Alleviating Traffic Congestion along the M1 corridor - An economic perspective

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1 Background

With sustained economic growth since independence and a drastic fall in poverty level (from 45% in 1970 to 2% in 2010), the standard of living of the Mauritian population keeps on improving and it is now one of the highest in Africa. Road transport being the only means of mobility both for people and goods, road traffic continually grows at a rate between 5% and 8% p.a. Since the 1990s, traffic congestion has become a major problem and bears a significant impact on the economy and the environment. As from 2009, the Road Development Authority has, through a series of road construction and improvement projects, reversed the trend of congestion. This has been possible thanks to the willingness of Government to invest massively in road infrastructure development and to the significant contribution of Mauritian engineers, both from the public and private sectors, whose expertise and know-how are crucial in the successful completion of the projects.

This paper aims at analyzing the economic benefits of the improvements along the M1 corridor between Phoenix and Port Louis.

2 Introduction

Mauritius has a population of 1.3 million people with its principal area of activities concentrated within the Capital, Port Louis. The southern road facilities leading towards this district are the Motorway (M1) and the Port Louis – St Jean Road (A1) while those from the northern parts are the Motorway (M2) and the Port Louis – Central Flacq Road (A2). This limitation in accessibility was, by 2008, creating severe morning and afternoon traffic congestion which was estimated to cost the Mauritian economy around Rs 4 billion annually.

The Motorway M1 carries a daily traffic volume of 90,000 AADT. Prior to the implementation of the projects, the congestion in the morning peak started at around 7.00 a.m. and lasted until 10.00 a.m. In addition, a tidal flow between Montagne Ory and the entrance of Port Louis (reverse 3rd lane) has been in operation since 1997. At some critical junctions, like Caudan roundabout, Pont Fer roundabout and Place D'Armes there was a continuous need for police traffic control during long hours of the day to try to make traffic flow.

As from 2010, a series of road widening and junction improvement projects have been implemented between Pont Fer and Place D'Armes. These are listed in Section 2. Most of them have been completed except the widening of Colville Deverell Bridge which will be operational as from October 2013.

3 Project Descriptions

Since 2010, the Road Development Authority has implemented six major projects along the Motorway M1 between Pont Fer Roundabout and Place D'Armes. A list of these projects is provided in **Table 1** and their alignments are shown in **Figure 1**.

Link	Road Infrastructure Projects	Length (km)
A-B	Bidirectional Lanes from St Jean to Pont Fer on Motorway M1. The project consists of the provision of an additional lane on both Northbound and Southbound and a bypass southbound to Pont Fer roundabout.	2.0
B-C	Widening of Motorway M1 from St Jean to Coleville Deverell Bridge. The project consists of the provision of an additional lane on both Northbound and Southbound.	5.4
C-D	Widening of Motorway M1 from Colville Deverell Bridge to Grewals (Northbound only).	3.6
D-E	Widening of Motorway M1 between Pailles and Caudan. The project consists of the provision of an additional lane on both Northbound and Southbound.	4.0
E-F	Construction of a Grade Separated Junction at Caudan.	0.1
F-G	Widening of Motorway M1 from Ruisseau Creole Bridge to Place D'Armes (Northbound only).	0.8

Table 1 – List of Projects

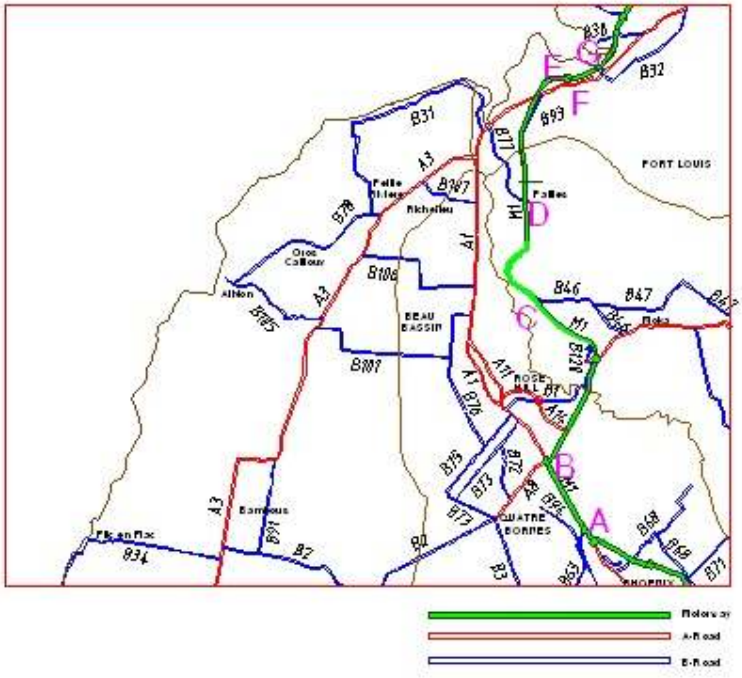

Fig 1

4 Traffic Impact

4.1 Capacity and Level of Service Analysis

The Highway Capacity Manual (2010) defines levels of service (LOS) for motorway lanes as in Table 2.

LOS	Flow conditions	v/c limit	Service volume	Speed km/h
A	Free	0.35	700	>97
B	Stable	0.54	1100	>92
C	Stable	0.77	1550	>87
D	High Density	0.93	1850	>74
E	Near Density	1.0	2000	>48
F	Breakdown	Unstable		<48

Table 2 – Capacity and Level of Service Analysis

LOS A represents free flow while LOS F represents saturation level, i.e. a point at which the lane cannot take more traffic and traffic congestion starts. Consequently the maximum capacity of a lane on a motorway (without junctions) is 2000 vehicles per hour. Roundabouts and traffic light junctions are bottlenecks which increase delays considerably and for this reason the theoretical speeds given in Table 2 are much higher than what are measured in practice in Mauritius. In a real freeway, traffic lights and roundabouts must be replaced by grade-separated junctions to induce full capacities. Considering the constraints of our local highway compared with the American freeway, the maximum lane capacity will be assumed to be 1800 instead of 2000.

The Caudan roundabout has already been replaced by a grade-separated junction. The bottleneck at Colville Deverell Bridge is compensated by the tidal flow put in place by the Police Department in the morning. Consequently we can assume an improvement from 2-lane capacity to 3-lanes capacity between Phoenix and Place D'Armes for the purpose of this analysis.

4.2 Projected Traffic

The traffic flow which has been used in the economic analysis is provided in **Table 3**. These data were obtained from Traffic counts which were carried by the RDA in 2011 and represent the morning peak volume per hour. The traffic growth rate has been maintained at a constant value of 6% per year. .

Year	Traffic Growth Rate	Motorcycles	Car	Class B Heavy Vehicles	Class C Heavy Vehicles	Buses	Total Vehicles
2011	6%	289	2874	155	7	214	3539
2012	6%	306	3046	164	7	227	3750
2013	6%	324	3229	174	8	241	3976
2014	6%	343	3423	184	8	255	4213
2015	6%	363	3628	195	9	270	4465
2016	6%	385	3846	207	9	286	4733
2017	6%	408	4077	219	10	303	5017
2018	6%	432	4322	232	10	321	5317
2019	6%	458	4581	246	11	340	5636
2020	6%	485	4856	261	11	360	5963

Table 3 – Projected Traffic Flow

The above table indicates saturation flow (2 X 1800) for 2-lanes highway in 2011. This is normal because the traffic cannot increase beyond saturation. It results in severe traffic congestion which lasts for longer periods. With the improvement to 3 lanes, the capacity increases to 5400 which (1) reduces the duration of traffic congestion immediately and (2) provides extra capacity for the coming years. In the theoretical analysis indicated in Table 3, it is expected that, by year 2020, the 3-lanes will be at saturation level, if no other scheme is implemented.

5 Economic Analysis

The investments include the initial construction costs as well as the maintenance costs. The three main benefits of such road improvement schemes are (i) savings in vehicle operating costs (ii) savings in travel time and (iii) improvement in road safety. For the purpose of this study only the first two benefits will be used because road accidents depend on numerous other factors and the benefits arising solely from the projects cannot be quantified. After calculating the costs and benefits, the Net Present Value (NPV), Benefit/Cost(BC) ratio and Internal Rate of Return(IRR) are produced.

5.1 Methodology

For the purpose of this study, travel time surveys were carried during morning peak (between 7.45a.m and 8.45a.m) from Pont Fer Roundabout to Place D'Armes. The time taken for a vehicle to travel from Pont Fer Roundabout

to specific entry points along the motorway M1 were recorded until the vehicle reached Place D'Armes. The average speed for a vehicle to travel between specific entry points along the motorway M1 was obtained by recording both the distance travelled to reach these entry points and the time of travel. Same exercise was carried out both before and after completion of all the road projects mentioned above and the result was then used to quantify Vehicle Operating Costs and Travel Time Savings.

5.2 Analysis of Results

A summary of the results are provided in the table below.

Entry Points	Distance (m)	Before Projects		After Projects		Difference	
		Time	Ave Speed	Time	Ave Speed	Time	Ave Speed
Jumbo							
Pont Fer	380	1	22.8	1	22.8	Nil	Nil
St Jean	2380	3	47.6	3	47.6	Nil	Nil
Reduit	5580	10	33.5	6	55.8	4	22.3
Colville Bridge	7780	26	18.0	9	51.9	15	33.9
Pailles Underpass	11380	34	20.1	12	56.9	22	36.8
Autopont	13580	40	20.4	15	54.3	25	33.9
Caudan Ramp	15280	56	16.4	18	50.9	38	34.5
Place D'Armes	16180	60	16.2	20	48.5	40	32.5

Table 4 – Summary of Results

The following observations can be made from **Table 4**:

1. Before project implementation it took almost one hour for a vehicle to travel from Pont Fer Roundabout to Place D'Armes. After the provision of a third lane, this journey has been reduced to only 20 minutes with an average speed of 48.5 km/h compared to 16.2 km/h.

2. Vehicles coming from Quatres Bornes and joining the Motorway M1 at St Jean will now take 17 minutes to reach Places D'Armes compared to 57 minutes when the projects were not implemented.

3. Vehicles coming from the East via Moka and join the Motorway M1 at Reduit will now take 14 minutes instead of 50 minutes.

4. By analyzing the results in **Table 2**, it is noted that before the provision of a third lane along the average speed along the motorway was below 48km/h which correspond to a Level of Service F whereas after construction of the third lane, the average speed increases above 48 km/h which correspond to a Level of Service E.

The figures in **Table 4** clearly demonstrates that there has been a major improvement in traffic flow along the Motorway M1 during Morning Peak between Pont Fer Roundabout and Place D'Armes after the addition of a third lane. It may also be noted that traffic congestion is more likely to occur as from Reduit where there is an influx of vehicles from Moka and Rose Hill onto the motorway.

5.3 Construction Costs

The construction costs for the above mentioned projects are summarized in **Table 5** below.

No.	Road Infrastructure Projects	Construction Costs (Rs)
1	Widening of Motorway M1 between Pailles and Caudan	250,000,000
2	Construction of Grade Separated Junction at Caudan	370,000,000
3	Bidirectional Lanes from St Jean to Pont Fer on Motorway M1	220,000,000
4	Widening of Motorway M1 from St Jean and Coleville Deverell Bridge	290,000,000
5	Widening of Motorway M1 between Collevill Bridge and Pailles	240,000,000
6	Widening of Motorway M1 from Ruisseau Creole Bridge to Place D'Armes	70,000,000
		1,400,000,000

Table 5 – Construction Costs

5.4 Maintenance Costs

It is assumed that a 50mm thick asphaltic layer be overlaid along the Motorway M1 (Northbound) in 2020 for periodic maintenance. The unit cost for this operation is assumed to be Rs 400/m^2. The cost estimate for maintenance cost is Rs 67,200,000.

5.5 Benefits

Two types of benefits have been taken into account: (1) benefits due to changes in the vehicles operation costs and (2) benefits due to travel time savings.

5.5.1 Vehicle Operating Costs

Operation costs include (a) maintenance, repairs and spare parts and (b) tyres' wear and tear. The changes in the vehicle operation costs are calculated as a function of changes in number of kilometres travelled and petrol consumption and travelling speed. In this case, the number of kilometres travelled remains unchanged because it is assumed that apart from the Motorway M1 there is no alternate route between Phoenix and Port Louis (The Port Louis – St Jean Road, A1 is highly congested and mostly used as a secondary road which links major towns such as Quatres Bornes, Rose Hill and Beau Bassin. Therefore, before implementation of the abovementioned projects, it is unlikely that people were using A1 instead of the Motorway M1 to travel between Phoenix and Port Louis).

Vehicle speed is the dominant factor affecting vehicle operating costs. Typically operating costs decrease with increasing speed to a certain point, and then begin to increase with increasing speed. The relationship between fuel consumption rates and speed is the most widely understood of the operating cost factors. The Cal-B/C model uses the following fuel consumption rates (see **Table 6** below), obtained from the California Air Resources Board's Motor Vehicle Emission Inventory (MVEI) models, and consumption-by-speed relationships modeled in HEEM. The change in Vehicle Operation Costs has been calculated by using the figures in **Table 6** and the actual costs of fuel which is **Rs 52.25 per litre**.

Speed (mph)	5	10	15	20	25	30	35	40	45	50
Auto	0.182	0.123	0.089	0.068	0.054	0.044	0.037	0.034	0.033	0.033
Truck	0.310	0.181	0.135	0.118	0.120	0.133	0.156	0.185	0.223	0.264

Table 6 - Fuel Consumption Rates (gallons/mile)

5.5.2 Travel Time Savings

The results from **Table 4** show that the provision of the third lane along M1 generates travel time savings equivalent to 60% of total time spent travelling between Phoenix and Port Louis with two lanes only. The values used to calculate the cost of time per vehicle per hour are given in **Table 7**. These values were taken from the Traffic and Transport Specialist Study for the PPP Road Decongestion Programme (2013).

Motorcycles	Light Vehicles Business	Class B Heavy Vehicles	Class C Heavy Vehicles	Buses
Rs 81	Rs 493	Rs 357	Rs 279	Rs 940

Table 7 – Cost of Time per Vehicle

The estimation of the annual travel time savings is based on the critical path which is between Reduit and Place D'Armes. Therefore, the Annual Travel Time Savings is equal to (Number of vehicles/hour) x (Duration of morning peak) x (Change in travel time) x (Cost of time per vehicle per hour) x (Number of working days per year).

5.6 Net Present Value

Table 8 shows the results of the cost-benefit analysis in the form of Net Present Value (NPV) of the Project, using a 6% discount rate.

Year	Investment Cost MUR	Operation Costs MUR	Travel Time Savings MUR	Total Benefits MUR	Total Net MUR
2013	1,400,000,000	46,234,751	429,531,975	475,766,726	-924,233,274
2014		92,446,182	858,796,132	951,242,314	951,242,314
2015		92,427,808	858,641,732	951,069,540	951,069,540
2016		92,433,364	858,620,581	951,053,945	951,053,945
2017		92,434,653	858,598,560	951,033,213	951,033,213
2018		92,422,701	858,518,488	950,941,189	950,941,189
2019		92,420,882	858,437,429	950,858,311	950,858,311
2020	44,691,838	92,407,352	858,304,455	950,711,807	906,019,969
	1,414,691,838	**739,462,443**	**6,868,981,328**	**7,608,443,771**	**5,687,985,207**

Table 8- Net Present Value

5.7 Benefit-Cost Ratio

The total discounted benefits are divided by the total discounted costs. Projects with a benefit-cost ratio greater than **1.0** have greater benefits than costs; hence they have positive *net* benefits. The higher the ratio, the greater the benefits relative to the costs. A Benefit-Cost Ratio of **5.2** is obtained from **Table 8.**

5.8 Internal Rate of Return

The internal rate of return (IRR) is the discount rate for which the net present value of a project is zero. In other words, the sum of discounted costs is

equal to the sum of discounted benefits when discounted by the IRR. It is normally used to compare competing projects and it indicates which project gives the highest return on investment. In our case we are analyzing a group of non-competing projects taken together. Therefore we compare the IRR with the cost of money, i.e. the interest rate of a commercial loan. Based on the figures in column 6 of Table 8, an analysis carried out in excel gives an IRR of **102%.** This represents an extremely high return on investment since commercial loans are available at rates of 10% or lower.

6 Conclusion

The results demonstrates that the investment made by the government to reduce traffic congestion during morning peak between Phoenix and Port Louis by improving the road infrastructure along the motorway M1 has proved to be highly beneficial to the society and the Mauritian economy. The travel time saving of 60% together with the savings in vehicle operating cost result in a total benefit of 1 billion rupees annually until 2020. It should be noted that this report has assessed the projects in terms of travel time savings and vehicle operating costs only. However, there are several other benefits which have not been taken into consideration, viz:

(i) Road Safety benefits

(ii) Reduced police control and better law enforcement

(iii) Environmental benefits (carbon emission, noise etc.)

(iv) Benefits to adjoining roads and their users

(v) Improved business and commercial activities etc.

(vi) Benefits to the society (people spend less time in congestion and more on other activities)

7 Future projects

This analysis concerns the corridor from Phoenix to Port Louis only. Congestion is still a problem in other parts of the country. In parallel, the traffic will keep on growing and there is a demand for further improvement in the road infrastructure. The Road Decongestion Programme, which will be implemented in the very near future as a Public Private Partnership Scheme, will be the first toll road network for Mauritius. It will incorporate an assortment of the most challenging civil engineering endeavors which the country has ever witnessed. Its main constituents are:

- Terre Rouge Verdun Ebene Highway with a link to Valentina, which will reduce the travel time from Phoenix to Calebasses to 25 minutes;

- Grade –Separation of Jumbo, Pont Fer and Phoenix roundabouts, which will eliminate all delays at these junctions;

- Grade-Separation of Terre Rouge, Riche Terre, Roche Bois, Quay D roundabouts and widening of M2 to 3 lanes which will reduce delays from Terre Rouge to Port Louis;

- A Harbour Bridge to bypass the Place D'Armes area and the Capital;

- A bridge over GRNW (A1-M1 Bridge) and a tunnel under Quoin Bluff to complete the Ring Road which will link the whole population of lower Plaine Wilhems to the centre of Port Louis without any congestion.

This massive investment will boost the GDP, create jobs, generate revenues for Government and prepare the country to face future challenges with a modern infrastructure.

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