SAVi Sustainable Asset Valuation

A Sustainable Asset Valuation of Non-Motorized Transport in Coimbatore, India

TECHNICAL REPORT

IISD International Institute for Sustainable Development

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DEUTSCHE ZUSAMMENARBEIT

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International Institute for Sustainable Development

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Executive Summary

Purpose of this Assessment and the Sustainable Asset Valuation Methodology

This Sustainable Asset Valuation (SAVi) assessment of the non-motorized transport (NMT) network in Coimbatore, India, is part of a series of nine SAVi assessments on sustainable transport and mobility projects.

The assessments aim to raise awareness on sustainable transport infrastructure investments and inform decision-makers on the use of systemic approaches in supporting the transformation toward sustainable mobility. The assessments also integrate the economic valuation of social and environmental impacts, such as health and CO_2 emissions, and aim to highlight their importance for the transport investment decision making processes.

SAVi is an assessment methodology that provides policy-makers and investors with a comprehensive and customized analysis of how much their infrastructure projects and portfolios will cost throughout their life cycles, taking into account risks and externalities that are overlooked in a traditional valuation. A SAVi assessment is based on the following components:

- A combination of systems thinking and different modelling methodologies, spatial modelling, economic multiplier/multicriteria assessments, system dynamics and financial models.
- Customization to each individual infrastructure project, portfolio, or policy;
- Co-created with the decision-makers and stakeholders. A multistakeholder approach is taken that enables stakeholders to identify the material risks and opportunities unique to the projects or alternatives. This strengthens the capacity of decision-makers and stakeholders to take a systemic approach to investments and increases the likelihood of uptake, use, and impact of the results of the analysis.
- Based on project-level data (where available), the SAVi database (based on literature review and data from previous SAVi applications), and best-in-class climate data from the EU Copernicus Climate Date Store (built in to all SAVi models).

Non-Motorized Transport Plan in Coimbatore

The city of Coimbatore is the second largest city in the state of Tamil Nadu in southern India, with a population of 1.6 million people across 257 km^2. Like many other densely populated cities in India, Coimbatore faces numerous urban mobility and transport challenges, such as high traffic volumes, congestion, long commuting times, safety concerns, and air pollution. Current transport mode shares of walking and cycling in Coimbatore are 14% and 1%, respectively, as 43% of the city's residents use public transport and a further 33% use private motor vehicles. To address these challenges, the Coimbatore City Municipal Corporation (CCMC) developed an NMT plan. The plan has identified 300 km of NMT routes across the city and will be implemented over a period of 15 years and completed by 2035. The plan

is expected to directly benefit approximately 60% of Coimbatore's population (1 million people), improve accessibility for women, the elderly, and low-income communities, and reduce up to 13% of the CO_2 emissions from passenger transport. The NMT network's overall investment costs amount to INR 9,895 million. A citywide NMT network can sustain existing NMT demand but also encourage new users and accommodate future demand.
A comprehensive NMT network could meet sustainable, low-carbon mobility targets not only by providing citizens with safe and convenient walking and cycling facilities but also by providing greater accessibility to public transport.

The CCMC, with the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), identified the pedestrian priority networks and cycling routes that are presented in a detailed 2020 GIZ project report. Following this plan, the German Federal Ministry for Economic Cooperation and Development invited the International Institute for Sustainable Development to customize the SAVi methodology for assessing the suggested NMT plan in Coimbatore. The SAVi assessment was largely based on local data and knowledge provided by GIZ India.

This report provides the SAVi assessment of the NMT plan. The SAVi assessment aims to provide a comprehensive analysis by not only estimating the value of the investment costs (capital and operation and maintenance [O&M]) but also the environmental, social, and economic added benefits and avoided costs that result from the NMT network. The assessment includes a low- and a high-value scenario, depending on the projected demand for NMT. It is important to note that the higher the demand for using the NMT network, the higher the added benefits and avoided costs.

The SAVi assessment for the NMT plan in Coimbatore consists of the following elements:

- A simulation of one NMT scenario for the implemented NMT network and the associated changes in transport use patterns in Coimbatore.
- A valuation of 10 added benefits and avoided costs related to the NMT.
- An integrated cost-benefit analysis of the NMT network, including the added benefits and avoided costs and a benefit-to-cost ratio for the NMT plan.

Findings

According to the analysis, the NMT network in Coimbatore has a wide range of economic, social, and environmental benefits that are typically overlooked in traditional infrastructure assessments. The results of the SAVi assessment demonstrate that the NMT network will have significant health benefits from increased physical activity and reduced levels of air pollution, positive changes in retail and property prices, and significant reductions in the cost of accidents and fuel use. The SAVi assessment also shows the resulting CO2 emissions reductions as well as diminishing costs associated with road maintenance and noise pollution.

Table ES1 summarizes the results of the integrated cost-benefit analysis (CBA). In addition, the SAVi results are separated into a low-value and a high-value estimate for some added benefits and avoided costs (shown with a * in Table ES1) because underlying data and assumptions for their valuation differ.

According to the SAVi NMT model, the total net value of the NMT scenario is positive, and the project is therefore profitable from both a macroeconomic and a societal perspective. The integrated CBA shows cumulative discounted net values of INR 37,104 million (USD 486.2 million) in the low-estimate valuation and INR 38,911 million (USD 509.88 million) in the high-estimate valuation. The SAVi NMT model considers a project period of 23 years, from 2022 to 2045. The construction period lasts 15 years, from 2022 to 2037 and we consider an operational phase of 8 years. This is in line with an average timeline for the operational phase of a road before heavy maintenance costs for re-pavement occur.

Table ES1. Integrated CBA (discounted values for the NMT scenario based on a project period of 23 years)

		NMT scenario 2022–2045	
Integrated CBA	**Unit**	**Low estimate**	**High estimate**
Total investment costs	**INR million**	**9,895**	**9,895**
Capital cost NMT system	INR million	9,209	9,209
O&M cost NMT system	INR million	686	686
Total added benefits	**INR million**	**11,128**	**12,672**
Income creation from employment	INR million	133	133
Health impacts*	INR million	6,857	7,484
Value of time saved	INR million	490	490
Increase in retail revenues	INR million	2,730	2,730
Increase in property prices *	INR million	917	1,834
Total avoided costs	**INR million**	**35,871**	**36,134**
Cost of CO_2 emissions	INR million	164	164
Cost of fuel	INR million	4,184	4,184
Cost of accidents	INR million	30,144	30,144
Cost of noise pollution	INR million	875	875
Cost of road maintenance *	INR million	504	767
Net results of valued added benefits and avoided costs			
Cumulative net benefits (undiscounted)	INR million	80,967	84,203
Cumulative net benefits (discounted)	INR million	37,104	38,911

* Added benefits and avoided costs that are impacted by the different demand scenarios.

As Table ES1 demonstrates, the avoided costs of accidents resulting from the shift from motorized transport modes to NMT modes show the largest values with INR 30,144 million, followed by health benefits, which are between INR 6,857 million and INR 7,484 million, considering both low and high estimates. All the SAVi assessment results for the NMT network, including investment costs, added benefits, and avoided costs are shown in Figure ES1 below.

Figure ES1. Investment costs, added benefits, and avoided costs of the NMT network in Coimbatore

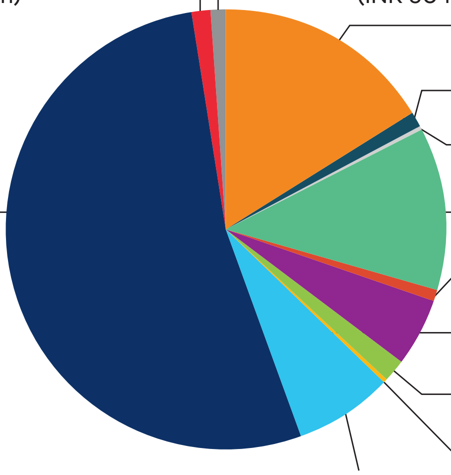

Table ES2 shows the conventional benefit-cost ratio (BCR) and the sustainable benefit-cost ratio (S-BCR) of the NMT. The BCR determines the overall value for money of a project. It illustrates the return for every unit (USD or INR) invested by comparing the project's total benefits with the total costs. In this case, we calculate a BCR that only takes into account tangible parameters such as capital costs, O&M costs, and avoided costs of fuel use and road maintenance, and we compare this with the S-BCR which takes into account the full range of economic, social, and environmental added benefits and avoided costs. The conventional BCR is significantly lower than the S-BCR. When all the benefits and avoided costs are taken into account, the S-BCR ranges between 4.75 and 4.93 for every USD/INR invested compared to 0.47 and 0.50 for a conventional BCR.

Table ES2. Conventional BCR vs S-BCR

	BCR		**S-BCR**	
Parameters considered	Investment and costs, avoided cost of fuel use, avoided cost of road maintenance		Investment and costs, full range of economic, social, and environmental added benefits and avoided costs	
	Low estimate	High estimate	Low estimate	High estimate
	0.47	0.50	4.75	4.93

The SAVi assessment of the NMT network primarily demonstrates that the project's benefits outweigh the investment costs by a factor of almost 5. Even under conservative assumptions, the calculated added benefits and avoided costs of the improved NMT infrastructure (INR 47 million) exceed by far the projected investment costs (INR 9.9 million). In addition, the comparison of the BCR and the S-BCR demonstrates that when only tangible impacts are considered in the analysis, the project is not economically viable, but when social and environmental non-tangible impacts are also considered, the benefits are 10 times higher. All of the above shows that the NMT network in Coimbatore is a highly profitable project from both a macroeconomic and a societal perspective.

The SAVi assessment provides benchmark values for policy-makers and public infrastructure planners when it comes to valuing the societal benefits and costs of NMT. Table ES3 indicates how different stakeholders and decision-makers can use the results of this assessment to make more informed decisions.

Table ES3. How different stakeholders and decision-makers use the results of the NMT SAVi assessment

Stakeholder	Role in the project	How can the stakeholder use the results of the assessment
Government	Design, implementation, and finance of the NMT network in Coimbatore	Urban and regional governments can use the assessment results to raise awareness for sustainable transport projects and to justify investments in NMT as well as make these assessments a standard and a requirement for investment decisions. Overall, the results of the assessment provide an integrated perspective on NMT networks and the wide range of economic, social, and environmental benefits that they deliver. This can help urban authorities and governments provide funding and support for such projects, tapping into different capital sources. Policy-makers can use the assessment results to make decisions on sustainable transport projects and NMT networks in particular, as well as on potential additional investments that may be required for realizing additional benefits.
Private sector/ industry	Project developers	Businesses and private sector entities can use the assessment results for additional advocacy for sustainable transport projects and NMT networks as well as for identifying new opportunities and business cases for additional investment in sustainable transport projects.

Stakeholder	Role in the project	How can the stakeholder use the results of the assessment
Donors and funders	Funding of NMT projects	Donors can include the assessment results in their reporting processes to show the impacts of their investments. The assessment results can also be used for awareness raising of the benefits for NMT projects in cities, including health benefits, avoided costs of air pollution and CO_2 emissions, and potential increases in retail and property prices. This can help make the case for further sustainable transport projects and active transport schemes (e.g., by making these assessments a formal requirement).
Civil society organizations	Consultation with government on NMT projects	Civil society organizations can use the assessment results and the valuation of the added benefits and the avoided costs of NMT projects to conduct more targeted advocacy for sustainable transport projects.Civil society organizations can also use the assessment results to promote integrated solutions for sustainable transport and to raise awareness of their value to society.

Integrated assessments such as this one conducted using the SAVi methodology can help make a stronger case for NMT infrastructure. Altogether, this assessment shows that the NMT network advances the realization of sustainable mobility targets in Coimbatore and improves the quality of life of its residents.

Glossary

Benefit-cost ratio: A ratio that determines the overall value for money of a project. It illustrates the return for every unit (USD or INR) invested by comparing a project's total benefits with the total costs.

Causal loop diagram: A schematic representation of key indicators and variables of the system under evaluation that shows the causal connections between them and contributes to the identification of feedback loops and policy entry points.

Discounting: A finance process to determine the present value of a future cash value.

Indicator: Parameters of interest to one or several stakeholders that provide information about the development of key variables in the system over time and trends that unfold under specific conditions (United Nations Environment Programme [UNEP], 2014).

Methodology: The theoretical approach(es) used for the development of different types of analysis tools and simulation models. This body of knowledge describes both the underlying assumptions used as well as qualitative and quantitative instruments for data collection and parameter estimation (UNEP, 2014).

Model validation: The process of assessing the degree to which model behaviour (i.e., numerical results) is consistent with behaviour observed in reality (i.e., national statistics, established databases) and the evaluation of whether the developed model structure (i.e., equations) is acceptable for capturing the mechanisms underlying the system under study (UNEP, 2014).

Net benefits: The cumulative amount of monetary benefits accrued across all sectors and actors over the lifetime of investments compared to the baseline, reported by the intervention scenario.

Scenarios: Expectations about possible future events used to analyze potential responses to these new and upcoming developments. Consequently, scenario analysis is a speculative exercise in which several future development alternatives are identified, explained, and analyzed for discussion on what may cause them and the consequences these future paths may have on our system (e.g., a country or a business).

Simulation model: Models can be regarded as systemic maps in that they are simplifications of reality that help to reduce complexity and describe, at their core, how the system works. Simulation models are quantitative by nature and can be built using one or several methodologies (UNEP, 2014).

System dynamics: A methodology developed by Forrester in the late 1950s (Forrester, 1961) to create descriptive models that represent the causal interconnections between key indicators and indicate their contribution to the dynamics exhibited by the system as well as to the issues being investigated. The core pillars of the system dynamics method are feedback loops, delays and nonlinearity emerging from the explicit capturing of stocks and flows (UNEP, 2014).

Abbreviations

BCR	benefit-cost ratio
CBA	cost-benefit analysis
CCMC	Coimbatore City Municipal Corporation
CMP	City Mobility Plan
CO_2	carbon dioxide
HC	hydrocarbons
HEAT	health economic assessment tool
NOx	nitrogen oxides
NMT	non-motorized transport
O&M	operation and maintenance
pkm	passenger kilometre
PM 2.5	particulate matter with a diameter of less than 2.5 micrometres
SAVi	Sustainable Asset Valuation tool
SCC	social cost of carbon
SD	system dynamics
S-BCR	sustainable benefit-cost ratio
vkm	vehicle kilometre
VSL	value of statistical life

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1.0 Introduction

1.1 Mobility Challenges and Transport Strategies in Coimbatore

Coimbatore, like many other densely populated cities in India and around the world, faces numerous urban mobility and transport challenges. The city is being forced to cope with various issues, such as rising numbers of private motorized vehicles that result in high traffic volumes, congestion and long commuting times, safety concerns, and air pollution. These problems are projected to worsen with climate change and continued urban development. In the past, urban transport planning has been predominantly focused on individual motorized transport modes, leading to a wide range of economic inefficiencies and negative health impacts. At the same time, other transport modes including public transport systems and non-motorized transport (NMT) are often negatively affected and cannot be used to their full potential.

The Comprehensive City Mobility Plan (CMP) for Coimbatore (2015), aims to address the mobility concerns arising from population and business growth of the Coimbatore Local Planning Area (LPA) through a number of key objectives:

- Development of a comprehensive, cohesive, and integrated traffic, transportation, and mobility plan.
- Discuss key interventions to be undertaken by respective stakeholders to enable implementation of the plan.
- Optimal utilization of funds, along with human and institutional resources for project implementation (toward efficient and effective city transportation).
- Illustrate a basic plan for urban development and include a list of proposed urban land-use and transport measures to be implemented within a time span of 20 years or more.
- Ensure that the most appropriate, sustainable, and cost-effective implementation program is undertaken in the urban transport sector.
- Identify feasible short-, medium-, and long-term traffic management measures and transport infrastructure needs to facilitate safe and efficient movement of people in the present and the future.

The CMP (2015) suggested a number of improvements and additional infrastructure for mobility, including three phases of bicycle paths as well as proposals for pedestrian and footpath zones. Additionally, in 2017, the Coimbatore City Municipal Corporation (CCMC), adopted the Coimbatore Street Design and Management Policy, which provided the first foundation for NMT-related projects in Coimbatore. Therefore, the CCMC has been making various efforts to improve the NMT infrastructure in the city.

Since then, an NMT Network Plan has been prepared by CCMC, with support from the GIZ GmbH. More specifically, the Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT) project (August 2017–July 2021) is jointly implemented by the Ministry of Housing and Urban Affairs and the GIZ. The project works with the three Smart

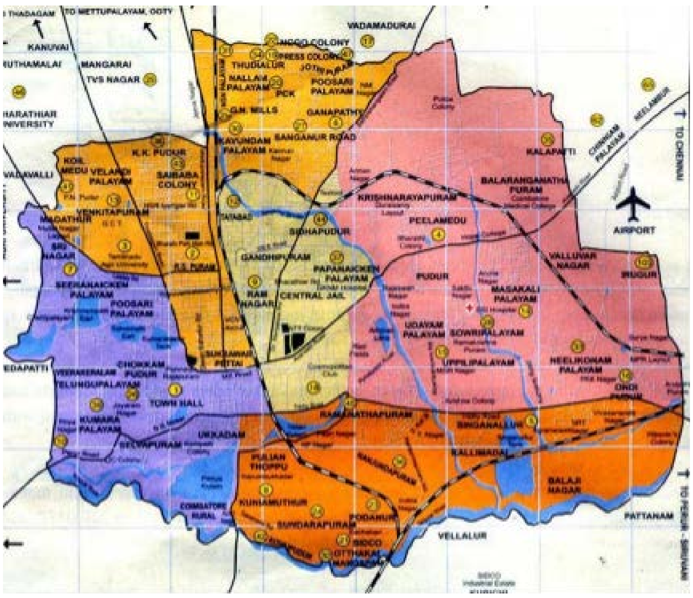
Cities of Bhubaneswar, Coimbatore, and Kochi, and their respective state governments, to promote low-carbon mobility, and to plan and implement sustainable urban transport projects in the fields of public transport, non-motorized transport, and modal integration. It also supports urban transport agencies in setting up the required institutional structures and processes and enhancing their capacities for efficient delivery of services. A consortium comprising GFA Consulting Group, World Resources Institute India, and the Wuppertal Institute is supporting GIZ in the implementation of this project (GIZ, 2020).

To meet the above objectives and to avoid a car-oriented, high-carbon mobility development pathway for the city of Coimbatore, this study analyzes the value of NMT infrastructure. A citywide high-quality pedestrian and bicycle network can not only sustain existing NMT demand in Coimbatore but also encourage new users and accommodate future demand. A comprehensive NMT network could meet sustainable low-carbon mobility targets by not only providing citizens with safe and convenient walking and cycling facilities, such as bicycle paths and street lighting, but also delivering greater accessibility to public transport.

1.2 Purpose of a Sustainable Asset Valuation for Coimbatore's NMT Network

Coimbatore is the second largest city in the state of Tamil Nadu in southern India, after Chennai. It has a population of 1.6 million across 257 km^2. The city has approximately 2,400 km of road network, consisting of national and state highways and corporation roads. The city has six major arterial roadways, three of which are National Highways that cut through the city. A lack of road hierarchy—leading to lateral ring movement and fewer opportunities to avoid thoroughfare movement of inter-city traffic—contributes to congestion and serious safety concerns for both pedestrians and cyclists. Current transport mode shares of walking and cycling in Coimbatore are 14% and 1% respectively, as 43% of the city's residents use public transport and a further 33% use private motor vehicles (GIZ, 2020). Figure 1 shows a map of the city.

Figure 1. Map of Coimbatore



Source: CMCC, 2015.

To address these challenges, the CCMC developed an NMT Network Plan that has identified 300 km of NMT routes across the city and will be implemented over a period of 15 years and completed by 2035. The proposed NMT Network Plan is expected to directly benefit approximately 60% of Coimbatore's population (or 1 million people), improving accessibility for disadvantaged groups such as women, the elderly, and low-income communities and reducing up to 13% of projected CO_2 emissions from passenger transport. In addition, the NMT network of pedestrian and cycling roads will complement and connect a proposed eco-mobility corridor in the 8 Lakes Rejuvenation and Restoration Plan under the Smart Cities Project. The NMT network's overall investment costs amount to INR 9,895 million (GIZ,2020).

The key objectives of the NMT Network Plan are:

- To provide safe accessibility through an integrated NMT network as well as high-quality NMT facilities that can reduce the number and severity of traffic collisions that involve pedestrians and cyclists.
- To encourage inclusive mobility and benefit women, the elderly, the differently abled, and the urban poor or any other groups that predominantly rely on NMT and public transport.
- To reduce traffic congestion by increasing active modes of transport and reducing road capacity.
- To improve accessibility to public transport by increasing safe access to stations by foot and bicycle.
- To provide cost-effective transport solutions since maintenance costs of NMT infrastructure are low compared to other modes of transport.
- To improve the health of residents who use the NMT network by increasing their physical activity and adopting more healthy lifestyles that can also positively affect productivity.
- To increase tourism by creating a more pleasant walking and cycling environment.
- To improve business profitability through improved walking and cycling conditions that are known to increase retail and property values.
- To mitigate against climate change by increasing energy efficiency and reducing air pollution.

The CCMC has analyzed secondary data on Coimbatore's transport system, mobility strategies, and socio-economic characteristics. It also conducted surveys to collect primary data on mobility patterns and transport needs in the city; this included data on traffic volumes, travel speeds, parking availability, travel characteristics of public transport passengers, modal split, accidents, as well as forecasts for future transport demand. Regarding the NMT network specifically, the CCMC, with the support of GIZ, has identified pedestrian priority networks and cycling routes and has developed primary, secondary, and tertiary modes, as well as how these interact with each other. The research results and strategies are presented in a detailed project report (GIZ, 2020).

Despite the above, a quantitative analysis that clearly demonstrates the numerous economic, social, and environmental benefits and costs of a well-implemented NMT network and the extent to which such a network can yield mobility improvements, has not been developed. For this reason—and in order to encourage public authorities to invest in pedestrian and cycling infrastructure—it is imperative to not only estimate the value of the investment (capital and O&M) but also the added benefits and avoided costs that result from the NMT network. In other words, the valuation of added benefits and avoided costs aims to strengthen the business and societal case for the NMT network and clearly show the multitude of benefits that it can have in the long term. The SAVi assessment of the NMT aims to fill this information gap.

The added benefits and avoided costs of the NMT network do not only include economic impacts often captured in conventional project analysis such as avoided fuel costs and road maintenance costs but also a full range of economic, social, and environmental externalities including the value of time saved, potential property and retail changes, as well as costs associated with air pollution and CO_2 emissions. As part of this assessment, the monetary values of the full range of added benefits and avoided costs is integrated into a CBA of the NMT network, creating an assessment of the societal value of the investment. Because demand for new and transformative active transport projects is difficult to forecast, the SAVi assessment includes an NMT scenario and compares the results to a baseline scenario (status quo) that does not include an NMT network.

This SAVi assessment of the NMT network in Coimbatore, India, is part of a series of nine SAVi assessments on sustainable transport and mobility projects that aim to raise awareness on sustainable transport infrastructure and inform decision-makers on the use of systemic approaches in supporting the transformation toward sustainable mobility.

1.3 Structure

Section 2 of the report presents the methodology of the SAVi assessment, including an overview of system dynamics and the causal loop diagram (system dynamics model) that was created for this assessment, as well as a summary of the valued added benefits and avoided costs. The scenarios and assumptions used in the assessment are provided in Section 3. The section summarizes demand figures and shifting mobility patterns associated with the NMT demand scenario and then presents the valuation methodologies and data sources used for each added benefit and avoided cost. Section 4 of the report presents the results. The section starts with the integrated CBA table that demonstrates the total cumulative monetary values generated by the NMT demand scenario. The values of added benefits and avoided costs are integrated into the CBA that includes the capital and operational expenditures for the NMT network to better represent the societal value of the NMT network in Coimbatore. Both parameters are also summarized separately. The last part of Section 4 includes the valuation results for each added benefit and avoided cost. Section 5 concludes by illustrating how the results of the SAVi assessment make a stronger case for NMT by highlighting the added value of integrating economic, social, and environmental parameters into transport assessments.

2.0 Methodology

This chapter introduces the system dynamics methodology used for this SAVi assessment. It provides an overview of the causal loop diagram (CLD), as well as a summary of the impacts of the NMT network in the city of Coimbatore, from a systemic perspective. The second part of this chapter summarizes the added benefits and avoided costs used in the assessment. A more elaborate description of the valuation process of the added benefits and avoided costs are included in Section 3. Some of the limitations of the methodology used are discussed in Section 5.

2.1 System Mapping

2.1.1 SYSTEMS THINKING AND SYSTEM DYNAMICS

The underlying dynamics of the NMT network in Coimbatore, including driving forces and key indicators, are summarized in the CLD displayed in Figure 2. The CLD includes the main indicators analyzed, their interconnections with other relevant variables, and the feedback loops they form. The CLD illustrates the interconnections of the economy with a wide range of social and environmental parameters while highlighting key dynamics and potential trade-offs emerging from different development strategies envisaged for the NMT network. The CLD is the starting point for the development of the mathematical stock and flow model.

2.1.2 READING A CAUSAL LOOP DIAGRAM

CLDs aim to accurately capture causal relationships within a system to increase the effectiveness of relevant solutions and interventions. Therefore, CLDs establish causal links between variables. CLDs include variables and arrows, with the latter linking the variables together with a sign (either + or –) on each link, indicating a positive or negative causal relation (see Table 1):

- A causal link from variable A to variable B is positive if a change in A produces a change in B in the same direction.
- A causal link from variable A to variable B is negative if a change in A produces a change in B in the opposite direction.

Table 1. Causal relations and causality

Variable A	Variable B	Sign
⬆	⬆	+
⬇	⬇	+
⬆	⬇	–
⬇	⬆	–

Circular causal relations between variables form causal, or feedback, loops. These can be positive or negative. A negative feedback loop tends toward a goal or equilibrium, balancing the forces in the system (Forrester, 1961). A positive feedback loop can be found when an intervention triggers other changes that amplify the effect of that initial intervention, thus reinforcing it (Forrester, 1961). CLDs also capture delays and nonlinearity. In addition, reinforcing loops tend to increase and amplify everything happening in the system (i.e., action – reaction), whereas balancing loops represent a self-limiting process that aims to find balance and equilibrium. A detailed description of all the reinforcing and balancing loops for the NMT network in Coimbatore is included in Appendix A.

2.1.3 CAUSAL LOOP DIAGRAM FOR THE NMT NETWORK IN COIMBATORE

The CLD is described at length in Appendix A. The impacts and relationships captured in the CLD were confirmed and validated by GIZ India.

The manifold and diverse impacts of the NMT network in the city of Coimbatore are presented in the CLD in Figure 2.

One of the main dynamics of the system is the shift from motorized transport to non-motorized transport and vice versa, which is represented by a reinforcing loop (R1) that is strengthened or weakened by the dynamics in the diagram. Historically, it has been observed that as GDP grows, demand for transport and mobility increases. As there is more disposable income and affordability, motorized transport demand grows, and the number of private vehicles increases. This leads to a wide range of undesirable outcomes, such as traffic congestion, higher fuel use, increased air pollution and noise pollution, increased number of road accidents and growing CO_2 emissions. These outcomes impact motorized transport demand in different ways by either reinforcing it or balancing the trend by counteracting it. For example, increased exposure to air pollution (R13) and growth in employment (R7 & R10) reinforce motorized transport demand. But impacts such as traffic congestion (B1), CO_2 emissions (B2 & B8), accidents (B3 & B9), physical activity (B5), employment from NMT (B7), noise pollution (B10), and retail revenues (B11) create a balancing effect.

Investment in NMT can address many of these negative effects. It is expected that the NMT infrastructure will result in numerous economic, social, and environmental benefits. The factors that reinforce the dynamics for the NMT infrastructure are physical activity (R6), accidents from motorized transport (R5), CO_2 emissions from fuel use (R3), traffic congestion (R2), employment (R8), changes in property values (R9), noise pollution (R11), and changes in retail revenues from improved walkability (R12). The only loops that can counteract the reinforcing dynamics for the NMT infrastructure are the accidents resulting from an increase in the use of NMT modes (B4), the effect of environmental awareness (B6), and the exposure to air pollution for people using the NMT network (B12).

Overall, investment in NMT stimulates economic growth, either directly through employment creation or indirectly through stimulating retail and property value increases. From the perspective of the public sector, higher GDP leads to government revenues, allowing the allocation of more resources to NMT infrastructure.

Figure 2. Causal loop diagram for NMT in Coimbatore

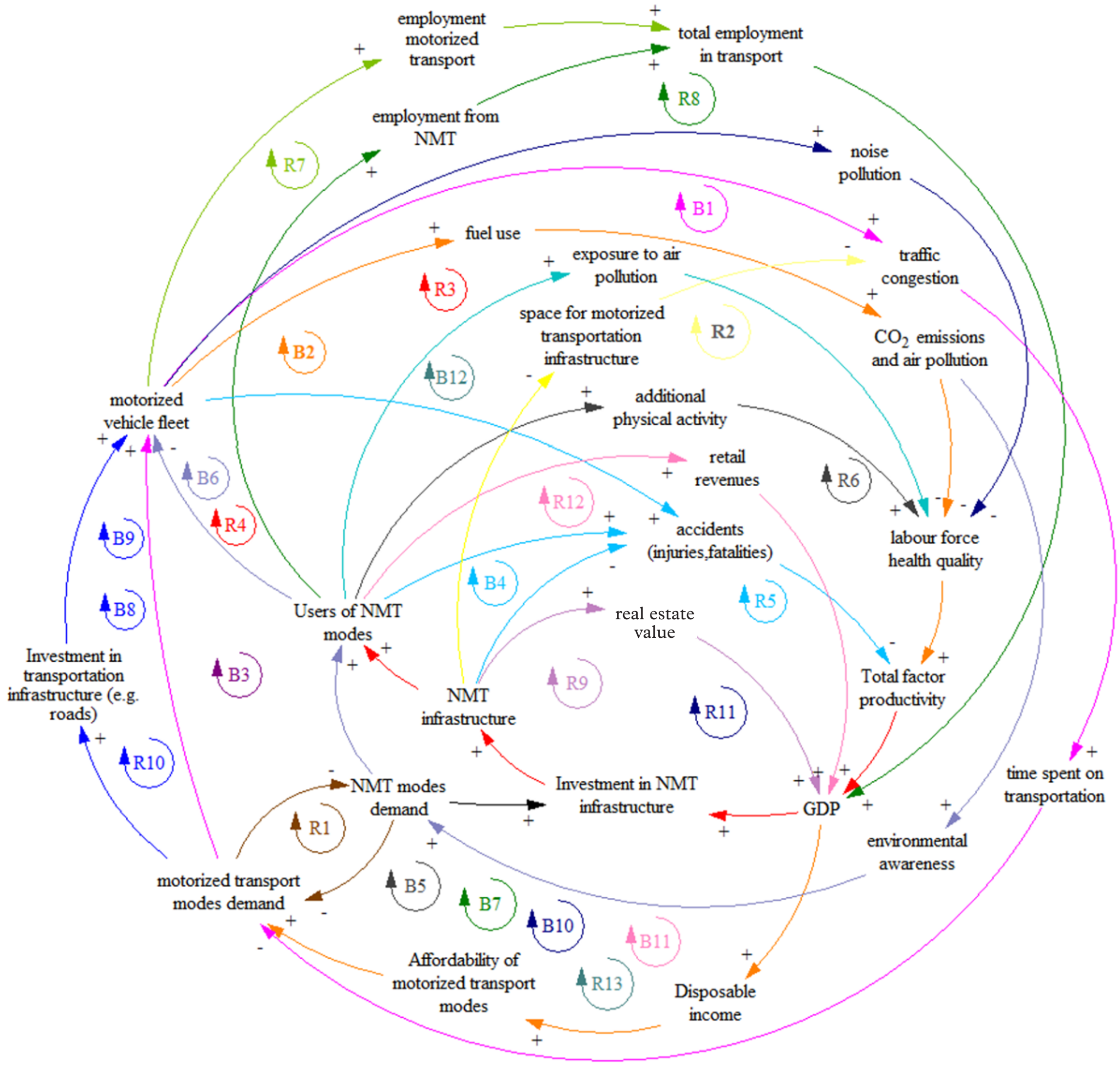
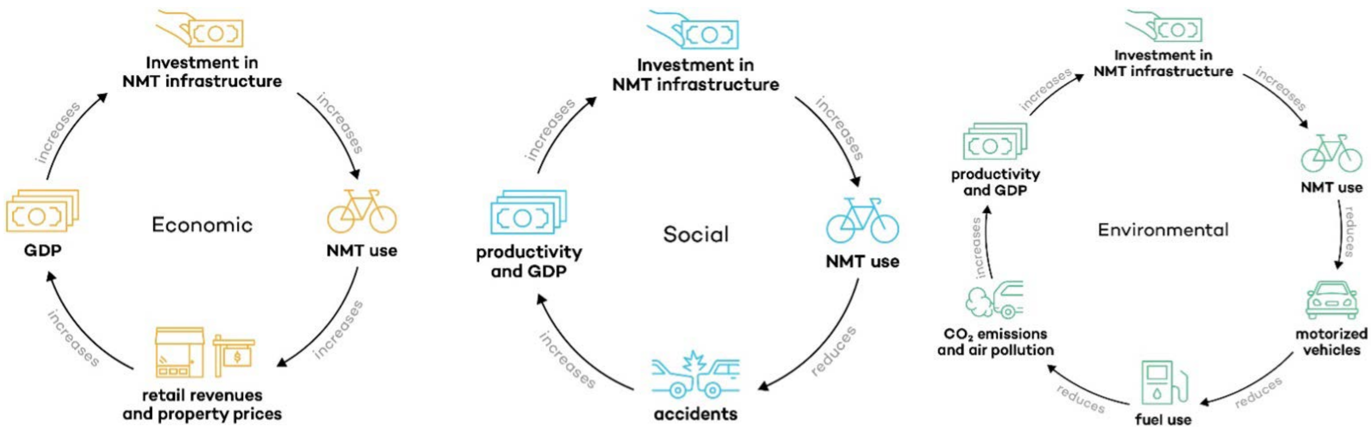


Figure 3. Examples of economic, social, and environmental causal relationships



The economic causal relationship above includes the following feedback loops from the CLD:

R9 – Property valuation driven by NMT infrastructure: an increase in NMT infrastructure increases the value of the surrounding properties, which increases GDP and leads to more investment in NMT.

R12 – Retail revenues driven by NMT infrastructure: An increase in NMT use increases retail revenues, which increases GDP. This leads to an increase in investment in NMT, which results in an increase in NMT use.

Similarly, the social causal relationship includes the following feedback loop from the CLD:

R5 – Accidents driven by NMT infrastructure: The increase in NMT infrastructure (crosswalks, cycling lines, bridges for NMT, stoplights, etc.) leads to a decrease in traffic accidents, increasing the total factor productivity and GDP. An increase in GDP leads to an increase in investment in NMT and an increase in NMT infrastructure.

Lastly, the environmental causal relationship includes the following feedback loop from the CLD:

R3 – NMT use driven by fuel use and investment: An increase in the use of NMT generates a decrease in the fuel use, CO_2 emissions, and air pollution, increasing the labour force health quality, the total factor productivity, and GDP. An increase in GDP leads to an increase in the investment in NMT, which results in an increase in NMT use.

2.2 Added Benefits and Avoided Costs Valued by the SAVi Assessment

The SAVi assessment provides the monetary valuation of project-related added benefits and avoided costs of an implemented NMT network and related infrastructure to use the network. Table 2 lists all added benefits and avoided costs considered in this assessment, as well as stakeholders and indicators of relevance. Section 3.2 explains in detail how each of these indicators is quantified and includes all data sources and assumptions.

Table 2. Added benefits and avoided costs considered in the SAVi assessment

Added benefit or avoided cost	Relevant stakeholder (government, households, private sector)	Social, environmental, economic
Income creation from employment	Government, households	Economic
Health impacts	Government, households	Social
Value of time saved	Households, private sector	Economic
Increase in retail revenues	Private sector, households	Economic
Increase in property prices	Government, private sector, households	Economic
Cost of CO_2 emissions	Households	Environmental
Cost of fuel	Households	Economic
Cost of accidents	Households	Social
Cost of noise pollution	Households	Social
Cost of road maintenance	Government	Economic

3.0 Scenarios and Assumptions

This chapter primarily introduces the scenarios simulated for the NMT assessment, including demand figures and shifting mobility patterns associated with the NMT scenario. Subsequently, it examines the underlying valuation methodologies of the SAVi assessment for the NMT scenario. This includes the assumptions, data sources, and valuation processes of the 10 added benefits and avoided costs valued by the SAVi NMT model. The chapter is followed by the SAVi assessment results of the NMT network in Coimbatore.

Table 3 provides an overview of the scenarios simulated for the SAVi assessment and related assumptions. The assessment consists of the status quo scenario and the NMT scenario. The status quo scenario is considered as the baseline scenario that assumes the modal shares of transportation from 2022 are going to remain constant during the simulation period. The NMT scenario is considered as the "action" scenario, which includes the construction of NMT infrastructure and changes in modal share, including increases in walking (by 3%) and cycling (by 2%) by the end of the project lifetime compared to the status quo scenario. The SAVi NMT model considers a project period of 23 years (2022 to 2045) for both scenarios. The construction period lasts 15 years (from 2022 to 2037), and the additional 8 years have been assumed for O&M activities, in line with average timeframes of heavy maintenance on road re-pavements.

Table 3. Scenarios simulated for the NMT SAVi assessment

Modal share of transportation	Unit	Status quo scenario (2022–2045)	NMT scenario (2045)
Private motor vehicles (cars, taxis, motorcycles etc.)	% of trips	33%	29%
Bus	% of trips	43%	43%
Auto rickshaw	% of trips	9%	8%
Cycle	% of trips	1%	3%
Walk	% of trips	14%	17%

Table 3 shows the different mobility shifts in the status quo and NMT scenarios, and, more importantly, the shift from other transport modes to walking and cycling (using the NMT network). An occupancy rate for each transport mode is assumed in order to calculate the passenger kilometres (pkm) per transport mode. The number of kilometres shifted to walking and cycling (i.e., the additional number of kilometres cycled using the NMT network) is also considered in the analysis as well as the amount of transport km that are avoided per vehicle mode thanks to the NMT network. It is crucial to calculate both the passenger km (pkm) shifted to walking and cycling and the vehicle kilometre (vkm) avoided per transport mode in order to quantify and value various added benefits and avoided costs appropriately as explained in the previous sections. The modal shares of the status quo scenario are assumed to be constant over the entire project period. For the NMT scenario we assume a change that is linear over time up until the end of the construction year (2037) from which point onwards values are assumed to remain constant up to 2045.

3.1 Valuation Methodologies of the Added Benefits and Avoided Costs

3.1.1 INCOME CREATION FROM EMPLOYMENT

Construction and O&M of the NMT network will lead to employment creation, which has beneficial socio-economic impacts, such as increased discretionary spending. Discretionary spending from labour income represents the amount of money that flows back into the economy in the form of additional consumption.

For employment creation during construction, an investment-based multiplier was used to calculate how many jobs will be created, based on the yearly capital investment of the NMT network. In addition, the total jobs created were calculated based on the direct jobs and indirect jobs generation potential per 1 million USD invested in NMT, valued at 4.2 and 2.2 jobs respectively (Garrett-Peltier, 2011). The induced job generation potential from investment in NMT was not considered in this assessment, so the overall increase in discretionary spending due to the NMT is very likely even higher than our current estimate. For employment creation during O&M, a value showing the employment creation per km considered in O&M costs was used (GIZ, 2020). Subsequently, the O&M job creation potential was estimated based on the length in km of NMT infrastructure that was outlined in the NMT plan.

Primarily, annual income creation was calculated. Subsequently, discretionary spending was estimated using a share of the annual income generation of both construction and O&M jobs created as a result of the NMT network. Values related to the average annual salary in Coimbatore were used to estimate income creation from construction jobs, and minimum wages in O&M costs per year were used to estimate income creation from O&M jobs, both of which were then multiplied by the share of annual income (19.9%) that corresponds to discretionary spending values in Coimbatore.

3.1.2 HEALTH IMPACTS

This section estimates health impacts by aggregating three different parameters, namely the health benefits from increased physical activity resulting from using the NMT network, the health costs of air pollution, and the health costs resulting from increased exposure to air pollution by NMT users. The avoided costs of traffic accidents are considered in a separate section.

Primarily, physical activity, such as walking and cycling, has beneficial health effects. The World Health Organization (WHO) has developed the Health Economic Assessment Tool (HEAT) to quantify and monetize health benefits from additional time spent on active modes of transport (WHO, 2017). The methodology of HEAT makes it possible to estimate the reduced risk of all-cause mortality due to increased physical activity. The reduction in relative risk of mortality is valued using the value of a statistical life (VSL). The VSL is derived from a method called willingness to pay, which considers the aggregated individual willingness to pay to reduce the risk of premature death in accordance with life expectancy. This includes factors such as consumption, inability to work, health-care payments, etc. (WHO, 2017).

The methodology is also applied in this SAVi assessment to value the benefits for people in Coimbatore switching from motorized transport modes to walking and cycling through the provision of the NMT network. To consider the national context in India for the valuation of health benefits, a crude death rate in Coimbatore of 3.6 people per 1,000 was used, based on values from Delhi (Wuennenberg et al., 2020) and a VSL of INR 28 million was obtained from a recent report by The Energy and Resources Institute (TERI) (2018). The report summarized estimations of the overall benefits of increased cycling rates in India using the HEAT methodology.

The calculation of benefits from physical activity in this SAVi assessment assumes a shift from motorized transport to walking and/or cycling, which increases the overall time spent active for that specific group and hence reduces mortality of those affected. Transport users switching to walking and cycling will benefit from reduced mortality. The weighted average reduction in mortality represents the net impact of the shift in mobility from all indicated modes toward walking and cycling. The value of health benefits increases progressively as the NMT network is built and used over a 15-year period. After the construction period, the estimated change in mortality is fully applied.

Regarding air pollution, the shift from motorized, fuel-based transport modes to the use of a non-polluting NMT network in Coimbatore will reduce air pollution. The avoided cost of air pollution is estimated based on each transport mode's air pollutants and the health costs associated with emitting 1 kg of a specific air pollutant. The SAVi NMT model includes the valuation of PM2.5, NOx, CO_2, and hydrocarbons (HCs). The difference in the total health cost of air pollutants between the baseline and the NMT scenario is calculated by multiplying the health cost per kg of each respective pollutant with the volume of air pollution avoided as a result of using the NMT network. Low- and high-value estimates for the health cost of the pollutant PM2.5 have been used in the analysis based on different pollution levels in Coimbatore (proportional to values used for pollution in New Delhi). Transport-related air pollution is likely to decrease over time as fossil fuel-powered vehicles will become more energy efficient and will be gradually replaced by electric vehicles.

Table 4 summarizes these input parameters for the motorized transport modes that are partly replaced by using the NMT network.

Table 4. Air pollutants (in g/km) per transport mode in Delhi and health cost valuation per emitted air pollutant

Emission factors (in g/km)	Unit	PM2.5	NOx	CO_2	HCs
Bus	g/km	2.672	21.38	11.92	3.311
4-wheeler	g/km	0.05	0.243	3.595	0.469
2-wheeler	g/km	0.071	0.086	2.027	2.049
Auto rickshaw	g/km	0.108	0.329	2.958	5.137
Pedal rickshaw	g/km	0	0	0	0
Cycle	g/km	0	0	0	0
Walk	g/km	0	0	0	0
Metro	g/km	0	0	0	0
Railway	g/km	0	0	0	0
Valuation of emissions					
Health cost of pollutants (low value)	INR/kg	1,371.53	0.98	0.01	0.08
Health cost of pollutants high value	INR/kg	10,523.37	0.98	0.01	0.08

Source: CE Delft et al., 2011; Rahul et al., 2013.

Lastly, cycling in urban environments such as Coimbatore's—with high background concentrations of air pollutants—tends to have worse health effects than using motorized forms of transport. This is the case because the pollutant dose increases for cyclists due to direct exposure in traffic and higher inhalation rate during physical activity as opposed to sitting in vehicles (Rabl & Nazelle, 2012). The other exposure factor is the ambient air pollution concentration faced by cyclists. Depending on traffic volumes, location of the cycle path and filter technologies used in vehicles, the ambient concentration of air pollutants can vary for cyclists compared to vehicle users. However, given the high concentration of air pollution in Coimbatore and the effects of higher inhalation rates, we assume an increased exposure for transport users that switch from motorized transport to cycling. The negative health effects caused by PM2.5 with respect to all-cause mortality are considered in this SAVi assessment—they include higher risks for strokes, heart disease, lung cancer, and respiratory diseases.

The cost of increased exposure to air pollutants is estimated based on the health cost per km travelled per person per year as indicated by Rabl and Nazelle (2012) and the total km shifted to NMT. It is important to note that given the significantly higher PM2.5 background concentration in Coimbatore compared to the European context of the study by Rabl and Nazelle (2012), we are likely underestimating the negative health costs from a switch from driving to cycling in Coimbatore. In addition, the exposure (and hence the negative health effects) strongly depend on where cycling takes place. If it takes place on a separate cycling path next to the road with motorized traffic, the negative health effects will be much lower compared to cycling on the main street behind cars and buses. Due to the lack of these contextual factors, the calculations rely entirely on Rabl and Nazelle (2012).

3.1.3 VALUE OF TIME SAVED

The value of time saved represents the economic value of improved mobility resulting from the NMT network. The value of time saved is estimated in real terms, meaning that the assessment does not apply a growth rate to the value of time saved over time. An average speed for each assessed transport mode has been assumed for the calculation. TERI (2018) estimates the speed of walking and cycling in India as 5 km/h and 12 km/h respectively. The assumed speeds of the other transport modes are informed by literature and consultations with the client. It has not been assumed that the speed of travel for motorized transport declines in the future due to increases in congestion. The inputs used are as follows (Wuennenberg et al., 2020; WHO, 2014):

- Walking: 5 km/h
- 4-wheel: 26 km/h
- 2-wheel: 23 km/h
- 3-wheel auto rickshaw: 16 km/h
- 3-wheel pedal rickshaw: 10 km/h
- Buses: 12 km/h

The shift from other transport modes to walking and cycling will result in differing travel speeds. Consequently, depending on the current mode of transportation, the NMT network will lead to either time savings or additional time spent for commuting. The respective hourly figure of time saved is multiplied by the hourly salary of commuters to calculate the value of the hourly time saved. The hourly salary is based on assumed 2,511 annual working hours, taken from values in Delhi (UBS, 2018) and an average annual salary in Coimbatore amounting to INR 359,000 (Salary Explorer, 2022). The analysis does not differentiate NMT users based on income and socio-economic background. If a dominant share of users is connected to a specific income class, this will impact the calculation of the economic value of time saved, which is based on average salary.

3.1.4 CHANGES IN RETAIL REVENUES

Studies suggest that both the mode of transport and commuting speed affect retail spending. For instance, walking is associated with higher retail spending. If the walkability of an area improves, people tend to spend more time—and money—in that area (Rabl & Nazelle, 2012; Victoria Transport Policy Institute [VTPI], 2018).

It is assumed for this assessment that an implemented NMT network will be complemented by improved walking infrastructure, such as street lighting. It is also assumed that the average number of trips per day changes over time, with an average value of 1.68, a minimum value of 1.5 and a maximum value of 1.76. It is important to note that the value of trips per day changes due to future projections of transport trip demand and population growth. Lastly, the average retail spending value used is based on the average salary of Coimbatore for 2022.

The approach for quantifying additional retail sales assumes increased spending of approximately 42.2 % (VTPI, 2018) per additional trip that is shifted to NMT, excluding the walking or cycling trips that were already taking place before the NMT network was implemented. The additional retail spending volume is based on the additional number of daily walking trips that occur as a result of the NMT. The number of trips is then multiplied with the average minimum daily retail spending in Coimbatore (calculated based on New Delhi values) and the difference in spending that occurs if people are on foot as opposed to any other means of transportation, which is approximately 42.2% higher (Rabl & Nazelle, 2012). The result yields the total additional daily retail spending resulting from improved walkability.

While the NMT network will increase retail revenues around NMT infrastructure, there will likely be a shift of retail spending from other areas in Coimbatore to areas with NMT infrastructure. However, there is a stronger economic multiplier, as smaller shops near NMT infrastructure will increase their retail revenues, which, coupled with reductions in vehicle and energy use, will contribute to the city's vibrancy.

3.1.5 CHANGES IN PROPERTY VALUES

Shifting from motorized transport to active forms of transportation, such as walking and cycling, tends to have positive impacts on property values because it leads to changes in provided transport and safety infrastructure, which improves walkability in affected areas. Other impacts, such as the reduction in air pollution and noise pollution, as well as higher retail spending, can also have positive effects on real estate values.

In this SAVi assessment, the impact of improved walkability on property value is considered, based on the assumption that the implementation of the NMT network will be accompanied by cycling and pedestrian infrastructure that enables safe cycling and associated co-benefits for improved walking. Research has shown that improved walkability in a city can increase property values by 5% to 15% (Buchanan, 2007; Song & Knaap, 2003; VTPI, 2018). The scale of increase depends on the degree of improved walkability but also on perceived improvements in safety.

The average property value in Coimbatore is INR 362 per m^2 (Housing.com, 2022). The total property value increase is estimated by multiplying the average property price per m^2 with the estimated cumulative area impacted by the NMT in m^2. This is, in turn, multiplied by the increased value of property due to improved walkability, which is assumed to be 5% for the lower-end valuation scenario and 10% for the higher-end valuation scenario. The results represent the total one-time increase in property values in the area affected by the NMT network.

The forecast of the potential increase in property values is based on the direct impacts of the investment assessed. Citywide dynamics are not considered in the assessment.

3.1.6 CO_2 EMISSIONS

The replacement of motorized, fossil fuel-based transport modes by the NMT network and increased volumes of walking and cycling is accompanied by a reduction of the transport sector's CO_2 emissions. The social cost of carbon (SCC) per kg of CO_2 is based on Nordhaus (2017) and amounts to USD 31 per ton of CO_2.[1] The SCC is multiplied by CO_2 emission values per transport mode (Sharma et al., 2014), as indicated in Table 5, which is, in turn, multiplied by the total avoided emission costs as a result of implementing the NMT network. It is important to note that CO_2 emissions generated during the construction of the NMT network are not considered in this analysis.

Table 5. CO_2 emissions per transport mode in Coimbatore (based on Delhi values)

Emission factors (in g/km)	Unit	CO_2
Bus	g/km	806.5
4-wheeler (average)	g/km	134
Gasoline	*g/km*	*115*
Diesel	*g/km*	*153*
2-wheeler	g/km	24.4
Auto rickshaw	g/km	77.7
Pedal rickshaw	g/km	0
Cycle	g/km	0
Walk	g/km	0
Metro	g/km	0
Railway	g/pkm	1.27
Valuation of emissions		
SCC	USD/kg	0.031
SCC in INR	INR/kg	2.37

Source: Nordhaus, 2017; Sharma et al., 2014.

[1] SCC values for India can oscillate among studies. Nordhaus (2017) proposes a value for India of USD 2.93 per ton of CO_2, while for Ricke et al. (2017) the country-level SCC for India is USD 86 per ton of CO_2. The approach taken was to use the global value of USD 31 per ton of CO_2 because it is close to the average of the two values mentioned.

3.1.7 FUEL USE

The shift from motorized, fossil fuel-based transport modes to NMT modes is accompanied by a reduction in fuel costs that result from fuel savings. The number of trips by transport mode per vkm that have been shifted to walking and cycling are used to estimate the total amount of fuel saved through the shift. The fuel efficiency by transport mode in kms per litre and the average annual mileage by transport mode in kms are included in the calculation (Goel et al., 2016). Where appropriate, a weighted average value is used, based on fuel shares of diesel, petrol, and LPG in Coimbatore. Where this has not been possible, fuel per km values from case studies from other Indian cities are used. Subsequently, the amount of fuel saved as a result of the shift from motorized to active transport modes due to the introduction of the NMT network is multiplied by the price per litre of fuel in Coimbatore (Goodreturns, 2022). Information for fuel prices and types, transport modes, and case studies used is summarized in Table 6.

Table 6. Fuel prices per fuel type, mode, and case study used

Fuels shares transport sector in Coimbatore	Unit	Fuel shares
Diesel	%	0.65
Petrol	%	0.33
Liquefied petroleum gas	%	0.02
Fuel use per km	**Unit**	**Fuel use**
Rajkot case study		
Diesel cars (all engine sizes)	ltr/km	0.074
Petrol cars	ltr/km	0.063
Petrol motorized two-wheelers	ltr/km	0.019
Diesel three-wheelers	ltr/km	0.042
Visakhapatnam case study		
Diesel cars (all engine sizes)	ltr/km	0.062
Petrol cars (all engine sizes)	ltr/km	0.067
Petrol motorized two-wheelers	ltr/km	0.021
Diesel three-wheelers	ltr/km	0.034
Weighted average		
Diesel+petrol cars	ltr/km	0.066
Petrol MTWs	ltr/km	0.020
Average cars+MTWs	*ltr/km*	*0.043*
Diesel three-wheelers	ltr/km	0.038

Fuel prices		
Average (diesel and petrol) in Coimbatore	**INR/Ltr**	**97.665**
Diesel	INR/Ltr	92.69
Petrol	INR/Ltr	102.64

Source: Goel et al., 2016; Goodreturns, 2022.

3.1.8 NUMBER OF ACCIDENTS

The valuation of traffic accidents is calculated using several factors. The number of accidents per 100,000 persons or the accident risk for the state of Tamil Nadu is used to estimate the number of annual accidents in Coimbatore (Ministry of Road Transport and Highways, 2017). In addition, three different degrees of accident severity are considered: minor, major, and fatal. The share of accidents per severity type in Coimbatore is then calculated and subsequently multiplied by the cost of accidents per severity from values provided from Nagpur city, Maharashtra, India (Bora et al. (2018))

The annual accident rates in Coimbatore prior to the implementation of the NMT network per accident severity are shown in Table 7. Annual accident rates following the implementation of the NMT network are estimated based on changing accident risk levels. The number of accidents is assumed to decrease if the number of motorized vkm is reduced. Table 7 presents the number of reduced accidents per accident severity category in the status quo scenario.

Table 7. Annual number of accidents in Coimbatore prior to the implementation of the NMT network

Type of accident severity	Unit	Accidents in Coimbatore (status quo)
Fatal	Accidents/year	450
Major	Accidents/year	504
Minor	Accidents/year	1,996
Total	Accidents/year	2,950

Source: Government of Tamil Nadu, 2020.

The next step in valuing the reduced accident costs is to estimate the economic value per accident, depending on accident severity. Fatal accidents are those in which a human life is lost and are consequently valued the highest among the three accident categories. Table 8 provides an estimate for the monetary value of fatal accidents as well as for values for minor and major accidents (Bora et al., 2018). The indicators considered for the cost valuation are human capital cost (consumption loss) and resource cost (damages, administrative costs, medical costs) considered as public cost, and human suffering cost, considered as private cost. This reference also provides details about the various cost items and amounts associated with each respective accident severity level.

Table 8. Valuation of accidents per accident severity

Cost of accidents per severity	Unit	Cost per accident
Fatality	INR/accident	2,838,768
Serious injury	INR/accident	217,924
Minor injury	INR/accident	36,953

Source: Bora et al., 2018.

3.1.9 NOISE POLLUTION

Noise emissions from various transport modes can cause negative health effects to humans exposed to the noise. These are usually stress-related health effects like hypertension and myocardial infarctions (heart attacks) (Ricardo-AEA et al., 2014). According to the source, the calculation of the cost of noise pollution follows a bottom-up approach that considers the number of people exposed to noise and the total cost of noise pollution, calculated by multiplying the cost of noise per person exposed by the total amount of people exposed. Finally, weighting factors are applied to account for differences in noise characteristics between different modes of transportation (CE Delft et al., 2011).

In this SAVi assessment, the avoided cost of noise pollution is estimated as the NMT scenario increases the use of walking and cycling which, as transport modes, are characterized by zero noise pollution. The total value is estimated based on the reduced noise emissions per vkm per transport mode being replaced by the NMT network. The estimation also considers different noise levels per transport mode, influenced by peak and off-peak travel times. Since cycling will replace only short trips, the SAVi assessment generates noise costs for different transport modes, as shown in Table 9.

Table 9. Noise cost per vkm by transport mode

Noise cost per vkm	Unit	in EUR	in INR
Bus	value/vkm	0.0016	0.1343
4-wheeler (average)	value/vkm	0.0017	0.1427
2-wheeler	value/vkm	0.0144	1.2086
Auto rickshaw	value/vkm	0.0144	1.2086
Pedal rickshaw*	value/vkm	0.0005	0.0420
Cycle	value/vkm	0.0000	0.0000
Walk	value/vkm	0.0000	0.0000
Other & trucks	value/vkm	0.0063	0.5288
Metro	value/vkm	0.0012	0.1007
Railway	value/vkm	0.0010	0.0839

3.1.10 ROAD MAINTENANCE

The shift from motorized transport modes to NMT modes is accompanied by some avoided costs of road maintenance. The avoided costs of road maintenance are assumed as the cost of road maintenance per km. This is subsequently multiplied by the kms of roads used for the NMT network, which are assumed to be taken from the current road network (not additional network built). Finally, the resulting value is multiplied by the frequency of maintenance work over the project period. Because the frequency of road maintenance varies significantly over the project period, it has been divided into routine maintenance and periodic maintenance. In addition, for periodic maintenance, a low-value estimate and a high-value estimate has been applied that is related to the average amount of road width maintained (Asian Development Bank, 2021). Routine maintenance costs increase every 5 years until the end of the project period and period maintenance costs increase significantly every 10 years. Routine and periodic maintenance costs are then summed up to estimate the annual avoided maintenance costs from the implementation of the NMT network.

4.0 Results

This section describes the results of the SAVi Assessment of the NMT network in Coimbatore. The first part of this section presents a discounted integrated CBA for the NMT network, shown in Table 10 below. It is an integrated analysis because, in addition to the NMT network's conventional investment costs (capital and O&M costs), the economic, social, and environmental added benefits and avoided costs are integrated in the analysis. The second part of this section includes a comparison between the conventional project finance analysis and the integrated analysis to demonstrate the importance of valuing the multiple added benefits and avoided costs. The last part of this section provides a summary of all economic, social, and environmental added benefits and avoided costs that have been quantified, as well as the valuation results for each added benefit and avoided cost of the NMT demand scenario.

4.1 Integrated Cost-Benefit Analysis

Table 10. Integrated CBA (discounted values for the NMT scenario based on a project period of 23 years)

		NMT scenario 2022–2045	
Integrated CBA	**Unit**	**Low estimate**	**High estimate**
Total investment costs	**INR million**	**9,895**	**9,895**
Capital cost NMT System	INR million	9,209	9,209
O&M cost NMT System	INR million	686	686
Total added benefits	**INR million**	**11,128**	**12,672**
Income creation from employment	INR million	133	133
Health impacts *	INR million	6,857	7,484
Value of time saved	INR million	490	490
Increase in retail revenues	INR million	2,730	2,730
Increase in property prices *	INR million	917	1,834
Total avoided costs	**INR million**	**35,871**	**36,134**
Cost of CO_2 emissions	INR million	164	164
Cost of fuel	INR million	4,184	4,184
Cost of accidents	INR million	30,144	30,144
Cost of noise pollution	INR million	875	875
Cost of road maintenance *	INR million	504	767

Integrated CBA	Unit	NMT scenario 2022–2045	
		Low estimate	High estimate
Net results of valued added benefits and avoided costs			
Cumulative net benefits (undiscounted)	INR million	80,967	84,203
Cumulative net benefits (discounted)	INR million	37,104	38,911
BCR		0.47	0.50
S-BCR		4.75	4.93

* Added benefits and avoided costs that are impacted by the different demand scenarios

Overall, an integrated analysis provides a more holistic view for assessing whether the NMT network generates net benefits and can be considered a worthwhile investment from a societal perspective. This is because the integrated cost-benefit analysis considers both conventional costs and revenues as well as added benefits and avoided costs. A project period of 23 years is considered to highlight the NMT network's net benefits and provide a reference point for the overall investments required for the wider NMT infrastructure. As mentioned earlier, the SAVi NMT model considers a project period of 23 years (2022 to 2045), including the construction period, which takes place over the first 15 years (2022 to 2037). The cumulative net benefits for the NMT scenario indicate the maximum amount of investment that is viable for the NMT infrastructure in order to consider the entire NMT network worthwhile from a societal point of view.

Table 10 provides the net results of the NMT scenario, differentiated into low and high estimates in accordance with valuations conducted for the different added benefits and avoided costs in Section 2 of this report. The low estimate of the NMT scenario yields undiscounted cumulative benefits of INR 80,967 million, while the high estimate of the NMT scenario yields undiscounted cumulative benefits of INR 84,203 million. In other words, the BCR of the low estimate of the NMT scenario is 4.75, and the BCR of the high estimate of the NMT scenario is 4.93. A more detailed table with undiscounted values for all added benefits and avoided costs can be found in Appendix D.

Once a discount factor is applied to future costs and benefits, the SAVi net results are naturally lower. A discount factor of 10% is applied for the tangible, cash flows indicators, being aligned with the cost of financing. Another discount factor of 5% is used for the intangible costs, which are primarily social and environmental, indicators that do not depreciate over time or depreciate less relative to tangible indicators. The added benefits and avoided costs calculated in this SAVi assessment primarily represent the environmental, economic, and social benefits of the NMT network; therefore, it appears appropriate to use a lower discount factor for these as opposed to conventional costs and revenues. Following the application of these discount rates, the low estimate of the NMT scenario yields cumulative benefits of INR 37,104 million, while the high estimate of the NMT scenario yields cumulative benefits of INR 38,911 million.

4.2 Summary of Investment Costs and Benefit-Cost Ratios

The SAVi assessment of the NMT network in Coimbatore starts with the conventional investment costs. As shown in the first part of the integrated CBA in Table 10, the investment costs include capital and O&M costs, which are always incorporated in a conventional financial analysis. Table 11 displays only the capital expenditures and the O&M expenditures for the NMT network as cumulative values over the project period.

Table 11. Capital and O&M costs of the NMT scenario

CBA	Unit	2022–2045
Investment and costs	**INR million**	**9,895**
Capital cost NMT system	INR million	9,209
O&M cost NMT system	INR million	686

It is important to differentiate between a conventional BCR and an S-BCR as indicated in Table 12. The former is based on estimations of only tangible parameters and includes capital costs, O&M costs, and avoided costs of fuel use and road maintenance. The latter considers the project from a societal point of view and is based on an estimation of the full range of economic, social, and environmental added benefits and avoided costs. As indicated in Table 12, the conventional BCR is significantly lower than the S-BCR. The next subsection examines the valuation of the added benefits and avoided costs in more detail.

Table 12. Conventional BCR vs. sustainable S-BCR

	BCR		S-BCR	
Parameters considered	Investment and costs, avoided cost of fuel use, avoided cost of road maintenance		Investment and costs, full range of economic, social, and environmental added benefits and avoided costs	
Scenario	Low estimate	High estimate	Low estimate	High estimate
BCR	0.47	0.50	4.75	4.93

4.3 Summary of Added Benefits and Avoided Costs

The SAVi assessment of the NMT network in Coimbatore calculates monetary values for a range of added benefits and avoided costs, arising from the implementation and use of the NMT network. Table 13 focuses on the cumulative monetary values of the added benefits and avoided costs over the 23-year project period. A high-valuation and a low-valuation estimate are presented for added benefits and avoided costs (shown with an * in Table 13) where literature and available data showed diverging figures to arrive at a customized and appropriate monetary valuation. For instance, the increase in property values resulting from improved walkability and less noise pollution due to the NMT network is considered as a one-time increase in property values.

Table 13 presents cumulative net values over the project period, indicated as discounted numbers. A discount factor of 5 % is assumed for added benefits and avoided costs (Institute of Economic Growth, 2018). The discounted net value of the NMT scenario amounts to INR 46,999 million according to the low-value estimate and INR 48,806 million according to the high-value estimate. In addition, for each valued added benefit or avoided cost, the table shows which stakeholders are the most relevant and whether social, environmental, or economic indicators are the most suitable.

Table 13. Summary table of valued added benefits and avoided costs of the NMT scenario (discounted at 5% and cumulative 2023–2045). Stakeholders are: G=government, H=households, P= private sector

		NMT scenario			
Costs and benefits	**Unit**	**Low estimate**	**High estimate**	**Stakeholder of relevance (G, H, P)**	**Social, environmental, economic**
Total added benefits	INR million	**11,128**	**12,672**		
Income creation from employment	INR million	133	133	G, H	Economic
Health impacts *	INR million	6,857	7,484	G, H	Social
Value of time saved	INR million	490	490	H, P	Economic
Increase in retail revenues	INR million	2,730	2,730	H, P	Economic
Increase in property prices*	INR million	917	1,834	G, P, H	Economic
Total avoided costs		**35,871**	**36,134**		
Cost of CO_2 emissions	INR million	164	164	H	Environmental
Cost of fuel	INR million	4,184	4,184	H	Economic
Cost of accidents	INR million	30,144	30,144	H	Social
Cost of noise pollution	INR million	875	875	H	Social
Cost of road maintenance*	INR million	504	767	G	Economic
Net results of valued added benefits and avoided costs					
Cumulative net benefits (discounted)	INR million	46,999	48,806		

4.4 Valuation Results per Added Benefit and Avoided Cost

4.4.1 INCOME CREATION FROM EMPLOYMENT

Construction and O&M of the NMT network will lead to employment creation, which has beneficial socio-economic impacts, such as increased discretionary spending. Based on the SAVi assessment, the NMT network will create an estimated 83 full-time equivalent positions during the construction phase, a number that increases to 102 after the first 5 years. Jobs created during the O&M phase are significantly lower in the beginning but increase every year. O&M employment starts at 38 jobs per year in 2022 and increases up to a maximum of 324 jobs per year in 2037, from which point onwards it stays the same. Moreover, additional discretionary spending per year from income generation of both construction and O&M jobs has been considered in order to calculate the total annual income creation. The total cumulative income creation from employment from 2022 to 2045 amounts to INR 133 million. Selected annual values of income from employment creation as a result of the NMT network are summarized in Table 14.

Table 14. Annual values of income creation from increased employment (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual income creation from employment	INR/year	6,861,597	7,773,888	6,952,095	2,860,301	2,241,121	133,000,000

4.4.2 HEALTH IMPACTS

The implementation of the NMT network leads to higher pedestrian and cycling rates in Coimbatore. It also leads to increased levels of physical activity for pedestrians and cyclists which has significant health benefits. The SAVi assessment values these benefits in terms of reduced mortality.

The total health benefits of the NMT scenario amount to INR 8,172 million. Values represent the cumulative net health benefits resulting from the new mobility pattern compared to the baseline, over the 23-year project period. In addition, the buildup period for realizing health benefits from increased cycling is 5 years (WHO, 2017). As mentioned earlier this is due to benefits only emerging after the construction period, once the NMT is in operation. Table 15 shows annual values of health benefits from increased physical activity for selected years.

Table 15. Annual values of health benefits from increased physical activity (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual values of benefits from physical activity	INR/year	53,008,111	258,599,544	501,472,723	549,217,798	430,326,516	8,172,000,000

In addition, the shift of transport users from motorized, fuel-based transport modes to the use of NMT will reduce the level of air pollutants emitted by vehicles. The SAVi NMT model considers the reduced emission levels of PM2.5, NOx, CO, and HCs. The decrease in air pollution is valued by estimating the avoided health cost of air pollution. The lower health costs resulting from reduced kilograms of air pollutants are differentiated into a low- and a high-value estimate. More details on the health cost assumptions are indicated in Section 3.2.2. Table 20 provides a summary of the avoided health costs of the NMT scenario caused by the shift from fossil fuel-based transport to NMT and shows both low- and high-value estimates. It is important to note that only emissions from fuel combustion are assessed and valued. Emissions originating from upstream supply chain stages for fuel production are not assessed.

It is expected that shifting from certain transport modes to NMT does not result in reduced air pollution costs. For instance, transport modes such as electric metro and railway are not associated with any health costs since no fuel combustion takes place during transport use. Similarly, transport modes such as the pedal rickshaw do not cause any emissions.

Table 16 below shows the avoided health cost of air pollution that will result from the implementation of the NMT network in both the low-estimate and the high-estimate scenarios.

Table 16. Cumulative avoided cost of air pollution in the NMT scenario (discounted at 5%)

	Unit	NMT scenario
Health cost of air pollution avoided (low estimate)	INR million	94
Health cost of air pollution avoided (high estimate)	INR million	722

Annual values of avoided air pollution costs for selected years, including both low- and high-value estimates are summarized in Table 17 below.

Table 17. Annual values of avoided air pollution costs (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual cost of air pollution (low estimate)	INR/ year	612,191	2,986,569	5,791,515	6,342,923	4,969,846	94,000,000
Annual cost of air pollution (high estimate)	INR/ year	4,681,372	22,838,027	44,287,191	48,503,762	38,003,967	722,000,000

Lastly, the negative health effects of air pollution (PM2.5) are experienced to an increased degree by commuter groups when switching from motorized or service transport to NMT, especially when switching to cycling, which requires more strenuous physical activity and higher inhalation rates. This negative health effect is considered and valued in this SAVi assessment. The cost of increased exposure to air pollution is estimated based on the health cost per km travelled by bicycle per person, as indicated by Rabl and Nazelle (2012) and the total vkm newly shifted to cycling. Details on assumptions are explained in Section 3.2.2 of this report. Increased exposure to air pollution is considered as an additional cost compared to the baseline (and hence a cost from using the NMT network); therefore, values indicated in Table 13 are negative. The results in the NMT scenario demonstrate that health costs are higher compared to the status quo, amounting to a cumulative net cost of INR 3,041 million. Selected annual values of costs from increased exposure to air pollution are included in Table 18.

Table 18. Annual values of costs from increased exposure to air pollution (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual costs of increased exposure to air pollution	INR/ year	-9,142,465	-44,601,423	-86,490,473	-94,725,206	-74,219,678	-3,041,000,000

4.4.3 VALUE OF TIME SAVED

The value of time saved represents the economic value of improved mobility resulting from the NMT network. In the NMT scenario, the cumulative value of time saved is valued at INR 490 million. The results are itemized per transport mode based on the pkm shifted to NMT. Assumptions for calculating the monetary value of time saved are explained in Section 3.2.3. Despite the higher speed of motorized transport modes compared to NMT, the NMT scenario yields a saved amount of time for commuting because of a simultaneous reduction of motorized transport and increase in cycling and walking rates. Selected annual values of benefits from time saved due to improved mobility as a result of the NMT network are summarized in Table 19.

Table 19. Annual values of benefits from time saved due to improved mobility (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual value of time saved	INR/ year	3,180,713	15,517,078	30,090,506	32,955,415	25,821,430	490,000,000

4.4.4 CHANGES IN RETAIL REVENUES

The shift from motorized transport to NMT modes will increase walkability around retail establishments and, hence, retail spending. The increase in retail revenue due to additional retail spending expected from NMT users amounts to INR 2,730 million. As explained in Section 3.2.4. the improved walkability due to better NMT infrastructure implies higher retail spending by people that use the NMT network but have not cycled or walked before since these groups are not responsible for any additional retail spending. The increase in retail revenues reflects the total additional retail spending in the NMT scenario. Naturally, the higher the demand for NMT infrastructure and the more people shift from motorized transport modes to walking, the higher the total amount of additional retail spending. The results of the NMT scenario provide evidence for that causal relationship, and selected annual values of additional retail spending are included in Table 20.

Table 20. Annual values of additional retail spending (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual values of increased retail revenues	INR/ year	21,484,017	98,953,205	182,838,182	167,467,372	131,215,068	2,730,000,000

4.4.5 CHANGES IN PROPERTY VALUE

Property values in Coimbatore will be affected by a successfully implemented NMT network. The NMT infrastructure in Coimbatore will improve the overall walkability of the area. It is expected that motorized transport will be reduced, and a higher number of safe places will be available for pedestrians and cyclists. Existing studies indicate an increase in property values if walkability is improved in a neighbourhood. The impact on property values found in the literature indicates a potential increase of between 5% and 15 %. The SAVi NMT model assumes that the implementation of the NMT network improves walkability and uses a low estimate of 5% and a high estimate of 10%, discarding the overly ambitious 15%. The scale of the increase in property values due to improved walkability is assumed to be independent of the scale of NMT demand. Accordingly, Table 21 presents the two valuation estimates for net property value increases in Coimbatore (5% and 10%).

Table 21. Cumulative net changes in property values in Coimbatore resulting from an implemented NMT network (discounted at 5%)

	Percentage increase	Unit	NMT scenario
Change in property value (low estimate)	5%	INR million	917
Change in property value (high estimate)	10%	INR million	1,834

Annual rising property values as a result of the NMT infrastructure for selected years are indicated in Table 22. It is important to note that after 2035 the property values remain constant because the area that is impacted by the NMT infrastructure reaches its maximum limit; therefore, years 2040 and 2045 reflect values of 0 in Table 22.

Table 22. Annual property value increase (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual increased property values (low estimate)	INR/ year	75,573,398	70,765,634	58,355,868		0	917,000,000
Annual increased property values (high estimate)	INR/ year	151,146,796	141,531,268	116,711,737	0	0	1,834,000,000

4.4.6 CO_2 EMISSIONS

The NMT network is expected to replace motorized, fossil fuel-based transport modes and increase volumes of NMT. These impacts will significantly reduce the CO_2 emissions from the transport sector in Coimbatore. These emissions are valued in terms of their SCC, described in more detail in Section 3.2.6. The highest reductions in the SCC are achieved by an increased NMT demand replacing private motor vehicles, followed by replaced auto rickshaw trips. This is because of the high carbon footprint of these transport modes in Coimbatore. Based on the above, in the NMT scenario, the reduction in the SCC is higher compared to the status quo scenario. Specifically, the cumulative avoided SCC that results from the NMT network amounts to INR 164 million. Annual values of avoided costs from CO_2 emissions for selected years according to the NMT scenario are included in Table 23.

Table 23. Annual values of avoided CO_2 emissions costs (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual avoided cost of CO_2 emissions	INR/ year	1,060,742	5,174,819	10,034,939	10,990,363	8,611,237	164,000,000

4.4.7 FUEL USE

The avoided cost of fuel is estimated based on the fuel savings resulting from the shift from motorized, fossil fuel-based transport modes to NMT modes. The number of trips by transport mode shifted to walking and cycling, the fuel efficiency of different transport modes, the average annual mileage by transport mode and the price per litre of fuel are all considered in the calculation. Results show that fuel savings from the implementation of the NMT network in Coimbatore amount to INR 4,184 million. Selected annual values of avoided fuel costs in the NMT scenario are included in Table 24.

Table 24. Annual values of avoided fuel costs (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual avoided cost of fuel	INR/ year	27,142,493	132,414,381	256,776,169	281,223,755	220,346,171	4,184,000,000

4.4.8 NUMBER OF ACCIDENTS

The SAVi NMT model distinguishes between three levels of accident severity: minor, major, and fatal. In addition, values are applied for the monetary valuation of fatal, major, and minor accidents. More details on accident statistics and risk levels in Coimbatore are explained in Section 3.2.8. of this report. The valuation results for the NMT scenario show that NMT reduces the number of annual accidents in Coimbatore. SAVi results indicate that the more vkm travelled by motorized transport are replaced by walking and cycling, the fewer accidents happen. This holds true for all accident categories.

The annual accident rates in Coimbatore before and after the implementation of the NMT network per accident severity are estimated based on changing accident risk levels. The number of accidents is assumed to decrease if total motorized vkm are reduced. The total cumulative avoided accident costs in the NMT scenario amount to INR 30,144 million. Annual values of avoided accident costs for selected years are indicated in Table 25.

Table 25. Annual values of avoided accident costs (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual avoided cost of accidents	INR/ year	195,526,707	953,875,096	1,849,741,628	2,025,855,003	1,587,310,405	30,144,000,000

4.4.9 NOISE POLLUTION

The avoided cost of noise pollution is estimated based on the noise emissions and the resulting negative health effects per transport mode. Avoided costs stem from replacing one additional vkm of noise-emitting transport modes by walking or using a bicycle for the respective vkm, since the latter two modes cause no noise pollution. The NMT scenario is associated with a reduced cost of noise pollution because motorized transport is partly replaced by the NMT network. Moreover, the metro and railway are not considered in the analysis since their vkm will not be reduced when the NMT network is implemented, and they will not contribute to the avoided cost of noise pollution. For the motorized transport that is going to be replaced by the NMT network, it is estimated that the total cumulative avoided health costs from noise is INR 875 million. Selected annual values of avoided noise pollution costs as a result of the NMT network are included in Table 26.

Table 26. Annual values of avoided noise pollution costs (discounted at 5%)

Year	Unit	2025	2030	2035	2040	2045	Cumulative (2023–2045)
Annual avoided cost of noise pollution	INR/ year	5,675,279	27,686,790	53,689,847	58,801,642	46,072,625	875,000,000

4.4.10 ROAD MAINTENANCE

The shift from motorized transport modes to NMT modes is accompanied by some avoided costs of road maintenance. The kms of road used for the NMT network are assumed to be taken from the current road network. In the SAVi NMT model, road maintenance costs are divided into routine maintenance and periodic maintenance costs. In addition, for periodic maintenance, a low-value estimate and a high-value estimate have been applied, valued at 2 m^2 and 3.6 m^2, respectively. The different value estimates are related to different scenarios of the average road width. Following the implementation of the NMT network and considering both routine and periodic avoided road maintenance costs. Table 27 shows the avoided cost of road maintenance in both the low-estimate and high-estimate scenarios.

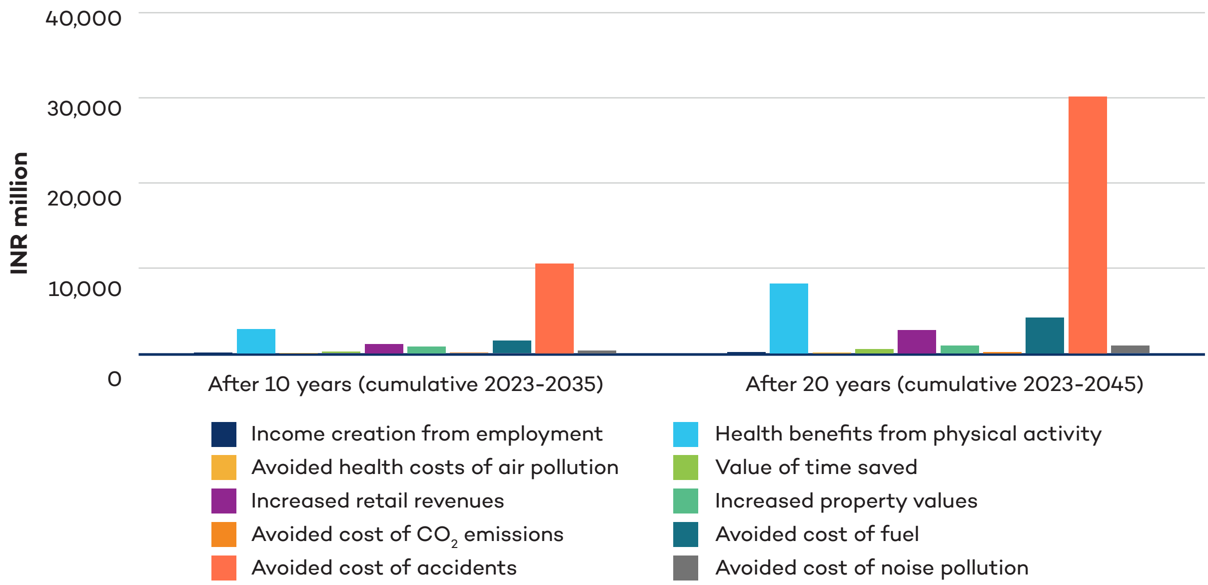
Table 27. Cumulative avoided cost of road maintenance in the NMT scenario (discounted at 5%)

	Unit	NMT scenario
Avoided costs of road maintenance (low estimate)	INR million	504
Avoided costs of road maintenance (high estimate)	INR million	767

4.5 Added Benefits and Avoided Costs Over Time

When considering different time horizons for the calculation of added benefits and avoided costs, we see the importance of taking a full life-cycle approach. Indeed, the cumulative values over a 20-year period are at least double, and at times triple, the value of the cumulative values over a 10-year period. Figure 4 shows the cumulative values of the different added benefits and avoided costs of the NMT network after 13 years (2022–2035) and after 23 years (2023–2045) from the beginning of the project period.

Figure 4. Added benefits and avoided costs of the NMT network in Coimbatore (cumulative values)



5.0 Conclusions

The SAVi assessment of the NMT network in Coimbatore provides a range of comprehensive results that aim to inform public infrastructure planners responsible for deciding whether to invest in the provision of a NMT network.

The conventional BCR based on estimations of only the capital costs, O&M costs, and avoided costs of fuel use and road maintenance, is 0.47 in the low-estimate scenario and 0.5 in the high-estimate scenario. However, the S-BCR that considers the project from a societal point of view and is based on estimations of the full range of economic, social, and environmental added benefits and avoided costs, is significantly higher, showing values of 4.75 and 4.93 in the low- and high-estimate scenarios respectively, as shown in Table 12. This provides evidence that the economic viability of the NMT network in Coimbatore increases significantly when the multiple environmental, social, and economic added benefits and avoided costs are considered.

In addition, if summing up and discounting the cumulative SAVi net results over a 23-year project period, the NMT scenario yields positive results between INR 37,104 million and INR 38,911 million, depending on the demand scenario, based on a INR 9,895 million investment.

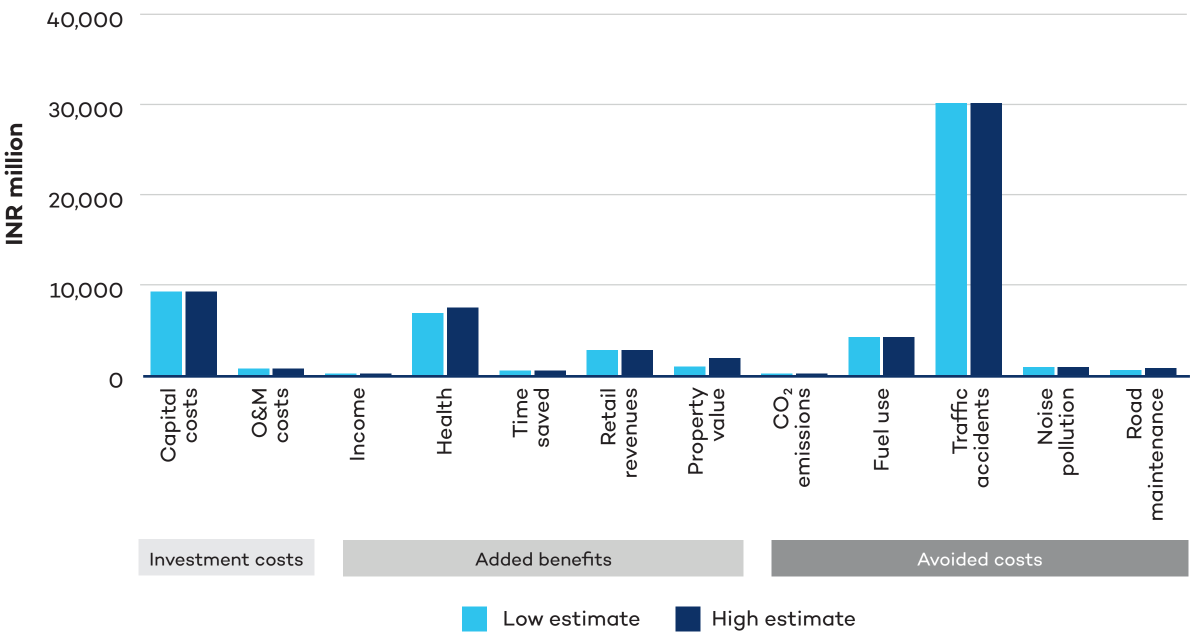
Even under conservative assumptions, the calculated added benefits and avoided costs of the improved NMT infrastructure (INR 47 million) exceed by far the projected investment costs (INR 9.9 million). Thus, the investment can be considered worthwhile from a societal and sustainable mobility point of view. It is also important to mention the causal relation between infrastructure provision and demand: the better the provided NMT infrastructure, the higher the demand—and the higher the added benefits and avoided costs—will be.

However, if infrastructure expenditures happen to be close to or higher than the low-value estimate of the NMT scenario, infrastructure planners need to coordinate with NMT operators and experts to ensure that demand for the NMT network in Coimbatore remains high in order to achieve overall positive net results.

Importantly, the low- and high-value estimates for the valuation of some added benefits and avoided costs yield very distinct results; therefore, a review of the underlying assumptions and data sources used is recommended. The chosen valuation methodologies can significantly influence the overall investment rationale, especially for added benefits or avoided costs that have a large scale and influence on the net results such as the “increase in property values” and the “avoided cost of air pollution.”

Integrated assessments such as this one conducted by employing the SAVi methodology can help make a stronger case for NMT and other forms of sustainable mobility solutions. Overall, this SAVi assessment has demonstrated that the NMT network meets sustainable mobility targets in Coimbatore and improves the quality of life of its residents; it therefore delivers the transport policy objectives defined in the CMP. Investment in NMT stimulates economic growth, either directly through employment creation or indirectly by stimulating positive retail and property price changes. From the perspective of the public sector, higher GDP can lead to increased government revenues, allowing the allocation of more resources to NMT infrastructure in the future. All of the results from the SAVi assessment, including investment costs, added benefits, and avoided costs, are demonstrated in Figure 5.

Figure 5. SAVi assessment results for the NMT network in Coimbatore



Overall, the NMT network will deliver the following:

- **Efficient, convenient, safe, and affordable transport:** The NMT network will enhance the efficiency of movement in Coimbatore as evidenced by the value of time saved, amounting to INR 490 million cumulatively over the project period in the NMT scenario. The NMT network will also allow for more convenient and affordable access to public transport, including last-mile connectivity, and hence will facilitate multi-modal transport use. Moreover, the required pedestrian and bicycle infrastructure (bicycle paths, street lighting) will improve safety in Coimbatore, and it will lead to a reduced number of fatality events and number of accidents in general, as shown by the SAVi results on "avoided cost of accidents," saving INR 30,144 million.
- **Health effects:** The implementation and use of the NMT network in Coimbatore will lead to significant health benefits associated with increased physical activity and reduced noise pollution, indicators that lead to an overall quality-of-life improvement. Benefits from increased physical activity amount to INR 8,172 million and avoided costs of noise pollution are valued at INR 875 million, both cumulatively over the project period. Only the increased cyclists' exposure to air pollution will have adverse health effects, valued at a cost of INR 1,409 million. This impact provides another good reason to address severe air pollution issues in Coimbatore and in other cities in India.
- **Reduced emissions:** The SAVi results demonstrate that the shift from motorized transport to NMT contributes to reduced CO_2 emissions from private vehicles. The results of the NMT scenario show that significant health costs will be reduced cumulatively over the project period. In particular, the avoided SCC amounts to INR 164 million or 277,408 tons of CO_2 avoided. In addition, the overall air pollution costs that will be avoided range between INR 94 million and INR 722 million, depending on the assumed health costs of air pollutants.

- **Economic benefits:** The implementation of the NMT network will also provide more road space to pedestrians and cyclists. This new allocation of road space will lead to considerable economic benefits, captured by the SAVi assessment. The NMT scenario yields an increase in retail revenues of INR 2,730 million cumulatively over the project period as well as a one-time increase in property values in Coimbatore ranging between INR 917 million and INR 1,834 million.

Based on the above, the SAVi assessment demonstrates that the biggest social benefits of the NMT network in Coimbatore are the avoided costs of accidents and the positive health benefits that result from increased physical activity and diminishing air pollution levels. In addition, potential increases in retail revenues and fuel savings make up the largest economic benefits of the project. Lastly, NMT infrastructure will also have significant environmental benefits, such as reductions in CO_2 emissions that result from the shift from motorized transport to active transport modes.

The limitations of the methodology used for this SAVi assessment are related to the valuation and quantification of some qualitative indicators. While the CLD (qualitative model) can identify a wide range of impacts, not all can be quantified due to the lack of data and literature that support their valuation or limitations in their scope. This is the case of indicators such as GDP, labour force health quality, or environmental awareness.

The application of SAVi allows for performance assessments that go beyond what has been applied for valuing the NMT network in Coimbatore and provides insights to government, citizens, and investors on the different value-creation elements of NMT networks. This can help inform future sustainable mobility strategies and make the case for better transport investments in cities, as well as identifying sources of funding/financing that match the different financial and social returns of the project.

It is crucial that decision-makers design and implement processes that recognize and account for the wider benefits of these projects so that decisions are made in favour of transport investments that provide the largest benefits to society while minimizing environmental impacts.

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Appendix A. CLD Description of the Non-Motorized Transport Network in Coimbatore

Reinforcing Loops

R1 – Transport demand shift dynamics: An increase in demand for non-motorized transport (NMT) generates a decrease in the demand for motorized transport modes, which in turn generates an increase in NMT demand. Conversely, an increase in the demand for motorized transport modes generates a decrease in the demand for NMT, which increases the demand for motorized transport modes.

R2 – NMT demand driven by less space for motorized transport: If NMT infrastructure increases, the space for motorized transportation decreases, increasing traffic congestion and time spent on transportation, which leads to a decrease in motorized transport demand, increasing the demand for NMT and, as a consequence, increasing NMT infrastructure.

R3 – NMT use driven by fuel use and investment: An increase in the use of NMT generates a decrease in fuel use, CO_2 emissions, and air pollution, increasing the labour force health quality, total factor productivity, and GDP. An increase in GDP leads to an increase in the investment of NMT, which results in an increase in NMT use.

R4 – Motorized transport use driven by investment in NMT: An increase in the use of NMT generates a decrease in the use of motorized transport and a decrease in fuel use, which leads to a decrease in CO_2 emissions and air pollution, increasing labour force health quality, total factor productivity, and GDP. An increase in GDP leads to an increase in the investment in NMT, which results in an increase in NMT use next time around.

R5 – Accidents driven by NMT infrastructure: The increase in NMT infrastructure (crosswalks, cycling lines, bridges for NMT, stoplights, etc.) leads to a decrease in traffic accidents, increasing the total factor productivity and GDP. An increase in GDP leads to an increase in investment for NMT and an increase in NMT infrastructure.

R6 – Investment in NMT driven by additional physical activity: An increase in the use of NMT leads to additional physical activity, increasing labour force health quality, total factor productivity, and GDP, which increases investment into NMT and NMT infrastructure, leading to an increase in the use of NMT next time around.

R7 – Employment from motorized transport modes driven by affordability of motorized transport modes: An increase in the demand for motorized transport modes increases the motorized vehicle fleet, increasing the employment from motorized transport and increasing the total employment from transport. An increase in employment leads to an increase in GDP, increasing the affordability of motorized transport modes and increasing the demand for motorized transport modes as a result.

R8 – NMT employment driven by investment in NMT infrastructure: Increased NMT use increases the employment from NMT and total employment from transport, which increases GDP and investment for NMT, increasing NMT use next time around.

R9 – Property valuation driven by NMT infrastructure: An increase in NMT infrastructure increases the value of the surrounding properties, which increases GDP and leads to more investment in NMT.

R10 – Investments in motorized transport infrastructure driven by total employment: An increase in investment in transport infrastructure increases the use of motorized transport modes and employment from motorized transport, increasing the total employment from transport. An increase in employment leads to an increase in GDP, increasing the affordability of motorized transport modes and increasing the demand for motorized transport modes and investment in transport infrastructure as a result.

R11– Noise pollution driven by motorized transport: An increase in the use of NMT generates a decrease in the use of motorized transport and a decrease in noise pollution, which increases the labour force health quality, total factor productivity, and GDP. An increase in GDP leads to an increase in investment in NMT, which results in an increase in NMT use next time around.

R12– Retail revenues driven by NMT infrastructure: An increase in NMT use increases retail revenues which increases GDP. This leads to an increase in investment in NMT, which results in an increase in NMT use.

R13– NMT demand driven by exposure to air pollution: An increase in the demand and use of NMT modes leads to higher exposure to air pollution, which decreases labour force health quality and hence total factor productivity. This decreases GDP and disposable income and affordability of motorized transport modes, which decreases demand for motorized transport and increases the demand for NMT modes as a consequence.

Balancing Loops (B)

B1– Effect of traffic congestion on demand for motorized transport: An increase in motorized transport demand leads to an increase in the motorized vehicle fleet, increasing traffic congestion and time spent on transportation, which reduces the motorized transport demand the next time around.

B2 – Effect of fuel use on motorized transport demand: An increase in the demand for motorized transport modes increases the use of motorized transport modes, which increases fuel use, CO_2 emissions, and air pollution, decreasing the labour force health quality, total factor productivity, and GDP. A decrease in GDP leads to a decrease in the affordability of motorized transport modes, leading to a decrease in the demand for motorized transport modes as a result.

B3 – Effect of accidents on motorized transport use: The increase in the use of motorized transport modes leads to an increase in accidents, leading to a decrease in total factor productivity and hence a decrease in GDP and affordability of motorized transport modes, decreasing demand for motorized transport modes, which leads to a decrease in the use of motorized transport modes and a decrease in accidents next time around.

B4 – Effects of accidents on NMT use: An increase in the users of NMT modes increases accidents from NMT use, decreasing total factor productivity and GDP, which leads to a decrease in NMT infrastructure investment and a decrease in the use of NMT.

B5 – Effect of accidents on investment in NMT: An increase in the capacity of NMT transport increases accident rates, decreasing total factor productivity and GDP, which leads to a decrease in investment into NMT infrastructure and a decrease in the capacity of NMT transport.

B5 – Effect of physical activity and affordability of motorized transport modes on NMT demand: An increase in NMT demand leads to an increase in NMT users, increasing the additional physical activity and the labour force quality, which increases GDP and disposable income, increasing the affordability of motorized transport modes and decreasing NMT demand as a consequence.

B6 – Effect of NMT use on environmental awareness: An increase in the motorized vehicle fleet generates an increase in fuel use, CO_2 emissions, and air pollution, which leads to an increase in environmental awareness. An increase in environmental awareness increases NMT demand and NMT use, which reduces the use of motorized vehicles.

B7 – Effect of NMT employment on NMT demand: An increase in the number of users of NMT generates an increase in employment from NMT and total employment from transportation, which increases GDP. An increase in GDP leads to an increase in disposable income and, as a consequence, an increase in affordability of motorized transport modes and motorized transport modes demand. An increase in the motorized transport demand leads to a decrease in NMT demand and a decrease in NMT users as a result.

B8 – Effect of CO_2 emissions and air pollution on motorized transport modes infrastructure investment: An increase in transportation infrastructure leads to an increase in the motorized vehicle fleet, increasing fuel use, CO_2 emissions, and air pollution, and decreasing total factor productivity as a result. The decrease in total factor productivity generates a decrease in GDP, disposable income, and affordability of motorized transport modes, leading to a decrease in demand for motorized transport modes and a decrease in investment in transportation infrastructure as a result.

B9 – Effect of accidents on motorized transport infrastructure investment: An increase in transportation infrastructure leads to an increase in the motorized vehicle fleet, increasing the use of motorized transport modes and traffic accidents, which leads to a decrease in labour force health quality and total factor productivity. The decrease in total factor productivity generates a decrease in GDP, disposable income, and affordability of motorized transport modes, leading to a decrease in the demand for motorized transport modes and a decrease in investment in transportation infrastructure as a result.

B10 – Effect of noise pollution on motorized transport infrastructure investment: An increase in the motorized vehicle fleet leads to an increase in noise pollution, which leads to a reduction in labour force health quality and total factor productivity. This in turn reduces GDP, which reduces investment in NMT infrastructure and hence the use of NMT modes.

B11 – Effect of NMT infrastructure on retail revenues: An increase in the use of NMT modes increases retail revenues and GDP. This increases disposable income and affordability of motorized transport modes, which increases the demand for motorized transport modes.

B12 – Effect of NMT infrastructure on exposure to air pollution: An increase in the use of NMT increases exposure to air pollution for cyclists, which reduces the total labour force health quality and total factor productivity. This in turn reduces GDP, which reduces investment in NMT infrastructure and hence the use of NMT modes.

Appendix B. System Dynamics/ Excel-Based Model

This approved methodology for infrastructure valuation is based on multistakeholder engagement techniques, the use of systems thinking, and project finance modelling to capture the life-cycle costs of environmental, social, economic, and governance risks. Moreover, SAVi calculates the monetary value of environmental, social, and economic added benefits and avoided costs that result from deploying infrastructure projects. The SAVi assessment for the NMT network in Coimbatore focuses on this latter element.

SAVi uses a spreadsheet-based modelling approach that integrates data from project-specific documents and peer-reviewed research and scientific reports to estimate infrastructure performance and related externalities. In the case of the NMT network in Coimbatore, data on demand for transport, vehicle mix, and the expected reduction in vehicle km (vkm) and passenger km (pkm), were obtained from project feasibility studies. The added benefits and avoided costs analyzed were identified in collaboration with local stakeholders. Where required, in most cases due to the presence of strong causality but lack of location-specific data, additional data sources were used to quantify variables that served to measure and monetize added benefits and avoided costs in Coimbatore.

The SAVi approach quantifies and monetizes the costs and benefits of the assessed infrastructure projects. The added benefits and avoided costs assessed for this SAVi application are illustrated in the form of a causes tree in Figure B1. A causes tree highlights the causal chain of variables used for estimating the outcomes (positive and negative) of the NMT network. For example, the cost of air pollution is estimated based on the vkm travelled and the emissions factors of air pollutants per km of various transport modes. The vkm travelled with motorized vehicles are affected by the number of people that shift to NMT, reducing system-wide air pollution, which leads to lower health costs in return. All valued added benefits and avoided costs and the results are discussed in detail in Sections 2 and 4 of this report. Each added benefit and avoided cost is calculated and valued separately and contributes to estimating the net benefits of the NMT network.

It is worth noting that a causes tree does not indicate the sense of causality (i.e., direct or inverse relation) that connects two variables. This is only captured in the mathematical model through the use of specific equations. For instance, in the case of "costs of accidents," it is assumed that a shift from motorized vkm travelled to kilometres travelled by NMT modes contributes to a reduction in accidents. This, in turn, reduces the health costs incurred from accidents. A similar causal relation is made for the cost of air pollution: the more people shift from motorized modes of transport to NMT, the higher the reduction in air emissions such as PM2.5 or NOx. The reduction in emissions leads to a reduction in emissions-related health impacts and hence reduces health costs.

Figure B1. Causes tree of the SAVi assessment for the NMT network in Coimbatore

SAVi estimates the net difference of biophysical parameters between a baseline scenario and an intervention scenario (e.g., kilogram of reduced NOx emissions due to the use of the NMT network instead of motorized vehicles). These biophysical parameters and their changing values between scenarios are the underlying elements for determining the economic value of an added benefit and avoided cost (e.g., a reduction of health costs due to lower air pollution and fewer health implications for citizens). The valuation of added benefits and avoided costs is based on scientific literature providing an economic value linked to a specific biophysical parameter. These multipliers are applied and customized to the local context to the extent possible, using studies conducted in Coimbatore or India.

Appendix C. Main Assumptions and Data Sources Used for the SD Model

Table C1. Overview of key assumptions used in the NMT Coimbatore SAVi Assessment

Parameters for calculating added benefits and avoided costs				Level of data collection			
Added benefit or avoided cost	**Indicator**	**Value**	**Data source**	**Project-specific**	**Urban/ Regional**	**National**	**International**
Income creation from employment	Job generation potential per USD 1 million invested	4.2 direct jobs and 2.2 indirect jobs	Garrett-Peltier (2011)				X
	Employment creation per km considered in O&M costs	One job per km	GIZ (2020)	X			
	Discretionary spending	19.9% = restaurants – 11.3%. sports and leisure – 5.9%. clothing and shoes 2/7%	Numbeo (2022)		X		
	Average annual salary	359,000 INR per year	Salary Explorer (2022)		X		
Benefits from physical activity	Value of statistical life	28,000,000	TERI (2018) – using the HEAT methodology from WHO (2014)				X
	Crude death rate	3.6 people per 1,000	Ministry of Home Affairs, (2017)			X	

Parameters for calculating added benefits and avoided costs				Level of data collection			
Added benefit or avoided cost	**Indicator**	**Value**	**Data source**	**Project-specific**	**Urban/ Regional**	**National**	**International**
Value of time saved	Value of average speed per transport mode	Walking – 5 km/h, Cycling –12 km/h	TERI (2018)			X	
	Hourly salary	2,511 annual working hours	Wuennenberg et al., (2020)				X
	Average annual salary	INR 359,000 per year	Salary Explorer (2022)		X		
Increase in retail revenues	Average minimum retail spending per year	40,29 INR	Statista (2015)			X	
	Average added retail spending from walkability	42.2%	Rabl & Nazelle, (2012)				X
Increase in property prices	Increased value of property due to increased walkability	5%–15%	Centre for Green Mobility (2015)		X		
	Average property value in Coimbatore	362 INR/m^2	Housing.com (2022)		X		
Cost of air pollution	Cost of air pollution	INR/1 kg of air pollutants	Rahul & Verma (2013)			X	
Cost of increased exposure to air pollution	Cost of exposure to air pollution	EUR 20 /year	Rabl & Nazelle (2012)				X

Parameters for calculating added benefits and avoided costs				Level of data collection			
Added benefit or avoided cost	**Indicator**	**Value**	**Data source**	**Project-specific**	**Urban/ Regional**	**National**	**International**
Cost of CO_2 emissions	SCC	USD 0.031/kg	Nordhaus (2017)				X
	Amount of CO_2 emitted by transport mode	4-wheeler (134 g/km), Bus (806 g/km), 2-wheeler (24.4 g/km)	Sharma et al. (2014)			X	
Cost of fuel	Fuel efficiency by transport mode	14.9–16.2 km/L	Goel et al. (2016)			X	
	Average annual mileage by transport mode	7,255–12,804 km	Goel et al. (2016)			X	
	Fuel price in Coimbatore	Petrol (INR 103.35/L), Diesel (INR 93.40/L). LPG (INR 929/L), Autogas (INR 32.90/L)	GoodReturns (2022)		X		
Cost of accidents	Cost of accidents per severity	Fatal (INR 2,838,768/ year), Serious injury (217,924 INR/year), Minor injury (INR 36,953/year)	Bora et al. (2018)		X		
	Risk of accident	94 accidents per 100,000	Ministry of Road Transport and Highways (2017)			X	
	Share of accident per severity	Fatal (20%), serious injury (16%), minor injury (64%)	Government of Tamil Nadu Home (Transport) Department (2020)		X		

Parameters for calculating added benefits and avoided costs				Level of data collection			
Added benefit or avoided cost	**Indicator**	**Value**	**Data source**	**Project-specific**	**Urban/ Regional**	**National**	**International**
Cost of noise pollution	Cost of noise pollution	4-wheeler (0.0017 INR/ vkm), 2-wheeler (0.0144 INR/vkm), Bus (INR 0.0016/vkm)	CE Delft (2011)				X
Cost of road maintenance	Cost of road maintenance (routine and periodic)	Routine maintenance (INR 150,000/km), periodic maintenance (INR 5,900,000/km)	Asian Development Bank (2019)		X		

Appendix D. Undiscounted Integrated CBA

Table D1. Integrated CBA (undiscounted values for the NMT scenario based on a project period of 23 years)

		NMT scenario 2022–2045	
Integrated CBA	**Unit**	**Low estimate**	**High estimate**
Total investment costs	**INR million**	**19,557**	**19,557**
Capital cost non-motorized transport (NMT) system	INR million	17,044	17,044
O&M cost NMT System	INR million	2,513	2,513
Total added benefits	**INR million**	**23,170**	**25,857**
Income creation from employment	INR million	218	218
Health impacts *	INR million	14,795	16,148
Value of time saved	INR million	1,058	1,058
Increase in retail revenues	INR million	5,766	5,766
Increase in property prices *	INR million	1,333	2,667
Total avoided costs	**INR million**	**77,353**	**77,903**
Cost of CO_2 emissions	INR million	353	353
Cost of fuel	INR million	9,028	9,028
Cost of accidents	INR million	65,038	65,038
Cost of noise pollution	INR million	1,888	1,888
Cost of road maintenance *	INR million	1,046	1,596
Net results of valued added benefits and avoided costs			
Cumulative net benefits (undiscounted)	INR million	80,967	84,203
Benefit-cost ratio		0.47	0.50
Sustainable benefit-cost ratio		4.75	4.93

SAVi Sustainable Asset Valuation

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