Methodological **Framework** for **Evaluating Sustainable Transport Measures** Towards **Achieving Sustainable Development Goals**

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Introduction

- **Sustainable Transportation**: Satisfying current transport and mobility needs without compromising the ability of future generations to meet these needs (WCED, 1987).
- Traditional development strategies have **degraded** the resources to a huge extent.
- United Nations (UN) in 2015 prepared **17 Sustainable Development Goals (SDGs)** to be achieved by all the UN member states by 2030.
- These **17 goals** were measured with **169 targets**.
- There are 27 direct transport-related targets defined under 17 goals (Nitwal et al., 2022).

Objectives

- To evaluate sustainable transport interventions and measure progress towards selected SDGs.
  - Few studies have endeavored to integrate SDGs into frameworks for the creation of sustainable transportation indices (Gudmundsson and Regmi 2017).
- To develop a methodological framework for evaluating sustainable transport measures and advancement towards SDGs.
  - However, a structured approach to evaluate such interventions and to measure progress toward Sustainable Development Goals (SDGs) remain rare in developing economies.
- Conduct scenario analysis for Business-As-Usual (BAU) 2031 and Sustainable Transport (ST) 2031 scenario.
  - There are almost no studies to date that compare SDGs' progress using sustainable transportation policy scenarios through the application of a monitoring index.
- To develop a composite index using sustainable transport indicators (STIs) for BAU and ST Scenario 2031.

Methodology

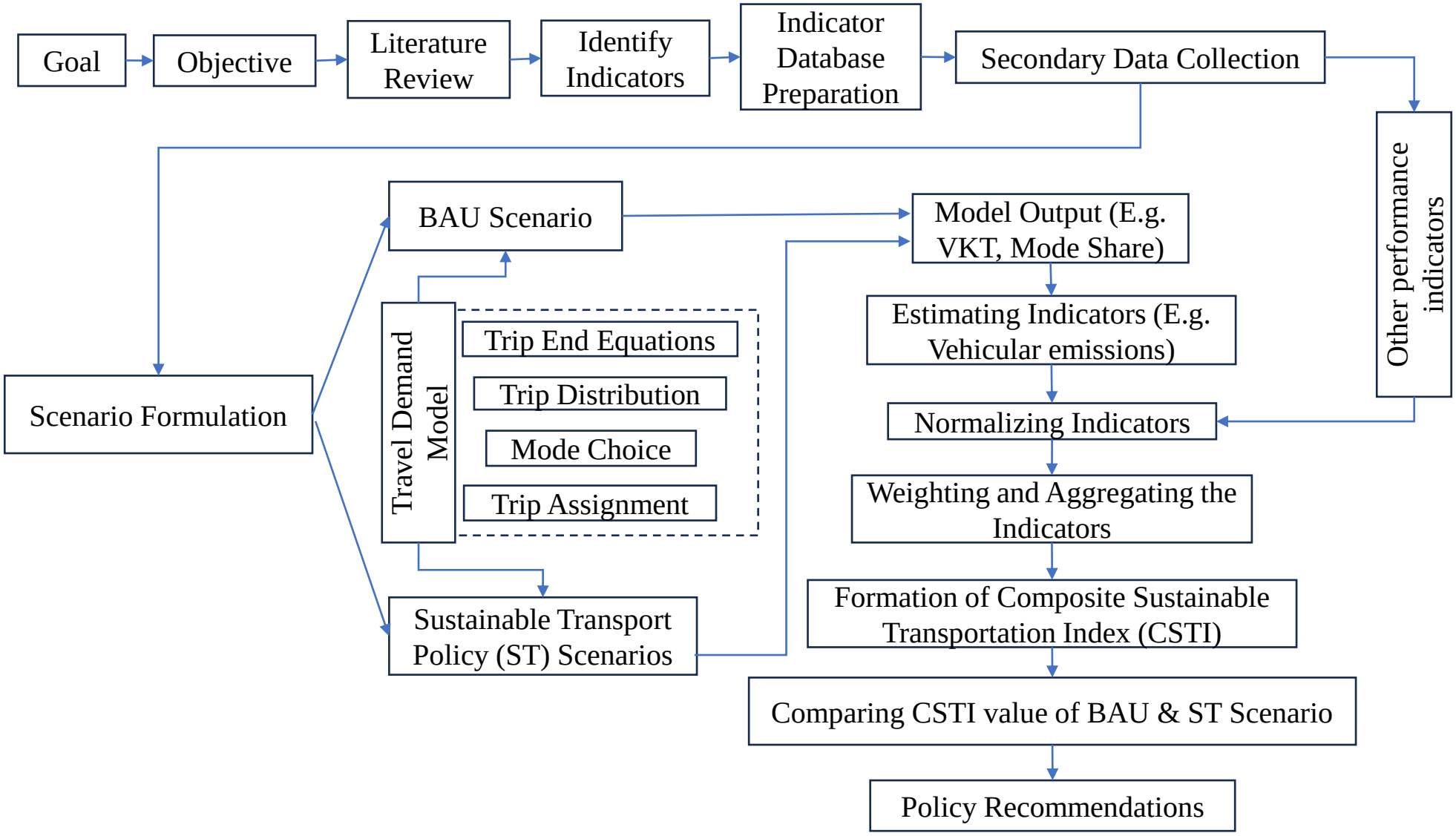


Fig. Overall methodological framework

Sustainable Transport Indicators

- List of 15 STIs.

S. No.	Sustainable Transport Pillars	Sustainable Transport Indicators (Impact/ Direction towards sustainability)	Definition (& Unit) of Indicator	Link to SDG Target
1	Environment	CO Transport emission (-)	CO emission from transport (Tonnes/ Year)	7.3, 11.6 and 13.2
2		HC Transport emission (-)	HC emission from transport (Tonnes/ Year)	7.3, 11.6 and 13.2
3		NOx Transport emission (-)	NOx emission from transport (Tonnes/ Year)	7.3, 11.6 and 13.2
4		CO2 Transport emission (-)	CO2 emission from transport (Tonnes/ Year)	7.3, 11.6 and 13.2
5		PM Transport emission (-)	PM emission from transport (Tonnes/ Year)	7.3, 11.6 and 13.2
6	Social	Traffic deaths (-)	Total number of traffic deaths over a year	3.6 and 11.2
7		Vehicle ownership per capita (-)	Total number of registered motorised vehicles per capita (Vehicles/Capita)	11.2
8		Drunk driving cases (-)	No. of drunk driving cases registered per year	11.2
9		Unsafe driving cases (-)	No. of unsafe driving cases registered (Signal jump, without license, etc.) per year	11.2
10		Vehicle Kilometre Travelled (-)	Total VKT (million Km/day)	11.2
11	Economic	Population Density (+)	Persons per square km	11.2
12		Per capita trip rate (-)	Average number of trips per person (Km)	11.2
13		Public transit network (Metro) (+)	Total public transit network coverage (Metro)	11.2
14		Public transit ridership (Bus) (+)	Public transit daily ridership per day (Bus)	11.2
15		Public transit ridership (Metro) (+)	Public transit daily ridership per day (Metro)	11.2

Normalization, Weighting and Aggregation

- Normalization (modified min-max): To convey the progress made in SDGs, targets for the selected SDGs are integrated into the index formation.

$$I_N = \frac{I - \min(I)}{\text{tar}(I) - \min(I)}$$

Indicators having a positive impact on transport sustainability

$$I_N = \left(1 - \frac{I - \text{tar}(I)}{\max(I) - \text{tar}(I)}\right)$$

Indicators having a negative impact on transport sustainability

- Normalized indicators are then weighted (Equal weighing) and aggregated (linear aggregation) to obtain the index.
- Sub-indices are formed for three pillars of sustainability, namely I_{Env}, I_{Econ}, and I_{soc}.
- Further aggregated to obtain the final composite sustainable transportation index (CSTI).

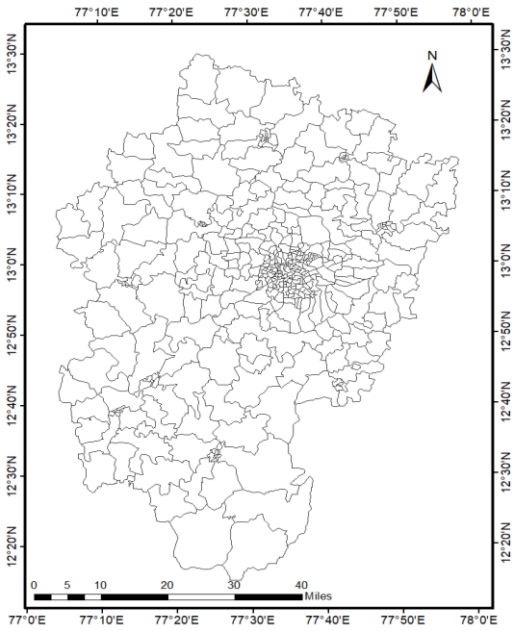
$$I_{Env} = \frac{\sum_i \alpha_i I_{Ni}}{\sum_i \alpha_i} \quad I_{Econ} = \frac{\sum_k \alpha_k I_{Nk}}{\sum_k \alpha_k}$$

$$I_{Soc} = \frac{\sum_j \alpha_j I_{Nj}}{\sum_j \alpha_j}$$

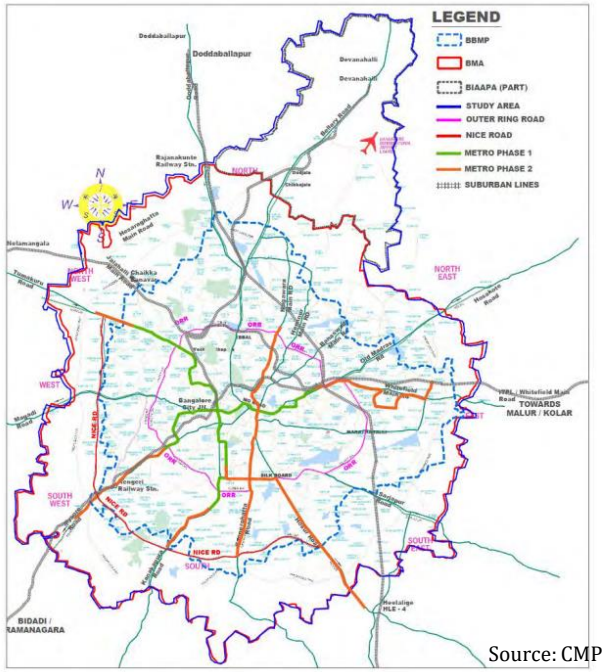
$$CSTI = \frac{\gamma_1 I_{Env} + \gamma_2 I_{Soc} + \gamma_3 I_{Econ}}{\gamma_1 + \gamma_2 + \gamma_3}$$

Case Study: Bangalore Metropolitan Region

- **Bangalore Metropolitan Region (BMR):** 8005 sq km; 384 Traffic Analysis Zones (TAZ).
- Travel Demand Model (TDM) is used to obtain indicators such as transport emissions, VKT, Public Transit ridership etc.
- The ST scenario 2031: completion of metro rail project (Phase 2, phase 2A and phase 2B) for year 2031 (200.86 kms).



BMR Zone Map



Source: CMP Bengaluru

BMR Metro Network

Results & Discussion: Scenario Analysis

- Traffic Assignment Maps: Comparing BAU and MS 2031.

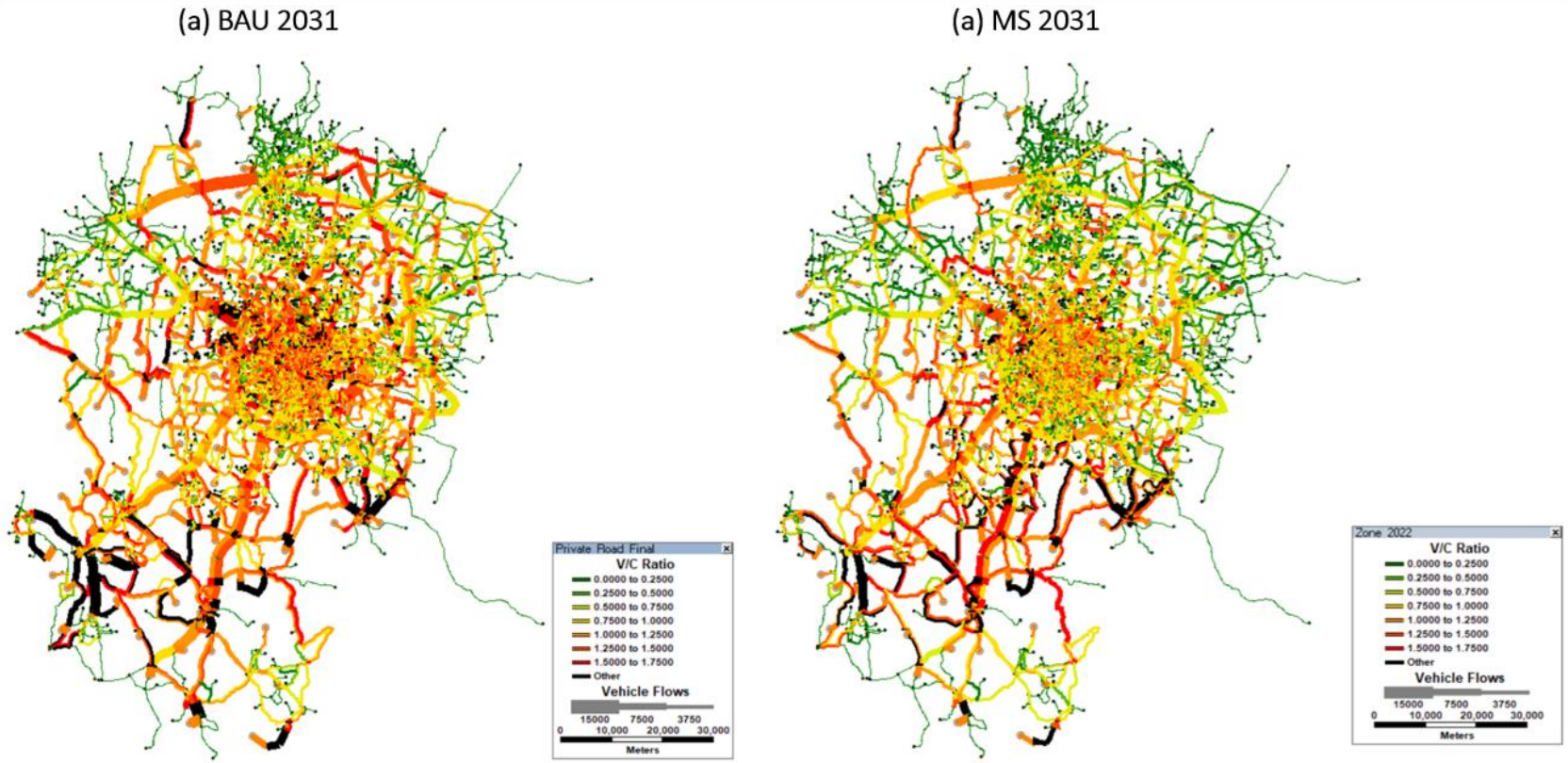
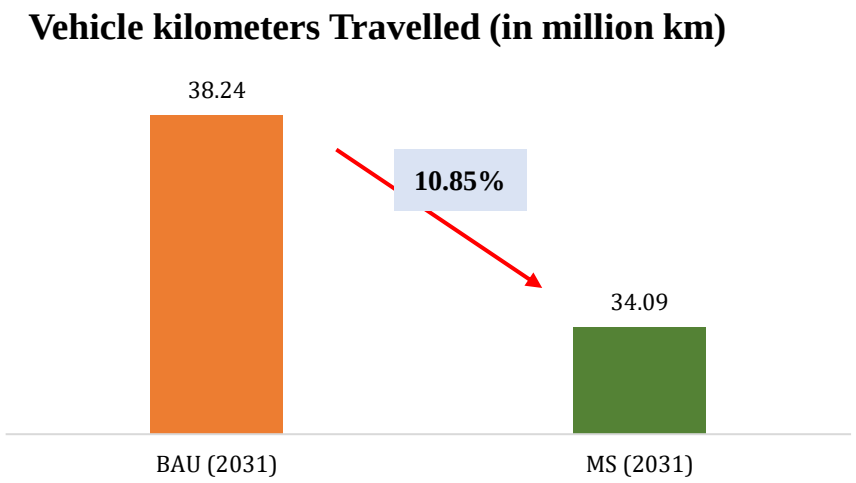
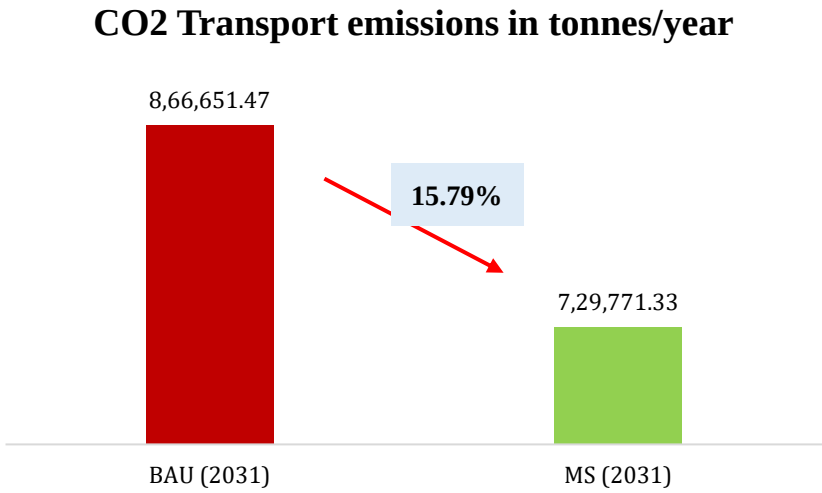


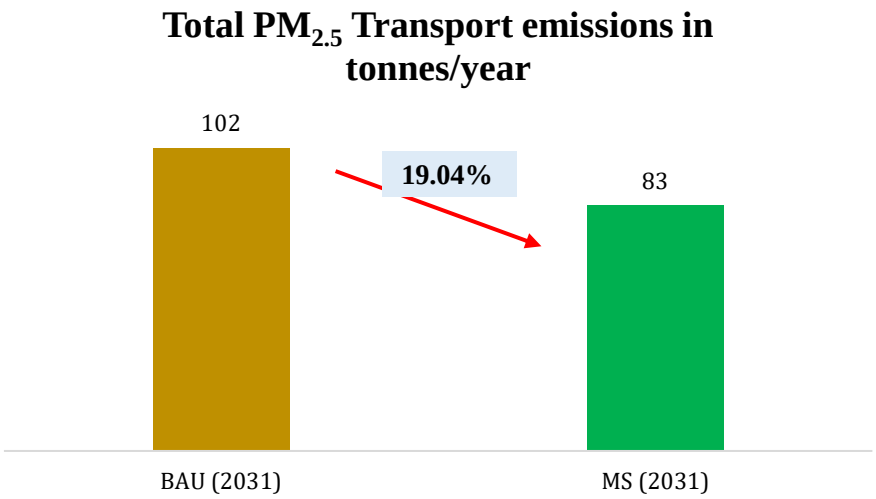
Fig. Traffic Assignment Map: (a) Business as Usual 2031 scenario and (b) Metro 2031 Scenario

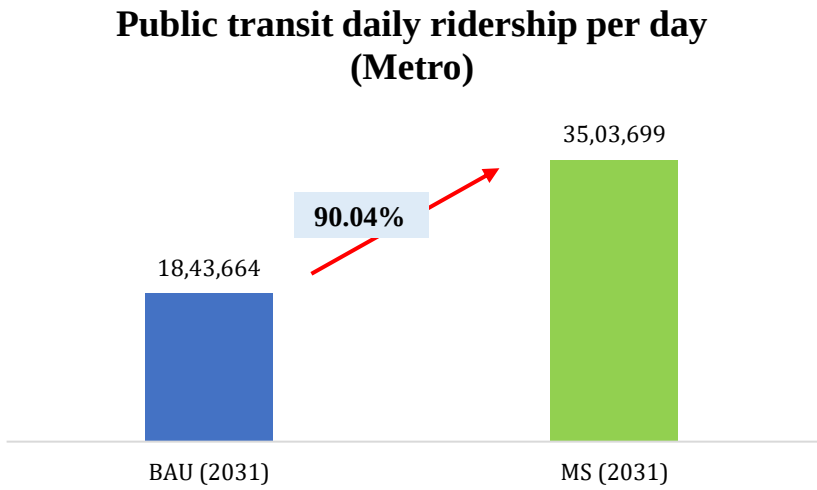
Results & Discussion:

- VKT, CO2, PM2.5 Emissions, Metro ridership per day.









Results & Discussion

Environment, Social, Economic sub-index and CSTI comparisons for BAU and Metro Scenario 2031.

- Evident rise in the sub-indices across both scenarios.
- Appreciable **8.74%** surge from BAU to Metro scenario.

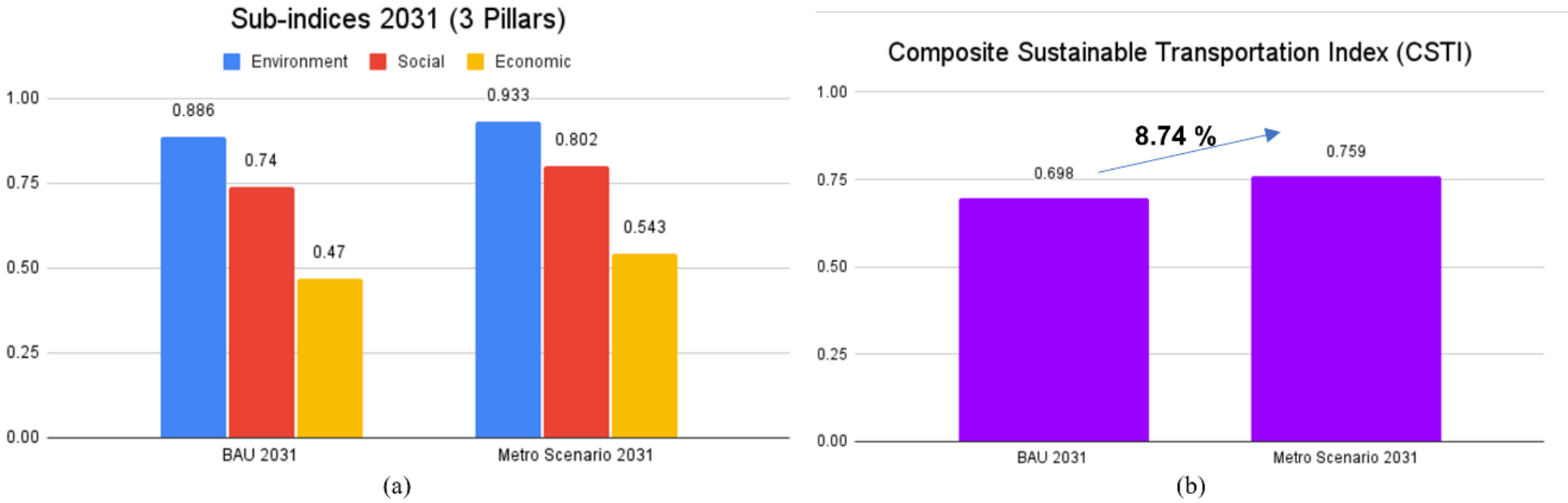


Fig. (a) Comparison of Sub-indices of main pillars for BAU and Metro Scenario- 2031; (b) Comparison of CSTI for BAU and Metro Scenario 2031

Conclusion

- Study proposes a methodological framework that uses STIs to evaluate sustainable transport measures and advancement towards SDGs using CSTI.
- Indicators used in the study are forecasted for the year 2031 for BAU and Metro Scenario which **enables** these **indicators to capture the improvements** caused by **different policy scenarios**.
- The findings indicate that substantial advancements in SDGs can be achieved by prioritizing the enhancement of the metro network for passenger transportation.
- A valuable tool for assessing the sustainability of different transportation strategies (policies), also connecting them to the progress of relevant SDGs (through inclusion of target-related indicators).

Conclusion

- STIs established in this study can serve as a template for creating databases for other Indian cities.
- Proposed CSTI framework provides clarity on the actual progress made towards SDG attainment.
- Study uses equal weights for the indicators.
- Future Scope:
  - Suitable statistical weighting methods and weights based on Expert opinion to obtain indicator and sub-index weights.
  - Bus Priority Corridors and NMT Infrastructure 2031 to test as another future policy scenario.

THANK YOU