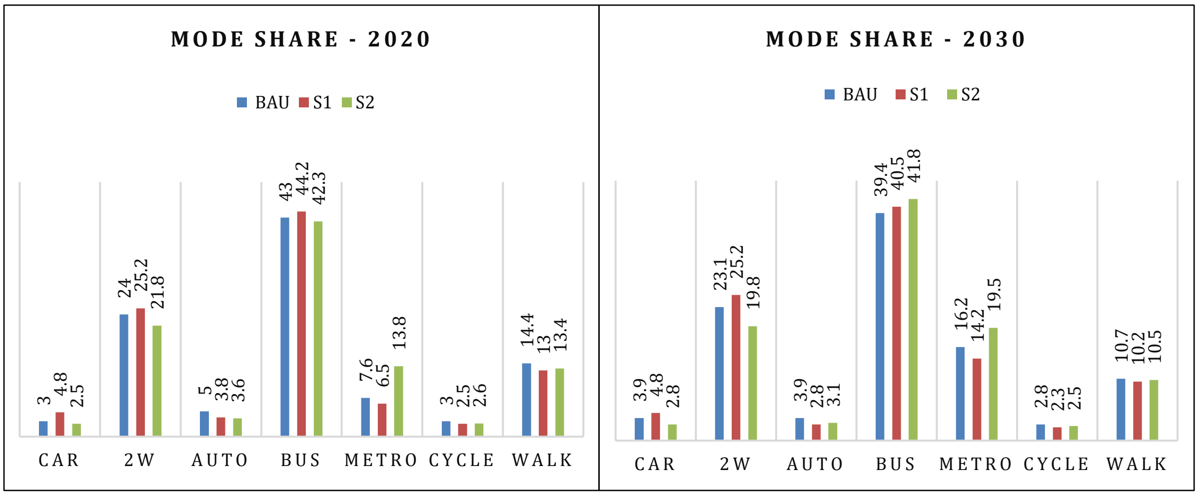


Figure 3. Comparison of the Modal Share for the years 2020 and 2030

It is observed from the figure 3 that the construction of Elevated Corridor will only encourage the usage of private vehicles such as cars and two wheelers in the future years which will eventually lead to traffic congestion. The share of non-motorised transport is also reducing with the Elevated Corridor scenario. The modal share of public transport accounts for about 56.1% and 61.3% in the Metro Rail corridor scenario.

The trips are assigned to the road network using User Equilibrium Trip Assignment method and Vehicles kilometres travelled, Volume on link and volume/capacity ratio (V/C) are estimated. The Vehicle Kilometres travelled for the future years is estimated by updating the road network for the three scenarios and is given in Figure 4. It is observed from the figure 4 that for 2020, there is 2.7 % increase for in VKT for Scenario 1 (Elevated Corridor) and 5.3 % reduction in VKT for Scenario 2 (Metro Rail corridor) from BAU 2020 whereas, for 2030, there is 4 %

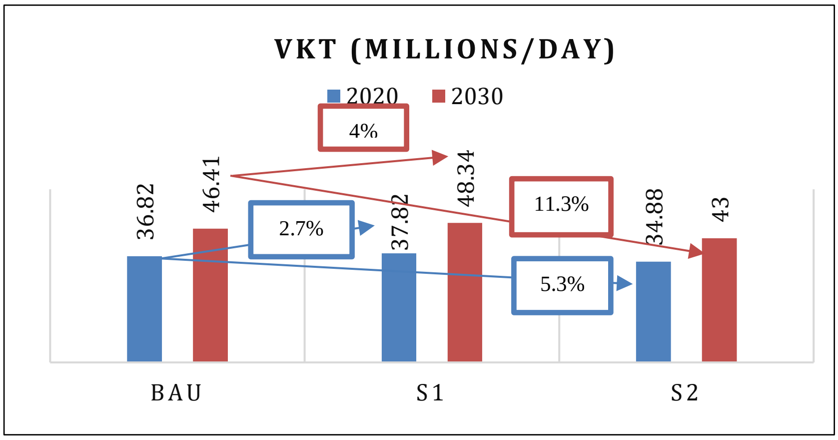
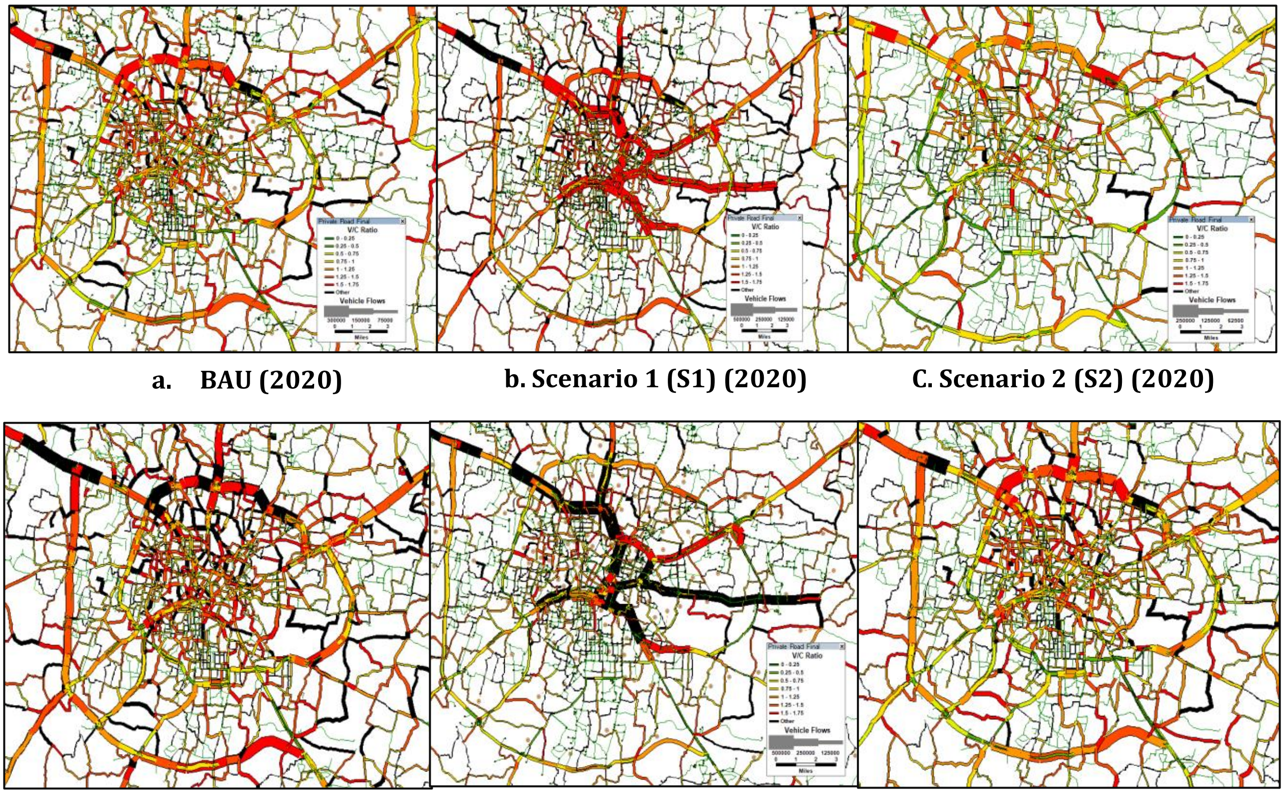


Figure 4. Total Vehicle Kilometres Travelled in 2020 and 2030

increase in VKT for Scenario 1 (Elevated Corridor) & 11.3 % reduction in VKT for Scenario 2 (Metro Rail bridge) from BAU 2030. The increase in VKT for scenario 1 is due to additional network being added to the road network. It is observed that people try to reach the Elevated Corridor to travel at faster speed eventually leading to congestion.



a. BAU (2020) b. Scenario 1 (S1) (2020) C. Scenario 2 (S2) (2020)

d. BAU (2030) e. Scenario 1 (S1) (2030) f. Scenario 2 (S2) (2030)

Figure 5. Trip Assignment of Vehicles in 2020 and 2030

Figure 5 shows the close up flows on the road network for the 3 scenarios. It is to be noted that the green colour links shows low congestion levels and the black coloured links have extreme congestion. It is observed that the Elevated Corridor grabs the attention of the private vehicle users (Fig 5b and 5c) thereby reducing the congestion on the neighbouring roads to the Elevated Corridor and increasing congestion on Elevated Corridor. Figures 4c and 4f shows the v/c maps under the Metro Rail scenario with less congested network due to availability of Metro Rail. A critical link like K R Puram Junction has been chosen to check the change in V/C for the 3 scenarios and it is shown in table 1.

Table 1: V/C estimates at KR Puram road junction

V/C					
Location	**BAU**	**S1**	**S2**	**Section**	**Year**
K R Puram JN	-	2.23	0.08	On bridge	2020
	1.9	0.61	0.45	Below Bridge	
	-	3.18	0.09	On bridge	2030
	2.7	0.81	0.58	Below Bridge	

The V/C has been calculated on the Elevated Corridor and the road adjacent to the Elevated Corridor to observe the change and it is found that the Elevated Corridor gets congested while the adjacent road gets decongested which does not serve the purpose of an Elevated Corridor construction. The V/C of Metro Rail as seen in the table 2 are 0.08 and 0.09 for the years 2020 and 2030 respectively for Scenario 2. The adjacent roads to the Metro Rail corridor will have a V/C of 0.45 and 0.58 for the years 2020 and 2030 respectively. This clearly shows how the transportation system benefits by providing a Metro Rail corridor as it reduces the burden on the roads and they will operate a Level of Service less than C (LOS 'C').

Further this article tries to estimate the emissions that are emitted from each of the scenarios. The emission factors are estimated by Munish et.al. 2018 from IIT Bombay based on World

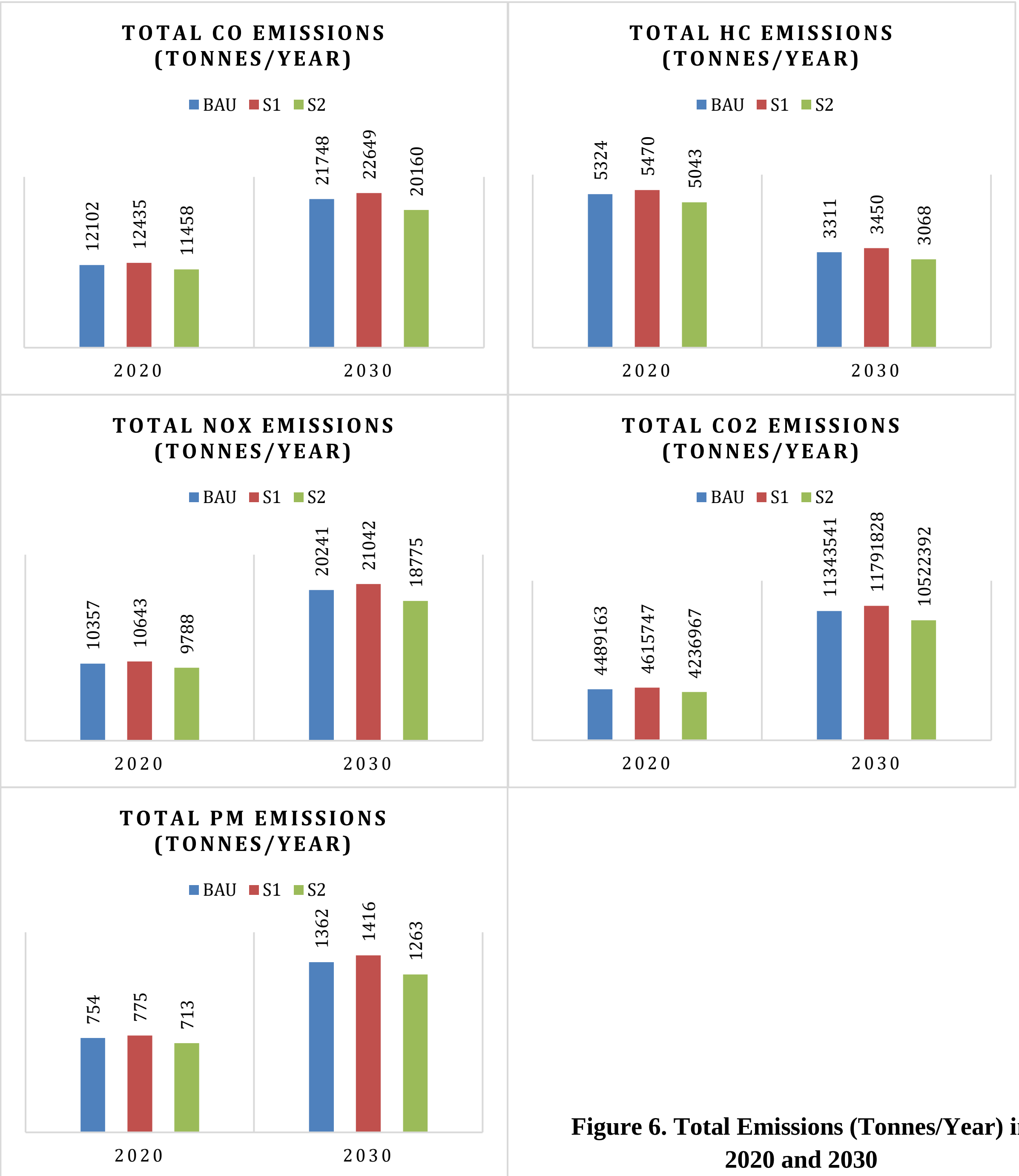
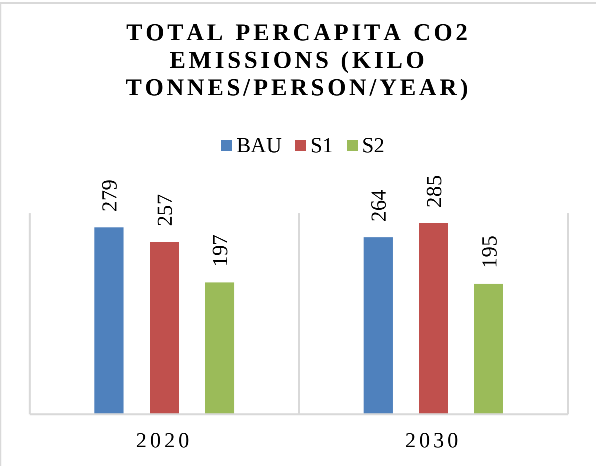


Figure 6. Total Emissions (Tonnes/Year) in 2020 and 2030

Energy Outlook report by IEA, 2015. Although the report consists of four scenarios with various energy mixes this report highlights the emissions for the BAU emission factor scenario. The pollutants considered are CO, HC, NOx, CO_2, PM.

From figure 6 it is observed that there is an increase in emissions for the S1 scenario (With Elevated Corridor) and reduction in emissions for S2 scenario (With Metro Rail) for 2020 and 2030. The construction of Elevated Corridor has increased the vehicle kilometres travelled because of the commuters trying to reach it from every direction thereby increasing the emissions. On the other hand, construction of Metro Rail has led to a shift towards Metro Rail reducing VKT from all private modes of transport there by reducing emissions. For the year 2020 emissions of the pollutants CO, HC, NOx, CO_2 have increased by 3% for S1 scenario and reduces by 5% for S2 scenario when compared with BAU. For PM pollutant there is an increase of 3% for S1 scenario and reduction of 6% for S2 scenario as compared with BAU scenario. In the year 2030, it is observed that the emissions of all pollutants increase by 4% for S1 scenario and decrease by 7% for S2 scenario when compared with BAU scenario



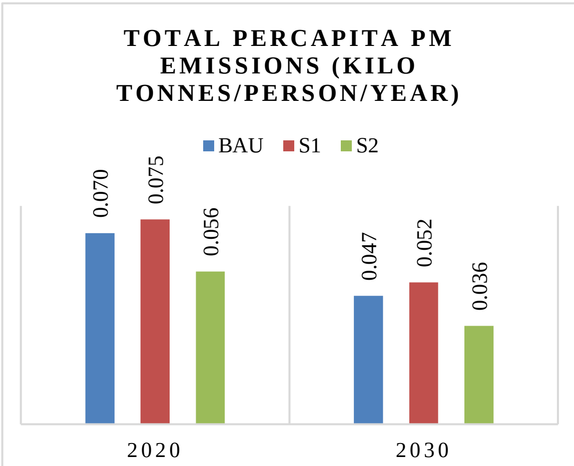


Figure 7. Total Percapita CO_2 Emissions in 2020 and 2030

The emissions percapita is an important factored to be determined as it shows the share a person contributes to the emissions for a particular mode. Figure 7 shows the total percapita emissions for CO_2 and PM from all the modes for the years 2020 and 2030. It is seen that the emissions percapita are much lower in S2 for the year 2020 compared to S1 scenario. In other scenarios the percapita emissions are increasing for S1 scenario and reducing for S2 scenario. For the year 2020 the percapita emissions for CO_2 reduce by 8% and 29% for S1 and S2 scenarios respectively. In the year 2030 the percapita emissions for CO_2 increased by 8% for S1 scenario and reduced by 26% respectively as compared to BAU scenario. For PM pollutant, in 2020 there is an increase of 7% in S1 scenario and a reduction of 20% in S2 scenario from BAU. In the year 2030 there is an increase of 11% for S1 scenario and a reduction of 23% for S2 scenario as compared to BAU.

Summary and Conclusions:

- It is observed that the construction of Elevated Corridor is attracting the traffic from all directions reducing the level of congestion on connecting roads and increasing congestion Elevated Corridor.
- Providing a Metro Rail corridor on the proposed Elevated Corridor reduces congestions more with lower V/C ratios.
- Since the project is connecting the main trip production centres, providing Metro Rail corridor seems to have resulted in mode shift towards Metro Rail and reduction in private vehicle trips.
- Due to high speeds on the elevated corridor and less congestion due to Metro Rail there is a 8 % reduction in total system travel time for scenario 1 & 40% reduction in travel time for scenario 2 when compared with BAU 2020.
- Similarly, there is a 5.3 % reduction in total system travel time for scenario 1 & 53.4% reduction in total system travel time for scenario 2 when compared with BAU 2030.
- From the emissions plots it is seen that the least amount of emissions are from the Scenario 2
- Although Bus and Metro Rail emit high amount of CO_2 their high occupancy levels leads to less percapita emissions (Less contribution to emission by Public Transport users).
- The percapita emissions for CO_2 reduced by 8% and 29% for S1 and S2 scenarios respectively in the year 2020. In the year 2030 the percapita emissions for CO_2 increased by 8% for S1 scenario and reduced by 26% respectively as compared to BAU scenario
- For PM pollutant, in 2020 there is an increase of 7% in S1 scenario and a reduction of 20% in S2 scenario from BAU. In the year 2030 there is an increase of 11% for S1 scenario and a reduction of 23% for S2 scenario as compared to BAU.
- Since, VKT is higher for S1 scenario with respect to BAU, the total energy (fossil fuel) consumption will also be higher for S1 as compared to BAU and S2 scenario.
- From the above results it is clearly evident that the Elevated Corridor construction will not yield any improvement to the city's traffic condition and is therefore not a sustainable solution and will also make Bengaluru city less liveable.
- Policies and infrastructure to encourage public transport system like bus and Metro Rail have shown better results in terms of congestions and sustainability.

For more comprehensive and specific solutions for BMR on the above lines, please refer to the project report of IISc Bengaluru titled "Sustainable Transport Measures for Liveable Bengaluru". The same can be downloaded from the link: -

http://civil.iisc.ernet.in/~ashishv/bengaluru/CLIMATRANS_Report_BENGALURU_P_April_2018.pdf