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ECONOMIC VIABILITY AND FINANCIAL EFFICIENCY OF THE PROPOSED PUBLIC BUS SYSTEM FOR SCHOOL AND COLLEGE STUDENTS- A CASE STUDY OF BELAGAVI CITY

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ABSTRACT

This study endeavors to investigate the cost-effectiveness of a proposed public bus system designed to serve school and college students who presently rely on private vehicles for transportation in Belagavi city. In an era marked by environmental concerns, traffic congestion, and rising costs associated with private vehicle ownership, the introduction of an efficient and affordable public transportation system for students is of paramount importance.

The research employs a comprehensive approach that combines economic and financial evaluations, considering various scenarios where different proportions of private vehicle users transition to the proposed public bus system. Specifically, shifts of 100%, 90%, 80%, 70%, and 60% from private vehicles to public buses are studied. Intriguingly, the analysis reveals that a 60% shift to public buses yields positive results in terms of cost-effectiveness, indicating the potential for substantial benefits. The financial evaluation rigorously assesses capital investments, operational expenses, fare structures, and revenue streams, providing insights into the financial sustainability of the public bus system under different scenarios.

The outcomes of this research will provide essential insights to policymakers, educational institutions, and transportation authorities. A thorough understanding of the cost-effectiveness of the proposed system will empower decision-makers to make informed choices that prioritize both economic efficiency and the welfare of students, potentially reducing the burden of private vehicle ownership while enhancing sustainable mobility solutions.

KEYWORDS. School transit modes; Modal shift analysis; Benefit-cost ratio; Financial evaluation; Economical evaluation.

1. INTRODUCTION

In India, school commuting transport systems are quite common, especially in urban areas where students often live at a considerable distance from their schools[1]. The school transport system in India shares similarities with those in other countries, but there are also some unique aspects due to the diverse nature of the country. The most common mode of school transportation is buses. Many schools have their own fleet of buses or hire private bus operators to provide transportation services. Economic evaluation of a transportation project involves assessing its

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financial feasibility, cost-benefit analysis, and potential economic impact[2]. The basic principle behind any method of economic evaluation is to measure the cost of the project, determine the benefits that are likely to accrue and comparison. The costs can be considered broadly under the following categories like capital cost of initial investment and maintenance costs.

Public transportation plays a pivotal role in ensuring efficient mobility, reducing congestion, and promoting sustainable urban development in India[3]. A benefit to the road user is measured by providing cheaper, more efficient, quicker and safer travel. In transportation and traffic-related analyses, benefits often represent the improvements and cost savings achieved through various factors, including reduced operating costs, travel time savings, and a decrease in accidents[4]. To determine the benefits, it is indeed necessary to have a clear understanding of the cost of operation [10]. This involves identifying and quantifying the costs associated with running the transportation system, which can include expenses related to vehicle maintenance, fuel, insurance and other operational costs.

Vehicle operation cost refers to the total expenses associated with owning and using a vehicle over a specific period[5]. It includes various expenses, both fixed and variable, that a vehicle owner incurs to keep the vehicle running. Some of the significant components of vehicle operation costs include:

- Fuel: The cost of purchasing fuel, such as gasoline or diesel, is a major expense for vehicle owners[9]. The fuel consumption depends on the vehicle's mileage and the distance driven.
- Maintenance and repairs: Regular maintenance, such as oil changes, tire rotations, and brake inspections, helps keep the vehicle in good condition. Additionally, unexpected repairs due to breakdowns or accidents can contribute to maintenance costs.
- Insurance: Vehicle insurance covers the cost of repairs or damages in case of an accident, as well as liability coverage for injuries or property damage to others. Insurance costs vary based on the vehicle's make and model.
- Depreciation: Vehicles typically lose value over time due to wear and tear, aging, and market fluctuations. Depreciation is the reduction in the vehicle's resale value and is considered a cost of ownership.
- Registration and Licensing: Vehicle owners are required to pay registration fees and obtain a license plate for legal operation.
- Taxes: Some regions impose annual taxes on vehicle ownership based on factors like the vehicle's value, age, and emissions.
- Tires: Replacing tires when they wear out is an essential maintenance cost for vehicle owners.

2. METHODOLOGY

2.1 Study area

Seven traffic analysis zones were created within the study area of Belagavi city in order to collect representative samples. The samples were from each of the seven zones, chosen at random. There were 2647 households in the sample. The chosen samples were conducted in-home interviews and all the respondents are parents in order to collect the required data using a

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questionnaire. The data collected from the local authority of Belagavi City reveals that there are a total of 93,466 children enrolled in various sections of the educational system. This student population consists of 47,936 boys and 45,530 girls. This information highlights the significant number of children who are actively engaged in pursuing education in the city.

The comprehensive data collected regarding private vehicles in Belagavi city is truly enlightening. With a staggering total of 4,52,447 privately owned vehicles currently active on city roads, it's evident that private transportation plays a significant role in daily life. These vehicles span across 27 diverse categories, ranging from auto rickshaws to cars and two-wheeler scooters. Among them, auto rickshaws constitute 4,306, while cars make up a substantial 57,230 and two-wheeler scooters dominate the landscape with 3,50,548 units. The data indicates that auto rickshaws and two-wheelers have emerged as the predominant choices of transportation among parents in the city. While this preference might offer convenience and flexibility, it has inadvertently contributed to congestion issues in and around schools.

2.2 Cost benefit analysis (CBA)

Cost-Benefit Analysis (CBA) is a systematic approach used in economics and project management to evaluate the potential benefits and costs of a project, program, or policy. After gathering the necessary data, the total costs for both private vehicles and public transit is estimated over the specified periods. Then, costs will be compared and identified the cost savings or additional expenses associated with the shift towards public transit[6]. Additionally, the non-monetary benefits like reduced pollution and traffic congestion to assess the overall benefits of adopting public transit is considered. Economic evaluation is a critical tool for decision-makers in healthcare systems worldwide. Two common approaches to economic evaluation in this context are cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA):

To conduct a cost-effectiveness study on shifting existing private vehicle users to a public transit system, the study compare the total vehicle operation costs for both private vehicles and the public transit system at different shift percentages such as 60%, 70%, 80%, 90%, and 100%. Here's how the costs over a specific period can be performed.

i. Gathering the data of private vehicle:
   - Average fuel efficiency (kilometers per liter).
   - Average fuel price per liter.
   - Maintenance cost for the vehicle per year.
   - Fixed costs (insurance, registration, etc.) per year.

ii. Gathering the data of public transit system:
   - Ticket or pass cost for the public transit system per year.

iii. Calculate private vehicle costs: Calculating the total vehicle operation cost for private vehicle users considering fuel, maintenance, and fixed costs. Then, cost after each shift percentage (60%, 70%, 80%, 90%, 100%) is compared.

Total private vehicle cost = Fuel cost + Maintenance cost + Fixed cost

Fuel cost = (Distance traveled / Fuel efficiency) * Price per liter

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iv. Calculate public transit costs: Calculating the total vehicle operation cost of public vehicle considering fuel, maintenance, and fixed costs. Then cost of public bus is calculated on each private vehicle shift percentage (60%, 70%, 80%, 90%, 100%).

v. For each shift percentage, calculate the total savings in vehicle cost.

vi. Compare costs: Compare the total costs of private vehicle usage and public transit system usage for each shift percentage.

Cost difference = Total private vehicle cost - Total public transit cost

A positive cost difference indicates that the public transit system is more cost-effective than using private vehicles. The magnitude of the cost difference will help determine the potential cost savings at each shift percentage.

vii. The invested capital cost on public transit system can be reimbursed by multiplying the ticket or pass cost with the number of users shifted to public transit.

Total public transit cost = Number of users shifted * Ticket or pass cost

2.3 Capital recovery factor (CRF)

The Capital Recovery Factor is based on the concept of the present value of an annuity. An annuity is a series of equal cash flows occurring at regular intervals over a specified period[7]. The CRF takes into account the interest rate (discount rate) and the number of periods (useful life) to calculate the equivalent annual cash flow.

The formula for calculating the capital recovery factor is as follows:

$CRF= r(1+r)^n/(1+r)^n-1$ …….(1)

Where:

r is the interest rate per period (expressed as a decimal).

n is the number of periods (useful life or duration).

The result of this formula is the capital recovery factor, which represents the equal annual cash flow needed to recover the initial investment over the given number of periods at the specified interest rate.

3. RESULTS AND DISCUSSIONS

The following are the important factors which are taken into the study to find out the motor vehicle operation costs:

I] Cost dependent on time expressed as cost per year such as interest on capital, depreciation cost, registration fee, insurance charges, garage, driver's salaries etc.

II] Cost depending on distance driven expressed as cost per vehicle-kilometre. The items which may be included are fuel, oil, tyres, maintenance and repairs etc.

3.1 Expenditure on private transit modes-Zonal analysis

To calculate traveling expenditures, factors to be considered are registration fees, insurance costs (periodic or one-time expenses), fuel costs and fare expenses are recurrent based on travel frequency. Table 1 gives the details of school going students with their share of different modes and a sample expenditure of auto-rickshaw as their mode of travel zonal-wise.

Table 1 Expenditure of auto-rickshaw usage

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Zone	Distance, in km	% share	No. of users	No. of auto required	VOC per km	Distance, max (km)	VOC, in Rs	Fixed cost
I	1	12.5%	809	135	3.33	1	449	1362035
	1 to 5	40.0%	2589	432	3.33	5	7185	4358512
	5 to 10	42.5%	2751	459	3.33	10	15268	4630919
	10 to 15	4.6%	298	50	3.33	15	2479	501229
	>15	0.4%	26	4	3.33	18	259	43585
	Auto expenditures is Rs. per day						25640	
	Expenditures in Rs. per year						4435708	10896280
	Total auto expenditures per year							**1,53,31,988**
II	1	8.6%	467	78	3.33	1	259	785548
	1 to 5	48.5%	2632	439	3.33	5	7303	4430125
	5 to 10	40.6%	2203	367	3.33	10	12227	3708517
	10 to 15	2.3%	125	21	3.33	15	1039	210088
	>15	0.0%	0	0	3.33	18	0	0
	Auto expenditures is Rs. per Day						20828	
	Expenditures in Rs. per year						3603281	9134277
	Total auto expenditures per year							**1,27,37,558**
IIIA	1	16.5%	902	150	3.33	1	501	1518939
	1 to 5	56.4%	3084	514	3.33	5	8559	5192010
	5 to 10	25.9%	1415	236	3.33	10	7855	2382433
	10 to 15	1.0%	56	9	3.33	15	464	93898
	>15	0.2%	11	2	3.33	18	109	18411
	Auto expenditures is Rs. per day						17488	
	Expenditures in Rs. per year						3025510	9205691
	Total auto expenditures per year							**1,22,31,202**
IIIB	1	18.6%	1468	245	3.33	1	815	2470864

	1 to 5	42.8%	3378	563	3.33	5	9373	5685644
	5 to 10	36.0%	2841	473	3.33	10	15767	4782317
	10 to 15	2.6%	205	34	3.33	15	1708	345390
	>15	0.0%	0	0	3.33	18	0	0
	Auto expenditures is Rs. per day						27663	
	Expenditures in Rs. per year						4785717	13284215
	Total auto expenditures per year							**1,80,69,931**
IV	1	22.5%	553	92	3.33	1	307	931519
	1 to 5	56.2%	1382	230	3.33	5	3836	2326728
	5 to 10	20.1%	494	82	3.33	10	2744	832157
	10 to 15	1.2%	30	5	3.33	15	246	49681
	>15	0.0%	0	0	3.33	18	0	0
	Auto expenditures is Rs. per day						7132	
	Expenditures in Rs. per year						1233856	4140086
	Total auto expenditures per year							**53,73,942**
V	1	8.9%	593	99	3.33	1	329	997911
	1 to 5	32.6%	2171	362	3.33	5	6026	3655269
	5 to 10	56.4%	3757	626	3.33	10	20850	6323839
	10 to 15	2.1%	140	23	3.33	15	1164	235462
	>15	0.0%	0	0	3.33	18	0	0
	Auto expenditures is Rs. per day						28369	
	Expenditures in Rs. per year						4907863	11212480
	Total auto expenditures per year							**1,61,20,344**
VI	1	2.1%	146	24	3.33	1	81	245239
	1 to 5	38.3%	2657	443	3.33	5	7373	4472686
	5 to 10	50.2%	3483	580	3.33	10	19328	5862372
	10 to 15	8.8%	610	102	3.33	15	5082	1027667
	>15	0.6%	42	7	3.33	18	416	70068
	Auto expenditures is Rs. per day						32281	
	Expenditures in Rs. per year						5584572	11678032

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	Total auto expenditures per year	**17262604**

Table 2 gives the summary on yearly expenditures of all private modes used by the children in city. There is a highest expenditure from two wheelers of Rs.10,71,99,875 and the lowest from tempo of Rs. 1,21,32,069. The total expenditure of all private vehicle usage is Rs. 31,68,38,747.

Table 2 Yearly Expenditures of private modes in study area (Rs.)

Mode / Zones	**I**	**II**	**IIIA**	**IIIB**	**IV**	**V**	**VI**	**Total, in Rupees**
Auto	15331988	12737558	12231202	18069931	5373942	16120344	1726204	**9,71,27,569**
2W	9373554	8474102	28230732	21917628	8615790	10968194	1961975	**10,71,99,875**
Car	1662831	1019099	3295136	38337959	1024256	8330686	2434127	**5,61,04,094**
Van	7311407	9259324	8548314	4246683	5092575	6811039	3005798	**4,42,75,140**
Tempo	1081706	213834	830499	281711	80967	0	9643352	**1,21,32,069**
Total expenditures of private vehicles for school trips								**31,68,38,747**

Similarly, analyzing the expenditure of a currently operated bus service involves assessing the various costs associated with running and maintaining the service. The detailed expenditures of public bus and the summary on bus expenditure are presented in table 3. The total expenditure of public vehicle is Rs. 3,81,95,205.

Table 3 Yearly expenditures on buses in study area

Mode/ Zones	**I**	**II**	**IIIA**	**IIIB**	**IV**	**V**	**VI**	**Total, in Rupees**
Bus	8492318	5505967	4262204	3866137	1110953	2042361	1291526	**3,81,95,205**
Total expenditures of public buses for school trips								**3,81,95,205**

3.2 Transition from private vehicles to sustainable transport

It is found by the data analysis that 87003 students are using private mode of vehicles and 38387 students are traveling by government buses and private school buses. Most of the school children travel with a distance range of 1 to 5 km and 5 to 10 km. The data was analyzed in all

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seven zones of the study area by considering the various distances they prefer. Table 4 gives the details of private vehicle usage in different zones of study area.

The total vehicle operation cost and fixed costs of all private vehicles are calculated to be aprox 31 crores per year. Estimating the vehicle operation cost of a bus service when there's a partial shift of private vehicle users to the public bus mode involves considering various factors[8]. Assuming the private vehicle users shifting to the public bus mode are distributed as follows: 100%, 90%, 80%, 70 % and 60%.

Table 4 Total private vehicle users in zones

Distance, km	Study zones							Total
	I	II	IIIA	IIIB	IV	V	VI	
1	1446	917	2648	2686	1525	1104	317	10644
1 to 5	4626	5173	9052	6181	3809	4045	5781	38668
5 to 10	4915	4331	4154	5199	1362	6998	7577	34536
10 to 15	532	245	164	376	81	261	1328	2987
>15	46	0	32	0	0	0	91	169
Total								87,003

3.3 60% of private vehicles shift to bus mode of transit

The study estimates that 60% of private vehicle users can be convinced to switch to buses. When 60% shift take place, the expenditures are estimated and given in table 5. Here the number of buses required will be 1160 to replace the existing 60% of private vehicle traffic. A bus can make minimum of 4 trips in peak hours of a day. Hence, 290 buses are enough to provide a proper bus service to school students in study area. Considering all the operational costs, administrative expenses, fuel, maintenance, and other factors, the study estimates the yearly expenditure of bus service will amount to Rs.4,04,27,752 by the replacement of 60% of private vehicles in study area.

Table 5 VOC at 60% shift of Private Vehicles

Distance	Private vehicle users	Bus required	Per km Charge	Distance, max	Vehicle cost saving, in Rs
1	6386	142	26.98	1	3829
1 to 5	23201	516	26.98	5	69550
5 to 10	20722	460	26.98	10	124238
10 to 15	1792	40	26.98	15	16116
>15	101	2	26.98	18	1094
VOC per day					2,14,827
VOC per year					3,71,65,129
Total Number of Buses required					1160
Minimum number of Bus trips per day					4
Actual Bus required					290

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Fixed cost per bus	11250
Total fixed cost for 290 buses	3262623
Total Expenditure including fixed cost	4,04,27,752

- Presently total city buses in depot = 445
- 40% of buses are utilized for other trips in peak hour time =178
- 60% of buses are utilized for school trips in peak time = 267
- Total number of new buses to be purchased = 23

3.4 Projected VOC of new buses

The projection of the vehicle operation cost for a new bus service with 23 buses is given in table 6.

Table 6 Projected VoC at 60% shift of private vehicles

Year	Number of buses	Maintenance/ year	Maintenance cost	VOC	Total
2022	-	-	-	40427752	-
2023	23	11250	258750	42044862	42303612
2024	23	11700	269100	43726656	43995756
2025	23	12168	279864	45475723	45755587
2026	23	12655	291058.6	47294752	47585810
2027	23	13161	302700.9	49186542	49489243
2028	23	13687	314808.9	51154003	51468812
2029	23	14235	327401.3	53200164	53527565
2030	23	14804	340497.3	55328170	55668667
2031	23	15396	354117.2	57541297	57895414
2032	23	16012	368281.9	59842949	60211231
2033	23	16653	383013.2	62236667	62619680
2034	23	17319	398333.7	64726133	65124467
2035	23	18012	414267.1	67315179	67729446
					70,33,75,290

3.5 Capital investment

The investment on purchasing new buses can be calculated based on the number of buses to be purchased and the cost of each bus. To calculate the total investment on purchasing new buses, the following formula is used. The invested amount with recovery factor is given in table 7.

Total investment= Number of buses × Cost per bus

- Total number of new buses to be purchased = 23
- Cost of each bus as per 2022 year quotation = Rs. 24,00,000
- Total investment on new buses = Rs. 5,52,00,000
- Total capital recovery amount = Rs. 6,33,69,600

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Table 7 Capital invested amount with an interest (60% shift)

Capital amount	Interest rates (%)	Capital recovery factor (CRF)	Capital recovery amount	Total amount
5,52,00,000	7	0.148	81,69,600	6,33,69,600

3.6 Capital recovery

Capital recovery of the investment made on the bus service can be recoup by implementing a daily or monthly pass system for students which is a common practice in many cities. This system offers students the convenience of unlimited bus travel within a specific period, making it more affordable and accessible for them to commute to school and other places.

Table 8 Capital recovery of the investment in 60% shift

Projected year	Total no. of students	Travelling cost per annum	Total amount returned
2023 to 2035	52,202	1200	81,43,50,755

Similarly, replacing 70%, 80%, 90% and 100% of private vehicle traffic by public bus service has been done and yearly expenditure for this bus service is shown in table

It is important to note that the comparison of vehicle operation costs between private vehicles and public buses can vary based on several factors, including the local fuel prices, maintenance costs, insurance rates, and the efficiency of the public transit system. Table 9 gives the detailed summary on cost-saving of different transformation of private vehicles to public buses.

Table 9 Summary on cost-saving analysis

Scenario	Expenditure after shift (in INR)	Remaining private vehicle expenditure (in INR)	Total expenditure per year (in INR)	Cost-saving per year (in INR)
60% shift to public bus	4,04,27,752	13,33,47,331	17,37,75,082	15,95,93,244
70% shift to public bus	4,71,65,711	10,00,10,498	14,71,76,209	18,61,92,118
80% shift to public bus	5,39,03,669	6,66,73,665	12,05,77,334	21,27,90,993
90% shift to public bus	6,06,41,628	3,33,36,832	9,39,78,460	23,93,89,866
100% shift to public bus	6,73,75,631	0	6,73,75,631	26,59,92,696

From the data provided, it appears that the potential cost savings increase as more people shift from private vehicles to public buses. The scenario with 100% shift to public buses would

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result in the highest cost savings of approximately Rs. 26,59,92,696, while the scenario with 60% shift would still yield substantial savings of approximately Rs. 15,95,93,244.

In a comprehensive cost-benefit analysis, all costs, including the total amount invested in purchasing new buses and the ongoing expenditures on vehicle operation, are considered. The benefits, on the other hand, are typically calculated based on the projected returns from students' ticket or pass system and any other relevant revenue streams. The summary on benefit-cost analysis is given in table 10

Table 10 Summary on cost-benefit Analysis

Scenario	**Capital investment (INR)**		**Capital recovery (INR) (c)**	**Benefit-cost ratio c/(a+b)**
	Purchasing buses (a)	**VOC upto 2035 (12 years) (b)**		
60% shift to public bus	6,33,69,600	70,33,75,290	81,43,50,755	1.06
70% shift to public bus	19,63,08,000	82,88,65,965	95,00,75,881	0.93
80% shift to public bus	32,99,35,200	95,45,43,692	108,58,01,007	0.85
90% shift to public bus	46,28,73,600	108,00,34,367	122,15,26,800	0.79
100% shift to public bus	59,58,12,000	120,54,56,646	135,72,46,800	0.75

4. CONCLUSIONS

Following conclusions may be drawn based on the study

- The BCR of 1.06 indicates that a 60% shift of private vehicle users to buses remains a beneficial investment over the 12-year period, with benefits slightly exceeding the costs.
- The BCR of 0.93 indicates that a 70% shift of private vehicle users to buses still results in benefits close to the costs, making it a relatively reasonable investment over 12 years.
- The BCR of 0.85, 0.79 and 0.75 suggests that an 80%, 90% and 100% shift of private vehicle users to buses results in benefits that are slightly lower than the costs. While the project might still have some positive impact in the long term more than 12 year period of projection.
- The BCR of 1.06 is a positive signal for decision-makers and communities. It demonstrates that investing in a significant shift from private vehicles to buses is not just a smart economic choice but a responsible one, contributing to the overall well-being and sustainability of our cities and societies. As future leaders and planners, understanding the significance of such evaluations empowers us to make informed decisions that shape our transportation systems for the betterment of all.

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