

URBAN TRANSPORT SUSTAINABILITY IN MAURITIUS: A BALANCED SCORECARD

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Abstract: Mauritius's urban land transport is of particular interest, mainly from two key corner points. Firstly, the transport sector is the third largest contributing sector to Mauritian economy and the urban land transport is recognized as one of the most important drivers for growth of Mauritius, especially because of the high reliance of other economic backbone sectors including industry, finance and tourism on urban land transport. Secondly, the urban transport in Mauritius exhibits many of the transport problems as faced in other global rapidly growing developing cities, such as worsening traffic congestion, traveler dissatisfaction on public modes, rapid growth of private motorization, air pollution and urban sprawling. While for a long term sustainable Mauritian economy the performance of urban transport is crucial, there is a lack of integrated study targeting to enhance the sustainability performance of urban transport. Therefore, a holistic sustainability evaluation is needed for this sector in order to identify the critical challenging areas, which will be helpful in setting off effective measures to enhance long term sustainability in this sector. In the past, studies mainly focused on certain aspects while others remained ignored resulting in the lack of a balanced evaluation. The aim of this study is to evaluate the sustainability of Mauritius urban transport using a Balanced Scorecard. The Balanced Scorecard reviews and assesses Mauritius's urban transport with an integrated framework of sustainability. Results show that, the overall sustainability performance of Mauritius's urban transport is marginally moderate and the performance of sustainability indicators fall in either moderate or poor categories. The major moderate performing areas include safety, social equity, affordability, employment growth, impact on global environment, energy consumption, revenue enhancement, economic growth, efficiency of commercial goods

transport, promotion of green vehicles, awareness and education, leadership and policy, investment effectiveness and skill development and training. In addition, the marginally moderate performing areas, where improvements are highly necessary, include management of transport infrastructures and parking facilities, noise control, external cost savings, integration among passenger modes, and promotion of vehicle sharing practices. On the other hand, areas that have performed poor and need immediate improvement include level of service, congestion management, air pollution, integration of land-use and transport, integration among institutions, promotion of public and non-motorized transport, control over private vehicles, emission control, public participation, innovation, technological deployment in infrastructures and vehicles, incident management, smart road pricing and traveler information.

Keywords: Balanced Scorecard; Mauritius; Sustainability; Sustainable Development; Sustainable Urban Transport

I. INTRODUCTION

Situated in the Indian Ocean, the island of Mauritius is a small yet densely populated developing nation with a total area of 2,050 square kilometers and a population of 1.3 million. Over the last two decades the country's economy has grown rapidly with an annual growth in the order of 5 to 6%. The Mauritian urban land transport is interesting, especially from two key corner points, firstly, the transport sector, contributing 13% to GDP, is the third largest contributing sector to Mauritian economy [1] and the urban land transport is recognized as one of the most important drivers for growth of Mauritius, especially because of the fact that the performance of other economic backbone

sectors including industry, finance and tourism is highly dependent on the performance of urban land transport [2]; and secondly, the urban transport in Mauritius exhibits many of the transport problems as faced in other global rapidly growing developing cities, such as worsening traffic congestion, air pollution, traveler dissatisfaction on public modes, high growth of private cars, urban sprawling and a lack of adequate facilities for walking and cycling. While for a long term sustainable economy of Mauritius the performance of urban transport is crucial, there is a lack of integrated study targeting to enhance the sustainability performance of urban transport. A holistic sustainability evaluation is needed for this sector in order to identify the critical challenging areas, which will be helpful in setting off effective measures to enhance long term sustainability.

In the past, studies mainly focused on certain aspects while others remained ignored resulting in a lack of balanced evaluation for Mauritian urban transport. For example, in the environmental aspect, the energy demand and supply options were studied by Deenapanray [3], while Soheea and Surroop [4] studied the fuel quality in Mauritian vehicles. There were studies on certain aspects of social sustainability of urban transport, e.g., Soonil [5], as well as of economic sustainability, e.g., Khadaroo and Seetanah [2]. In addition, there were studies on public transport, e.g., Soonil [5], as well as on private transport, e.g., Warren and Enoch [6]. These studies have reviewed different aspects of Mauritian urban transport from a pool of scattered angles. However, major significant areas which have yet not been adequately focused in the literature include air and noise pollution, non-motorized, green and commercial goods transport, employment growth, security, skill development, legislation and enforcement, public feedback, research and innovation, and smart technological deployment in Mauritius urban transport. While environment, society and economy characterize three key pillars of urban transport sustainability, the physical built environment, modal and user behavior, operational efficiency, institutional harmony, skill, research and innovation often act as major drivers to materialize the goals of sustainability. Without an integrated framework it may be very difficult to identify critical areas of success or deficiency as well as to set off effective policies with an aim to achieve long-term sustainability. The Balanced Scorecard (BSC) is an integrated framework for evaluation of sustainability performance in urban transport, which has recently

been introduced by Rahman and Chin [7] and used elsewhere [8]. It appears that a balanced sustainability performance evaluation has yet not been done for Mauritius urban transport.

The aim of this study is to evaluate the sustainability of Mauritius urban transport using the BSC. This study focuses only on urban Mauritius, represented by the closely-tied five urban municipalities including Port Louis, Beau Bassin/ Rose Hill, Quatre Bornes, Vacoas/ Phoenix and Curepipe, as presented in Fig. 1, spatially covering the west-central part of Mauritius, with a small area of about 270 square kilometers (13% of total area) but yet a high population of 550,000 (42% of total population). Mauritius urban transport has developed over this area placing the capital city Port Louis as the network hub.

Section II of this paper provides a brief description of the BSC for sustainable urban transport. The evaluation or scoring mechanism has been described in section III. The sections IV-VIII present a review of Mauritius's urban transport in sequence of the five perspectives of BSC, i.e., *social*, *environmental*, *economic*, *process*, and *organization and innovation*. Finally, section IX analyses and discusses on the results of this study.

II. THE BALANCED SCORECARD FOR SUSTAINABLE URBAN TRANSPORT

The BSC for sustainable urban transport consists of five perspectives: *social*, *environmental*, *economic*, *process*, and *organization and innovation*. In the BSC, the strategic mission and vision are strongly linked to the objectives of social, environmental and economic sustainability, and these sustainability components are represented as the themes of the *social*, *environmental* and *economic* perspectives, respectively. The themes of the *process* perspective play effective roles in the form of internal and external processes that facilitate achieving the sustainability outcomes. These themes include built environment and land use, transport modes, user behavior and operational efficiency. Finally, the themes of the *organization and innovation* perspective including institution, skill and innovation promote the organizational development of urban transport, which helps improve the process and thus helps to achieve sustainability goals. The framework of BSC for sustainable urban transport is presented in Fig. 2. Each theme of the BSC comprises a set of indicators, which has been presented in Table 1.

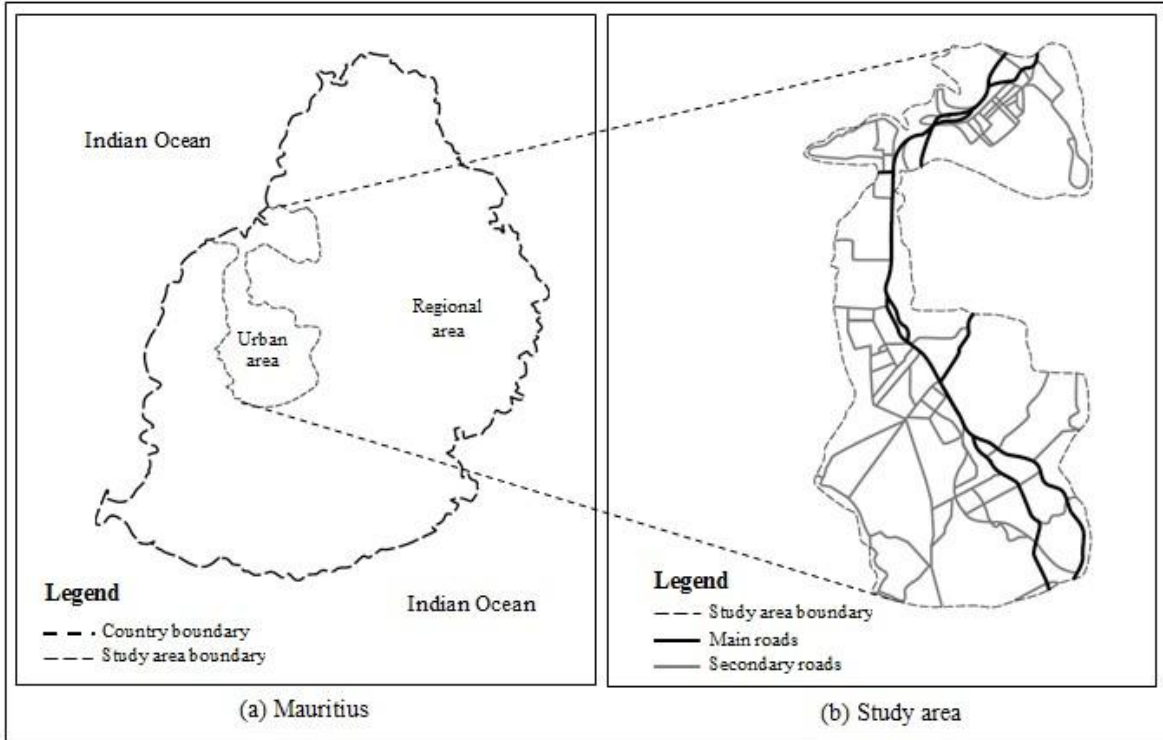


Figure 1: Geographical Map of (a) Mauritius; (b) Study Area

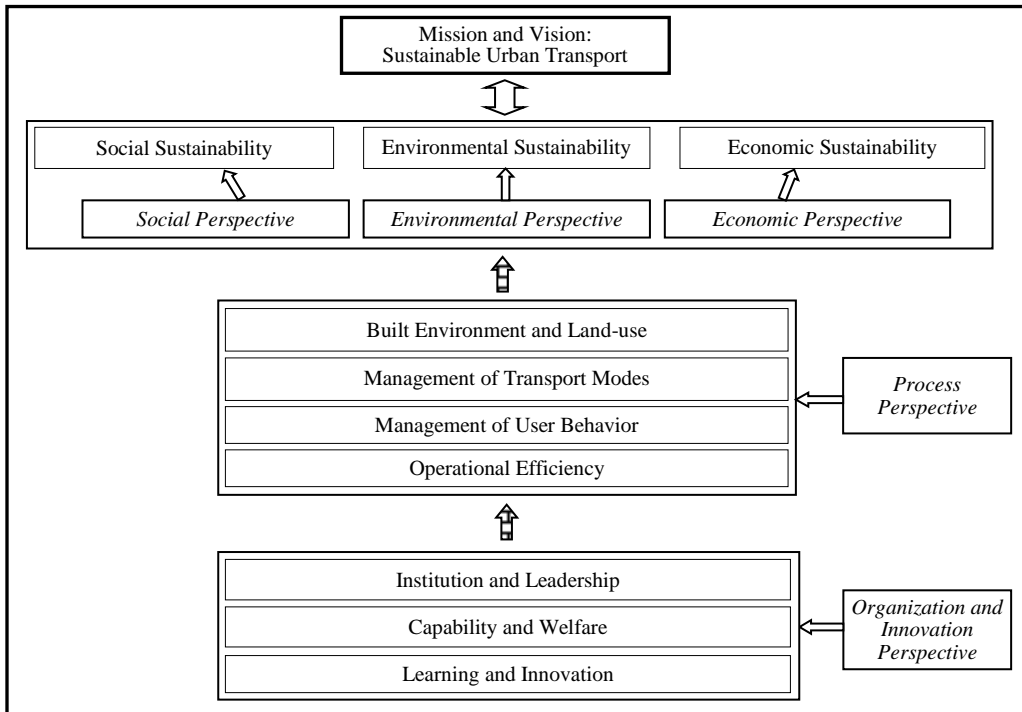


Figure 2: Framework of BSC for Sustainable Urban Transport (Note: Following mission and vision on the top, italic texts denote perspectives and normal texts denote themes).

III. EVALUATION MECHANISM OF BSC

This section describes the evaluation mechanism adopted in the BSC for sustainable urban transport. This includes two key steps: (i) determination of scores for individual indicators, (ii) using scores of individual indicators to obtain aggregated scores for the themes and perspectives as well as an overall score for BSC.

III.1. Determination of Scores for Individual Indicators

In scoring individual indicators, a triangulation method is used. This method, adopting three approaches in scoring (i.e., review of literature, field interview, and expert judgment), determines the final score by averaging the scores obtained from these approaches. In all cases, score was given to each of the indicators on a five-point Likert scale represented by: 1: Very poor, 2: Poor, 3: Moderate, 4: Good, 5: Excellent.

Review of literature: The comprehensive review of literature includes a review of the government policies and strategies as documented in master plans and policy books as well as government policy announcements; news articles and published information from relevant organization's web portals. For each of the indicators the score was determined based on subjective understanding developed from literature review.

Field interview: Out of the 45 indicators in the BSC, 22 are related to major user experience, and are denoted by an asterisk (*) symbol in Table 1. The field interviews were conducted on these user-indicators. A total of 52 interviewees (travelers) were interviewed with written questionnaires, each consisting of 22 evaluative questions on these indicators using the 5-point Likert scale. The travellers were selected and interviewed at 8 urban locations of Mauritius out of which 4 were in the city of Port Louis. For each of these user-indicators, score from field interview was determined by averaging the scores obtained from the total number of interviewees.

Expert judgment: A team of three experts were interviewed for opinion and judgments. Experts were chosen based on the criteria of comprehensive knowledge, experience, willingness and sufficient time. In this study the experts consist of professionals and academics, having detailed knowledge and experience in sustainability of Mauritius urban transport. For each indicator, score from expert judgment was determined by averaging the scores obtained from these experts.

The overall score for each user-indicator was determined by averaging scores obtained from all of the three abovementioned approaches. For other indicators the overall score was determined by averaging scores obtained from literature review and expert judgment.

III.2. Determination of Aggregated Scores

For obtaining aggregated scores, the weighted average method is used. In particular, the aggregated score of a theme, perspective or the BSC is determined through the weighted average of the indicators for that theme, perspective or the BSC, respectively. In obtaining weight or importance score of indicators the expert feedback approach was adopted. Indicators were weighted based on their perceived relative importance towards achievement of sustainable urban transport in Mauritius. A team of three experts were consulted for providing weight to each indicator. The experts were chosen based on the criteria that they must have detailed knowledge, experience, willingness and sufficient time. A 5-point Likert scale ranging from 1 (least important) to 5 (most important) was used. The final importance score was determined through averaging importance scores obtained from experts.

IV. SOCIAL PERSPECTIVE OF MAURITIUS URBAN TRANSPORT

This section reviews the social perspective of Mauritius's urban transport. The indicators of this perspective reflect the social satisfaction and development through provision of desirable, affordable and equitable transport services to users.

IV(a). Accessibility, connectivity and travel time: There is road access to all developed parts of the island. Buses are given exclusive franchises to operate along set routes. The bus network is quite extensive and is organized around Port Louis. Taxi-trains, which are shared taxis licensed to operate along a set route as a supplementary bus, also stop and pick up passengers along the route. However the connectivity is generally poor. Bus terminals in Port Louis are poorly located relative to workplaces, requiring passengers to walk to and from work on foot during inclement weather. Traffic congestion, severe within the conurbations, has led to extended travel times, especially when leading to the capital during peak hours. A 15-20 km journeys by car typically take around one hour during peak periods [9]. In addition, buses often wait for longer than scheduled at bus stops until they are full.

IV(b). Affordability: The bus prices are regulated by the government. As effective from the end of 2010,

fares range from MUR 10 to MUR 35 (MUR 1 = USD 0.034) per trip, depending on distance travelled and availability of concession. Although the government’s policy is to keep bus fares as low as possible, fares are increasing frequently. At present about 20-30% of the total household income of the population is allocated to transport [5]. The instability and fluctuation of oil prices is one important contributing factor in the fare rise, since

around 50% of all imported fossil fuel is used for transportation [9]. The park and ride in a bus from a popular car park is MUR 40 and the parking charge in the city is MUR 20 for a two-hour period. Children are charged half as of adult fares in almost all routes; there is up to 100% concession for students depending on the route and distance travelled during school days, and the disabled and the pensioners travel free of costs.

Table 1: BSC Perspectives, Themes and Indicators

Perspectives	Themes	Indicators	
I. Social	Social Sustainability	a) Accessibility, connectivity and travel time*	
		b) Affordability*	
		c) Level of service and comfort*	
		d) Safety enhancement*	
		e) Security enhancement*	
		f) Social equity, culture and coherence*	
		g) Employment growth*	
II. Environmental	Environmental Sustainability	a) Impact on global environment	
		b) Impact on local air quality and ecology*	
		c) Impact on local noise level*	
		d) Sustainable energy consumption	
		e) Sustainable waste management	
III. Economic	Economic sustainability	a) Revenue enhancement	
		b) External cost savings	
		c) Mobility and economic growth	
		d) Congestion and travel demand management*	
IV. Process	1. Built Environment and Land-use	a) Land-use and transport integration	
		b) Management of transport infrastructure*	
		c) Management of parking facilities*	
	2. Management of Transport Modes	a) Promotion of public transport*	
		b) Control over private vehicles	
		c) Facilitation of non-motorized transport*	
		d) Integration among passenger modes*	
		e) Efficiency of commercial goods transport	
		f) Promotion of green vehicles	
	3. Management of User Behavior	a) Awareness, education and transition*	
		b) Legislation and enforcement*	
		a) Smart infrastructure technologies	
		b) Smart vehicle technologies	
	4. Operational Efficiency	c) Smart road pricing	
		d) Smart fare collection*	
		e) Advanced traveler and goods information*	
f) Smart congestion and incident management*			
g) Operator capability			
h) Supplier capability			
V. Organization and Innovation		1. Institution and Leadership	a) Institutional coverage and integration
			b) Leadership and political dynamics
	c) Effective investment		
	d) Information and performance management		
2. Capability and Welfare	a) Skill development and training		
	b) Employee welfare		
	a) Local and global feedback*		
3. Learning and Innovation	b) Innovations and good practices		
	c) Research and development		

Note: An asterisk (*) denotes an indicator with major user-experience.

IV(c). Level of service and comfort: In general, the bus industry, which has been deteriorating for many years, needs major service expansion and improvements. The operation of buses by a mix of public corporation, private companies and individual operators has led to a restrictive regulatory system lacking the ability to encourage a responsive bus service. The government has tried to keep bus fares low only at the expense of level of service. Most buses are unsuited to urban conditions. The common complaints by commuters are that, the buses are slow, uncomfortable as they mainly use truck chassis, dirty, badly driven, overcrowded during the peak hours and less frequent. There is lack of proper form and standard for maintenance of buses, which has led to frequent breakdown of buses along the roads, including even sudden fires in fully passenger-packed buses. The bus stations are often unattractive and unpleasant. Nevertheless, the government has launched a Bus Modernization Program which will enable all bus operators to renew their fleet, at no extra cost, with new generation buses and with low floors to speed up and facilitate boarding, especially for the elderly and handicapped. The National Transport Council (NTC), one of the leading bus operators, has recently purchased 80 fully built buses with automatic transmission and 15 fully built air conditioned buses [10]. The Rose Hill Transport (RHT), another bus operator, has also introduced new air conditioned buses in the Port Louis-Rose Hill route.

IV(d). Safety enhancement: In year 2010, the total number of road accidents was 21,258 which increased from 18,517 in 2001, resulting in an annual increase of 1.5% [13]. On the other hand, the number of casual accidents increased from 3,264 in 2001 to 3,677 in 2010 with an annual increase of 1.3%. In 2010, the casual accidents represented 17.3% of the total accidents and out of these casual accidents 160 (4.4%) were fatal. The number of vehicles involved in casualties has increased from 3,934 in 2009 to 4,037 in 2010 with a 2.6% annual increase [13]. Out of these vehicles motorcycles, cars, vans and lorries, buses, taxis, and pedal cycles represented 37%, 33%, 16%, 7%, 2% and 4.4%, respectively. Among the casualties, riders (auto/ motorcycle), passengers, pedestrians, drivers and pedal cyclists represented 34.7%, 28.4%, 18.3%, 14.1% and 4.5%, respectively. In 2010, the number of total accidents and fatal accidents per 100,000 populations were 1,710 and 13, respectively. The fatality index, which is the number of fatalities per 100 casualties, was 4.4 in 2010 [13]. Nevertheless, the National Road Safety Council promotes the education and behavioral change towards enhanced road safety and adopts major road

safety measures including revision of speed limits and installation of few speed cameras at selected locations.

IV(e). Security enhancement: Although petty crime is not unexpected in Mauritius, there is very low threat from terrorism. In urban transport, major security concerns include theft of vehicles or automobiles as well as theft of belongings while traveling. In Mauritius, the total recorded automobile theft in 2005 and 2006 were 993 and 1,005 respectively [14], representing 80 and 80.3, respectively, as rates per 100,000 populations of Mauritius. On the other hand, the total recorded theft of automobile in the largest city Port Louis were 489 and 467, respectively, in 2005 and 2006, which represent 329 and 314, respectively, per 100,000 populations in Port Louis. The total number of theft of belongings from vehicles in 2005 and 2006 were 1,839 and 1,551, respectively, which represent 148 and 124, respectively, as rates per 100,000 populations [14]. Although there is little evidence of high-tech security installations in transport infrastructure and vehicles, the government provides easy loan facilities for operators to install GPS-based security and anti-theft instruments in their vehicles.

IV(f). Social equity, culture and coherence: The policy of Mauritius government is to make transport facilities supportive in raising the standard of living of its population and in this regard government has undertaken several initiatives. The new buses under the Bus Modernization Program are equipped with low floors for easy boarding of elderly and handicapped passengers. Mauritius provides concessionary fares to children aged below 13, who are charged half as of adult fares in almost all routes.

IV(g). Employment growth: Sustainable urban transport has a role in local job creation and employment facilitation. In Mauritius, the tourism sector involves a dominating share of employment and the performance of this sector is highly dependent on transport. There are employment opportunities in the transport industry itself as there is only little automation. Buses are still manned by a driver and a conductor who walks around collecting fares and issuing tickets. For commuters of work trips, the main transport problem in Mauritius is severe congestion afflicting all traffic entering and leaving Port Louis during the morning and evening peak periods. The Employers' Federation is concerned that the competitiveness of the nation is being affected by the traffic congestion [23]. The employers face problems getting their workers to the workplaces and very often, the workers had to make about 1.5-2 hours journey in buses to get to work.

V. ENVIRONMENTAL PERSPECTIVE OF MAURITIUS URBAN TRANSPORT

This section reviews the environmental perspective of Mauritius's urban transport. The indicators of this perspective cover impacts of urban transport on both local and global environment.

V(a). Impact on global environment: Urban transport affects global environment mainly by emitting greenhouse gases (GHGs). Globally, the carbon dioxide (CO₂) emission contributes to 95% of total GHG emission from transport [15]. In Mauritius, the CO₂ emission from the transport sector has increased from 0.62 million tons in 1995 to 0.85 million tons in 2009, leading to a 2.5% annual increase [26]. In 2009, the transport sector contributed to 25% of the total CO₂ emission, second to the energy industries (electricity). The per capita CO₂ emission from transport was 0.67 tons in 2009. The Ecological Footprint (EF) of Mauritius was 1.9 global hectares per capita in 2003, slightly lower than global average per capita EF of 2.2, and equal to global average per capita bio-capacity. The government strategizes to reduce CO₂ emission from the transport sector. Since July, 2011, an excise duty is imposed for import of new vehicles based on CO₂ emission potential of the vehicle. Other measures to reduce atmospheric pollution include the introduction of unleaded petrol, reduction in the sulfur content of diesel, legislation on smoke emission and phasing out of ozone-depleting substances.

V(b). Impact on local air quality and ecology: In urban Mauritius, vehicle emissions are one of the major sources of air pollution. With only two monitoring stations, there is no continuous time series data for overall ambient air quality in Mauritius. An integrated air quality monitoring and management system needs to be adopted, especially in transport. The maximum standards for total suspended particles (TSP), particulate matters (PM₁₀), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), lead (Pb), and ozone (O₃) are 50, 100, 50, 200, 10,000, 1.5, and 100 µg/m³, respectively [16]. Mauritius government has adopted several policies to encourage conversion of old vehicles to newer and less polluting vehicles. Other measures undertaken include introduction of unleaded petrol, reduction of sulfur content in fuels, duty waive on catalytic converters, promulgation of the Road Traffic Regulations 2002 to control vehicular emissions as well as promulgation of the Environment Protection Regulations 2005 to sustainable disposal of used oils.

V(c). Impact on local noise level: Noise from heavy traffic flow on Mauritius urban roads adversely impact on communication, school performance, sleep and general wellbeing and contribute to hearing problems, although there is a general lack of quantitative information on noise level. According to the Road Traffic Regulations 2002 [17], the maximum permissible noise level for motorcycles/auto-cycles, cars and light vehicles is 79 dBA, while it is 84 dBA for buses, goods vehicles and all other type of vehicles.

V(d). Sustainable energy consumption: In 2008, the transport sector was the largest energy consumer, accounting for 48% of total energy imports [9]. The whole of transportation fuel is imported and the road transport sector is 100% dependent on fossil fuel [3]. The per capita annual primary energy consumption in transport was 0.53 toe in 2007 [18]. Mauritius does not have an auto fuel economy standard in place. Nevertheless, there are initiatives to reduce energy consumption from transport. The Maurice Ile Durable Fund is financing the replacement of 15,468 street lights with more energy saving lights [9]. The motor fuel taxes are in place and are substantial. The current effective excise tax on petrol and diesel are MUR 17.8 and 10.3, respectively, per liter [19]. In addition, a Long Term Energy Strategy 2009-2025 is being implemented to reduce the country's dependency on fossil fuels and to increase the share of renewable energy. Other major plans include adoption of vehicle energy labeling and energy efficiency standards and introduction of E10 (gasoline with 10% ethanol) and E20 (gasoline with 20% ethanol) in the medium term for less energy consumption in the transport sector [20].

V(e). Sustainable waste management: From the growth in number of populations as well as increasing patterns of consumption and production it has been projected that total waste generation in Mauritius will increase by about 50% by 2030 [20]. In Mauritius, waste oil generated from vehicles remains as a concern. Waste oil is generated from vehicle engine, gear oil and lubricating oil, mineral insulating, non-chlorinated insulating as well as synthetic insulating. In addition, the car maintenance in garages also generates the heat transmission waste oil. The Mauritius government has promulgated the Environment Protection Regulation 2005 which deals with sustainable collection, recycling or disposal of used waste oil. There is an urgent need to adopt an integrated waste management strategy and legislation to promote better waste reduction, reuse and recycling of wastes.

VI. ECONOMIC PERSPECTIVE OF MAURITIUS URBAN TRANSPORT

This section reviews the economic perspective of Mauritius's urban transport. The indicators of this perspective involve both financial and economic growth measures.

VI(a). Revenue enhancement: In 2004, the transport sector was the third largest sector in contribution to Mauritian GDP, contributing 13.1% [21], which slightly reduced in 2006, contributing 11.6% to GDP [1]. In the transport sector, the road transport incurs the largest share of revenue [2]. In fiscal year 2008-09, fuel excise taxes, vehicle excise taxes (excluding registration fees and road taxes) and passenger fees raised MUR 2,213, MUR 1,852 and MUR 572 million, contributing 4.7%, 3.9% and 1.2%, respectively, to total tax collections [19]. There is a proposal to impose congestion charges on private cars and goods vehicles entering Port Louis during peak hours, the implementation of which is expected to incur revenue of MUR 370 million [22]. There is also proposal for parking tax to be included in price of all private parking paid by users. However, the bus owners are faced with a lack of funds to modernize the fleet of vehicles and to improve service quality.

VI(b). External cost savings: External cost savings mainly include cost savings from reduced congestion effects, accidents and environmental impacts. The marginal congestion cost is MUR 2.1 per vehicle-km for the nation as a whole while it is MUR 12 per vehicle-km for peak driving in Port Louis [19]. The external accident cost and environmental cost (resulting mainly from local air pollution and CO₂ emissions) are about MUR 0.8 and 0.14, respectively, per vehicle-km. Therefore, the external costs of congestion per km driven are 3 and 15 times the

accident and environmental cost, respectively. In 2010, the worsening congestion has been estimated to cost MUR 3 billion which is 1.3% of GDP and the total external cost is estimated at 4.2 billion, which is 1.8% of GDP [9]. In order to reduce congestion costs, the government has planned for measures including congestion pricing, promotion of bus transport, development of a suitable mass transit option and enhancement of enforcement. To reduce accident costs, major government initiatives include installation of few speed cameras and road safety education, campaigns and enforcement. To reduce environmental costs, major government initiatives include lead-free petrol, reduction of sulfur content in fuels, duty waive on catalytic converters, promulgation of the road traffic emission regulations, phasing out of ozone-depleting substances etc.

VI(c). Mobility and economic growth: The GDP per capita of Mauritius is USD 8,700 in 2011. Similar to most other developing cities, the demand for urban transport in Mauritius has raised dramatically due to several factors, including the steadily increasing population, increasing household income, migration of the middle classes to urban areas, urban sprawl, edge-of-town and out-of-town development and increasing commercial and industrial activities [31]. Travel demand is increasing over years and in line vehicle population is also increasing. The number of vehicles per 1,000 people has rose from 212 in 2001 to 300 in 2010, with a 3.9% annual increase. The density of vehicles per road-km has increased from 105 in 1996 to 173 in 2008, leading to a 4.6% annual increase [9]. Traffic is expected to increase even more in future, 80% by 2020 [5]. The estimated travel speed within the Port Louis city is 10-15 km/hr in morning and evening peak periods while it is 20-25 km/hr during off-peak hours [23].



Figure 3: Traffic congestion at Port Louis (Photo: by author)

VI(d). Congestion and travel demand management:

The dominant transport problem in Mauritius is the chronic and severe traffic congestion in and around Port Louis as well as in the Plaines Wilhems conurbation during the morning and evening peak hours (Fig. 3). Congestion problems are also prevalent in other urban areas but with milder levels. Traffic volumes during peak periods have reached more than 3,650 passenger-car units per hour along the main corridor to the capital city center [5]. However, the off-peak traffic conditions are tolerable in Port Louis and other urban areas. The government is putting prioritized attention in resolving the congestion problem. Several transport strategies being adopted to mitigate congestion, especially in Port Louis, mainly include bypass and ring road development, flexi-time policy for government and education sector, congestion pricing, service improvement of bus transport, taxi industry reform, development of a suitable mass transit option and regulations and enforcement [22]. The contra-flow traffic scheme is also in operation in selected motorways to ease congestion. The recommended congestion pricing scheme to enter congested parts of Port Louis for the morning peak period on weekdays, which will be applicable to only cars, dual purpose and goods vehicles, is expected to divert approximately 30% of current traffic [23].

VII. PROCESS PERSPECTIVE OF MAURITIUS URBAN TRANSPORT

This section reviews the process perspective of Mauritius's urban transport. The process perspective ensures that, sustainability goals are achieved through efficient processing of a pool of drivers. In the urban transport, these drivers include built environment and land use, management of transport modes, management of user behavior and operational efficiency.

VII.1. Built Environment and Land Use

VII.1(a). Land-use and transport integration: There has been a lack of coordination in land-use and transport integration. Land-use development is rarely, if ever executed, in conjunction with sound principles for transport planning [22]. The vast majority of the ministries, headquarters and offices are located in Port Louis that attracts huge traffic. The Trade Union Congress has suggested that government should decentralize many of its ministries and headquarters to the outskirts. Separation of work and living places has also added to traffic pressure. In a move to wider land-use and transport integration, one major constraint is the lack of a proper travel demand model capable of incorporating various land-use strategies,

e.g., compact cities; decentralization approaches as well as minimizing the distances people need to travel [23]. Nevertheless, the government has stated its policy goal as to combine transport with land use in order to give people and enterprises the accessibility to the activities and supplies they need, as easily and cheaply as possible.

VII.1(b). Management of transport infrastructure:

Mauritius has almost reached a saturated level regarding the provision for additional road capacity [5]. The total length of roads has increased from 2,000 km in 2002 to 2,208 in 2010, leading to a 1.2% annual increase. Of the total road network, main roads, secondary roads, motorways and other types of roads comprise 47%, 29%, 4% and 20%, respectively and 98% of the roads are paved [24]. The road network is generally in good condition; but there are also narrow and uneven roads with inadequate lighting. It has been estimated that, total roads in the built-up areas of Port Louis is 20% of its total land area [23]. The footpaths are insufficient in the city and are not very friendly. Although zebra crossings are fairly well-observed by motorists and pedestrians, some of their locations hinder traffic flow. There is a need to adopt uniform road signing and marking standards. The number of traffic signals at junctions is also not adequate. In addition, the general standards of maintenance of roads and traffic facilities are not sufficient and there is lack of proper guidelines for temporary road works. Nevertheless, the government is trying to improve the quality of urban transport infrastructure. In the next few years, government will invest on several infrastructure improvement and rehabilitation works to allow for a seamless movement of traffic [9].

VII.1(c). Management of parking facilities:

While convenient parking is essential to the life of the city, the supply of parking must be controlled to discourage private vehicle usage. At present, parking appears to be a problem in Port Louis. In Port Louis, currently it is just possible for motorists to find parking space, though often with difficulty. Parking regulations are too strict and the parking charges are also high. In 2004, there were 8,000 car parking spaces in Port Louis consisting of 4,000 on-street road side lots and 4,000 off-street lots [23]. Many of the on-street parking spaces are occupied by the same vehicle for the whole day, which makes it difficult for others to find car parking spaces in the city. A lack of adequate staffing for travel wardens and inadequate coordination with police has led to a high incidence of illegal parking. Legal parking on both sides of streets also reduces street capacity and uglifies the city with a clutter of private vehicles (Fig. 4). Nevertheless, government is planning to operate

and enforce the paid parking scheme, and to design and introduce appropriate residents' parking schemes [11].

VII.2. Management of Transport Modes

VII.2(a). Promotion of public transport: Public passenger transport in Mauritius is primarily met through the extensive bus and taxi network across the entire island. The bus network is mainly organized around Port Louis and has about 220 bus lines and 900 bus stops. There is no urban rail. The number of buses has increased from 2,400 in 2001 to 2,850 in 2010 with an annual increase of 1.9% and the taxicars have increased from 5,300 in 2001 to 6,900 in 2010 with an annual increase of 3% [13]. In 2010, the taxis and buses comprised 1.8% and 0.7% of the total vehicle fleet. The public transport modal split in Port Louis was 0.49 for morning peak and 0.39 for 12-hour period in 2001 [23]. Three types of bus operators are in service in the island: the NTC (a parastatal body), three major private operators and over 700 privately owned small companies grouped into 12 cooperatives [22]. The fragmented bus industry does not plan adequately for passengers. The public transport commuters during peak hours experience considerable difficulties including old fleet of buses, frequent breakdowns, inadequate maintenance, poorly equipped workshops and poor bus scheduling (Fig. 5). The age distribution of the fleet of public buses shows that, 35.3% of the buses are less than 5 years, 25.8% between 5 and 9 years and 38.9% between 10 and 18 years [25]. With no operational subsidy provided by the government, the bus operators are under pressure financially due to regulated revenues, a static and outdated regulatory environment, rising costs of operation, notably fuel costs, and competition with relatively low-cost automobile use and illegal informal transport operators.

The bus industry has introduced a small number of direct and speedy services which are attractive to passengers, but much of the route structure provides slow all-stops local service, which is not competitive when the informal sector offers illegal but much faster direct services [22]. With the problems of the bus industry, and the rise in general prosperity, taxis serve as a popular means of transport, especially for important trips. Broadly there are three types of taxi service: hire per trip, contract cars which are often hired by tourists for a daily rate and taxi-trains. Although taxi drivers are not provided with any subsidies to operate as a taxi-train, they are offered an 80% rebate by customs and excise on the purchase taxes of their vehicles. The regulatory structure for

the taxi industry also needs reform. The industry has grown in ways which have been insufficiently controlled, and licenses granted for patterns of operation which do not best serve the public. Nevertheless, new air-conditioned buses have been introduced to link Port Louis with the main residential areas of the island. The government adopted 'Mauritius Bus Modernisation Programme' enables all bus operators to renew their fleet, at no extra cost.

VII.2(b). Control over private vehicles: The number of cars and dual purpose vehicles has increased from 90,600 in 2001 to 170,000 in 2010, leading to a 7.2% annual increase. Similarly, the number of motorized private two-wheelers (motor cycles and auto-cycles) has increased from 119,950 in 2001 to 159,300 in 2010 with a 3.2% annual increase. Altogether these private modes represent a 5.1% annual increase over this period. Private cars and motorized two-wheelers represented 44.2% and 41.4%, respectively, of the total vehicle fleet in 2010 [13]. In 2001, the number of cars per 1,000 populations was 76, which has increased to 133 in 2010, leading to a 6.5% annual increase. The cars are expected to constitute 52% of the fleet and to account for 70% of the traffic volume by 2020 [5]. The availability of travel allowances and duty concessions on imported cars has accelerated the shift to private modes. The government has, so far, not acted pro-actively to restrict private motorization. Fiscal policy has so far focused entirely on purchasing and owning vehicles, rather than on using them.

VII.2(c). Facilitation of non-motorized transport: No figures are available for trends of cycle use or pedestrian trips in Mauritius cities. In Port Louis, the high density housing demands for pedestrian and cycle routes to enhance accessibility. However, over the years, the users of the motor vehicle have been given greater importance while non-motorized users, including cyclists and pedestrians have been neglected. In the city centre, both the moving and parked vehicles make conditions for pedestrians uncomfortable, disagreeable and dangerous. The footpaths are insufficient, poorly maintained and not friendly (Fig. 6). There is little effort to ease pedestrian flows, let alone to make it pleasant. The imbalance in treatment for pedestrian and biking facilities is often demonstrated through fatal pedestrian and pedal cyclist accidents and people urging for traffic calming measures. Nevertheless, the government undertakes enhancement of pedestrianization in the city as a priority task [11].



Figure 4: High share of private vehicles on street coupled with mix of legal and illegal parking on street-sides has reduced the street capacity (*Photo: by author*)



Figure 5: Bus passengers often experience considerable difficulties due to inadequate and poorly equipped bus stops with a generally poor level of passenger service (*Photo: by author*)

VII.2(d). Integration among passenger modes: In order to ensure a seamless passenger movement, there is a need for integration among passenger modes in terms of physical facilities, ticketing and fare collection system. In Mauritius, although the different passenger modes compete with each other to some extent, they are complementary from the perspective of passengers. There is no operator independent ticket which could be used across the island. The bus fares are collected manually by conductor and tickets are issued after boarding. The taxis usually do not use meters and fares have to be negotiated in advance. Since government is considering developing an open exclusive bus-way right-of-way in the Curepipe-Port Louis corridor and bus-only road in Port Louis, there is a high need to plan for integration to other passenger modes.

VII.2(e). Efficiency of commercial goods transport: The number of goods vehicles including lorries,

trucks and vans has increased from 31,600 in 2001 to 39,100 in 2010 [13] with a 2.4% annual increase. In 2010, the goods vehicles comprised 10.2% of the total vehicle fleet. Out of these goods vehicles, 13,200 (33.8%) were lorries and trucks and 25,900 (66.2%) were vans. The transport and logistics sector is well developed with internationally linked freight and customs clearance service available. However goods movement is routinely adversely affected by the severe peak hour congestion at Port Louis. A government study shows that, in 2003, the goods vehicles were the second-most contributor to peak hour traffic congestion at Port Louis, just next to private cars, where goods vehicles represented 27% and 33%, of the morning inbound and evening outbound peak hour traffic, respectively [23].

VII.2(f). Promotion of green vehicles: The green vehicle measures in Mauritius are at the preliminary stage. Other than approximately 10% of motorcars

that use either diesel or Liquefied Petroleum Gas (LPG), all vehicles are petrol-fuelled. About 3% of the motorcars have so far been converted to bi-fuel status and other types of vehicles including buses and vans are exploring the possibility of conversion. The emission standard of vehicles remains between Euro 0 and Euro 1 [3]. Under the vehicle emission regulations 2002, all petrol and diesel driven motor vehicles must comply with specified emission standards for pollutants including CO, PM₁₀, nitrogen oxide (NO_x) and hydrocarbon (HC) according to their vehicle categories. In order to reduce emission from vehicles, the government has waived duty on catalytic converters. Recently, the government has taken initiatives to promote lower emission vehicles and the age limit for buses has been reduced. The government is also considering privatization of vehicle examination centers in order to improve their efficiency. All petrol fuel has been unleaded since September, 2002. From August 2010, the sulfur content of automotive diesel fuel has been regulated to be lowered to 500 ppm (0.05%) and the government is further planning to switch to 50 ppm (0.005%) sulfur diesel fuel. Government is also taking initiatives for promotion of hybrid and electric vehicles (EV) through fiscal incentives. A bus fleet renewal is proposed at the MPILTS that involves renewal of buses with diesel-electric hybrid engines capable of reducing pollutant emissions [3]. In addition, a Mauritius based EV company has started with the aim of making Mauritius an EV friendly country.

VII.2(g). Promotion of vehicle sharing practices: Vehicle sharing is beneficial from congestion, pollution as well as social and economic perspectives therefore regarded as a sustainable means of transport. In Mauritius, given the severe peak hour congestion at Port Louis, it is essential that vehicle sharing be promoted especially during peak hours. However, private vehicles being comparatively affordable, their usage rate is high and apparently there is lack of car-sharing strategies. Few studies, e.g., Yashvin [30], have proposed for implementation of carpooling. It is essential to ensure charge-free entry for carpools to the city when congestion pricing will be implemented. Other than this, some companies provide company transport to their employees, which are often accomplished by using contract buses. There is a need to implement High Occupancy Vehicle (HOV) lanes.

VII.3. Management of User Behavior

VII.3(a). Awareness, education and transition: Awareness building generally involves safety,

environment, security and sustainable traffic attitudes. The road safety campaigns in Mauritius are conducted periodically, which mainly target drivers, passengers, pedestrians, bicyclists and school children. In addition to the general media campaign including posters, leaflets, billboards, radio clips and newspaper adverts, some more active forms of intervention are also carried out by MPILTS and the Police which include safety lectures/talks given at schools, colleges and social welfare centers and which targets audiences including senior citizens, adults, youngsters and children. For school children, in addition to the regular visits, safety awareness is also distributed through the textbook curriculum, teachers' guides, posters, leaflets and activity books. The government is also taking measures for promotion of fuel saving techniques in driving through education and information programs as well as for awareness of important security issues. The general level of driver obedience is satisfactory.

VII.3(b). Legislation and enforcement: There are evidences of traffic violation. Buses do not always stop in the bus bays provided for them; instead they stop on the left lane, as they find it difficult to get back into the main traffic stream after stopping. In addition to the problem of itinerant hawkers who block traffic flow on major roads, a lack of adequate staffing for travel wardens and inadequate coordination with police has led to a high incidence of illegal parking. Although there are vehicle service and examination centers to undertake vehicle maintenance and roadworthiness assessment, respectively, most of these are poorly equipped. Nevertheless, government plans to improve the highway condition monitoring system, which involves purchasing of new software, conduction of staff training as well as adoption of routine monitoring [11], and also plans to update the legislation and regulations associated with vehicle licensing and registration. In order to effectively employ these legislation and enforcements, NTA addresses the need for technological deployment and computerization [11]. The vehicle emission regulations are in place. In order to improve traffic safety, the road traffic act involves the permissible alcohol level in motorists, introduction of breath test, provision of tougher fines coupled with imprisonment for drink driving offences, mandatory use of helmets for motorcycle and auto-cycle drivers and pillion riders, mandatory use of seat belts, prohibition on use of hand-held microphone or telephone handset whilst driving, and mandatory conduction of safety audits for every construction of new roads and implementation of new traffic

schemes. The speed limits are periodically reviewed for in order to ensure safe yet efficient traffic flow.

VII.4. Operational Efficiency

VII.4(a). Smart infrastructure technologies: The technology deployment in Mauritius urban transport infrastructure is generally at the developing phase. Many traffic signals are still manually controlled by police (Fig. 7). There is lack of an advanced monitoring and advisory system and video surveillance systems for sensitive locations. Nonetheless, the government has adopted several initiatives to deploy technologies. The Traffic Management and Road Safety Unit (TMRSU) has signalized around 168 sites with traffic lights [12]. These sites include both a pelican type, e.g., signalized pedestrian crossing, as well as a junction type, e.g., T-junctions, four-arm junctions and staggered junctions. In addition, the TMRSU is now installing Light Emitting Diodes (LED) devices for traffic signals, which are less energy consuming, operationally efficient and more cost effective in the long term [12]. Considering speeding as one of the main causes of accident in Mauritius, government has recently procured 4 hand-held laser speed radars for the Police. In addition to these, initiatives are underway to convert motorway roundabouts to signalized intersections.

VII.4(b). Smart vehicle technologies: In general, vehicles lack advanced positioning and navigation technologies. However, there is a gradual move towards smart vehicle technologies. The NTC has recently purchased 80 fully built buses with automatic transmission [10]. Government has also purchased new electronic ticketing machines and introduced smart fare payment cards on a trial basis. Other than these, the government provides easy loan facilities for small and medium enterprises to install GPS-based security, anti-theft and energy-saving devices in vehicles. The government adopted 'Mauritius Bus Modernization Program' enables all bus operators to renew their fleet, at no extra cost, with new generation buses.

VII.4(c). Smart road pricing: Inspired by the success of electronic road pricing in reducing traffic congestion in other global cities including Singapore, London and Stockholm, this technology has been proposed for Port Louis since last decade, but yet not implemented. Recently, the government has planned to impose a congestion charge of MUR 100 for private vehicles and MUR 200 for freight vehicles, to enter or pass through Port Louis during the morning peak hours [27]. It has been recommended to initially employ a manual approach, such as a requirement to

purchase daily coupons, which can be further switched at a later period to an electronic road pricing [22].

VII.4(d). Smart fare collection: Smart fare collection makes use of technologies that increases the efficiency and accuracy of fare transactions and enhances seamless commuter travel experience. In Mauritius, bus fares are collected manually by a conductor who walks around collecting fares and issuing tickets after passengers have boarded. Taxis do not use meters and fares have to be negotiated in advance. Nevertheless, recently, the government has purchased new electronic ticketing machines and also introduced smart fare payment cards on a trial basis. The smart card named 'Etoile card' is both a contactless and contact smart card that can be conveniently used to pay bus fares as well as to make small purchases.

VII.4(e). Advanced traveler information: Advanced traveler information including bus routes, timetables and fares is imperative for a seamless travel experience, especially in the urban context. In Mauritius, although many commuters demand for information including timetables and routes to be posted at bus stops, it is lacking in many instances. There is no facility for real-time bus arrival information. However, information are available from the websites of Ministry of Transport (<http://www.gov.mu/>) and Mauritius Buses (<http://www.mauritius-buses.com/routing/>), which include bus service numbers by operators, bus routes, frequency, arrival time of daily first and last buses, fares and average journey times. Out of the bus operators, the RHT (www.rht.mu) currently provides information including bus routes and time tables.

VII.4(f). Smart congestion and incident management: With a general lack of advanced navigation, positioning and surveillance technologies in vehicles and infrastructures, there is little smartness in congestion and incident management. There is no incident detection system on the motorway. In managing post breakdowns/accidents on the motorway that impedes traffic flow, police depend entirely on their regular patrols and calls from stranded motorists. The police have few tow trucks on standby to tow away the broken down vehicles to the police pound.

VII.4(g). Operator capability: The bus owners are faced with a lack of funds to modernize the fleet of vehicles and to improve service quality. With no operational subsidy provided by the Government, the bus operators are under pressure financially due to regulated revenues, a static and out-dated regulatory

environment, rising costs of operation, notably fuel costs, and competition with relatively low-cost automobile use and illegal informal transport operators [22]. Although taxi drivers are not provided

with any subsidies to operate as a taxi-train, they are offered an 80% rebate by customs and excise on the purchase taxes of their vehicles [31].



Figure 6: Insufficient and often un-friendly pedestrian facilities coupled with poor enforcement results in interrupted pedestrian flow and jaywalking (*Photo: by author*)

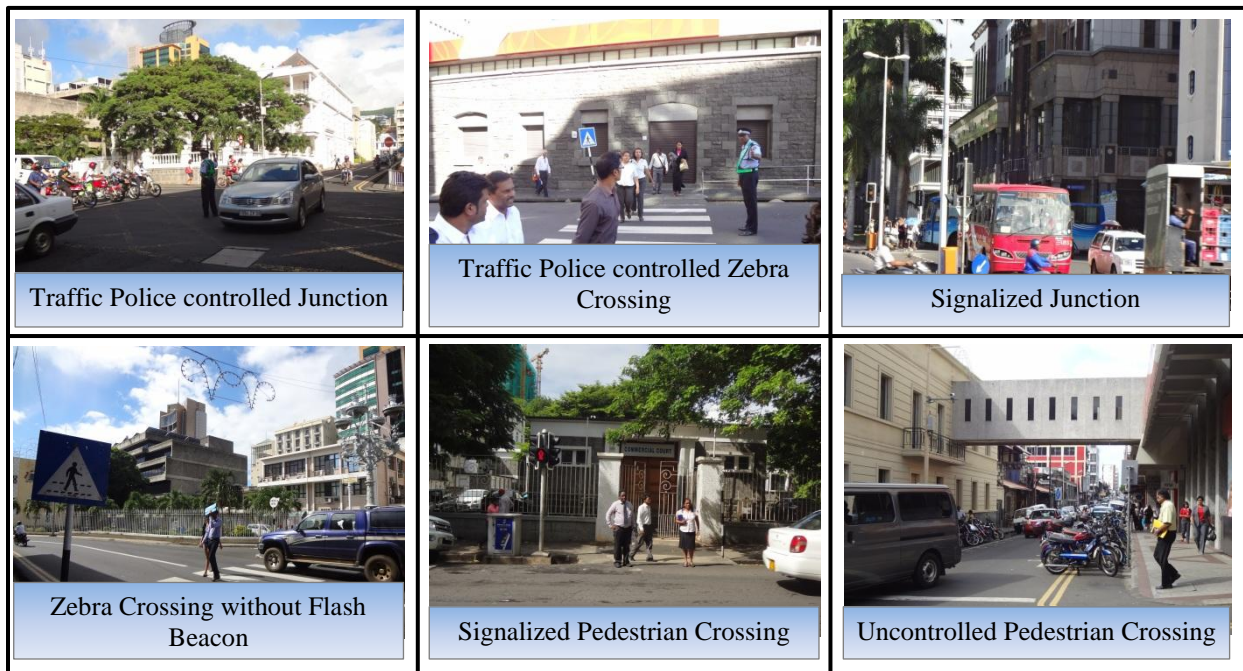


Figure 7: Traffic junctions and pedestrian crossings are only partially automated (*Photo: by author*)

VII.4(h). Supplier capability: The suppliers involve both the suppliers of products as well as those of services (e.g., infrastructural, vehicle and material manufacturers/ suppliers, contractors, consultants). The supplier's need much improvement in terms of materials, vehicles and services. The quality of public buses as well as the road infrastructure needs to improve with high quality suppliers.

VIII. ORGANIZATION AND INNOVATION PERSPECTIVE OF MAURITIUS URBAN TRANSPORT

This section reviews the organization and innovation perspective of Mauritius's urban transport. This involves three kinds of investments in the urban transport, i.e., institution, skill, and innovation, which promote the organizational development in a manner supportive for achieving sustainability goals.

VIII.1. Institution and Leadership

VIII.1(a). Institutional coverage and integration: The organization of transport in Mauritius is institutionally complicated. While responsibility for the land transport is largely overseen at the government level by the Ministry of Public Infrastructure, Land Transport and Shipping (MPILTS), planning, policy making, investment, design, construction, regulation, management and enforcement functions are carried out by a myriad of agencies and organizations [31]. Externally, the MPILTS coordinates with other major ministries, such as the Ministry of Finance for financial issues, Ministry of Environment for environmental issues and the Ministry of Housing and Lands for land-use and transport planning. Under the MPILTS, three key regulatory authorities for urban transport are the National Transport Authority (NTA), the Traffic Management and Road Safety Unit (TMRSU) and the National Transport Corporation (NTC). The NTC has been set up in the early 1980s to operate public transport services in Mauritius. The NTA is the regulatory body for implementing government policies and decisions relating to road transport, including legislation for vehicle licensing and operation, registration of ownership, licensing of motor vehicles, collection of road tax and other license fees, examination of motor vehicles, enforcement and monitoring, control of paid parking zones as well as planning for improved transport services. The TMRSU builds up reliable accident database for analysis. In addition, to maintain a safe, secured and efficient urban transport the NTA coordinates with other agencies including the Police Department, the Urban Transport Program Unit and the Road Development Authority (RDA). Further,

The MPILTS has set up the National Road Safety Council (NRSC) to enhance road safety. Similarly, the Road Transport Advisory Board (RTAB) has been set up to advise the Minister on formulation of policies on road transport planning and management. At the operator level, there are associations and societies including the Bus Owners Co-operative Society (BOCS), Contract Bus Operators Association and Taxi Owners Association. The Mauritius urban transport lacks appropriate institutional integration for effective adoption and implementation of transport policies. Responsibilities as well as lines of authority are ill-defined, and duplication exists between government agencies. Multiple agencies advocate competing projects, making it hard for political decision-makers to develop a clear vision of priorities for action [22]. This poor coordination and integration has led to failure of some past initiatives. The organizational and regulatory structure of the public transport industry is currently rather ad hoc. The MPILTS recognizes that a privatization study is required to investigate the most appropriate means of increasing private sector participation in the NTC, to bring it into line with the other private bus companies [11]. There are also needs to encourage individual operators to join co-operatives, to introduce a more liberal regulatory regime designed to encourage responsiveness to markets and to encourage more effective taxi operations. Nevertheless, in major urban transport functional units including the RTAB and the NRSC there has been direct representation of involved regulatory bodies, internally from the MPILTS, e.g., NTA, TMRSU, as well as externally from other ministries and associations, e.g., Ministry of Finance, Ministry of Health and Quality of Life, Association of Urban Authorities. The government has recently approved the setting up of the Mauritius Land Transport Authority (MLTA), which will integrate all functions presently carried out by the NTA, the RDA and the TMRSU. Policy has also been planned to maintain funding for minimum acceptable levels of agency functioning.

VIII.1(b). Leadership, policy and political dynamics: Leadership, policies and politics have direct influences on urban transport sustainability since major decisions and strategies are adopted and implemented by the government. Mauritius is a fully-fledged democracy with regularly contested and transparent elections. The elected government serves for five years term. After being ranked 54th out of 145 countries in 2004 for its level of corruption perception, Mauritius has improved to 46th position out of 183 countries in 2011 [28]. The transparency has improved from 41% to 51% over this period. The democracy is vibrant; however there are evidences of

debate regarding the validity of many government policies [21]. In the transport sector, with several government ministries involved in regulating and operating, it is essential that an integrated approach is taken to policy matters. In the absence of a strong, technically proficient, and goals-directed authority, changes of government have tended to lead to a rejection of previously-established policies. The ruling political government seemed to have the major role in deciding on all mega projects, in many of which the opposition parties might not agree [29].

VIII.1(c). Effective investment: The government budget and actual expenditure for transport and communication in financial year 2008-09 were 2,463 and 3,262 million MUR, respectively [32]. The share of transport and communication to total government expenditure has increased from 3.3% in 2007-08 to 5.4% in 2008-09 with a 64% annual increase, mainly due to increased road construction. Rising costs of operation in the bus industry with lack of subsidy from the government have led to a poor financial situation in the bus industry. In addition, over the last decade, the government contemplated the introduction of a mass rapid transit from the center of the island, through the main towns down to Port Louis in an aim to relieve congestion, which has not materialized because of the high level of investment required and uncertainty about the financial viability of the project. To some extent all modes of transport depend on the government funds. Therefore, government addresses the need for an integrated transport strategy that provides a long-term investment program covering all modes. The government policy is to use economic resources efficiently, to minimize the economic burden of transport on the community and to ensure that transport projects and policies are not approved unless and until they have the potential to provide adequate long-term economic returns.

VIII.1(d). Information and performance management: The transparency in information supply and availability has room for improvement. The websites do not provide all necessary information. There is a need to adopt performance measurement and management in the urban transport sector in order to improve sustainability performance.

VIII.2. Capability and Welfare

VIII.2(a). Skill development and training: At the decision making level, often consultation process is undertaken with appropriate mix of technical and administrative skills before moving on with any big projects, which may also involve foreign expertise; the decision making on choice among three

infrastructural alternatives in order to resolve the severe congestion problem at Port Louis is one such example [11]. At the operator level, there is evidence of employee training, as seen in NTC, which conducts information technology (IT) training courses for its employees [10]. The training of driving and issue and control of driving licenses are overseen by the Traffic Police Headquarters, where prospective drivers are trained and tested theoretically, orally and practically before being issued with driving licenses.

VIII.2(b). Employee welfare: Employee satisfaction is strategized by the government. Under an Industrial Relations Act, bus companies must employ seven conductors and seven drivers for every five buses, and must provide benefits such as pensions, holiday and sick pay [31]. The Bus Industry Employees Welfare Fund (BIEWF) has been set up as a parastatal body under the purview of the MPILTS, to promote the welfare of employees of the bus industry and their family. The objectives of the BIEWF is to further the social welfare as well as to develop schemes, including loan schemes and other form of financial assistance and projects for the welfare of the employees of the bus industry and their families.

VIII.3. Learning and Innovation

VIII.3(a). Local and global feedback: An effective public participation helps to identify potential pitfalls in major policies and plans beforehand as well as to create enthusiasm among citizens which is helpful in successful implementation of projects. There is little evidence of active public participation in the decision making process of Mauritius urban transport and in addition, public complaints are often ignored regarding service quality. Therefore, there have been suggestions that, every new transport project should be publicized and communicated to the public, which would remove the feeling in public that projects are done on a piece-meal basis when they see how they all fit in and it would also give confidence to the public that projects have been thought out properly [23].

VIII.3(b). Innovations and good practices: In order to benefit from the rapidly changing society, it is imperative to innovate as well as to learn from global innovations. There is little innovation in Mauritius public transport services, as seen in the bus industry, which does not plan adequately for its passengers. Given several lagging areas in Mauritius urban transport, including technology, institutionalization and finance, which are imperative for an innovation environment, Mauritius can learn from global benchmarking practices in order to improve the

congestion as well as overall urban transport situation. Such learning may involve areas including bus promotion schemes, smart traffic control measures as well as effective travel demand management strategies. Nonetheless, there are evidences of such learning. For example, congestion charging policy, which has been able to substantially drop peak hour traffic volume in Singapore and London, has recently been planned to be employed in Port Louis.

VIII.3(c). Research and development: In order to find solutions to major urban transport problems in Mauritius including the severe congestion at Port Louis, there is a need to adopt holistic research and follow-up initiatives. An origin-destination survey was carried out in Port Louis in 2005, with an aim to understand its traffic patterns under all prevailing activities, i.e., schools, commercial and work activities [12]. At the university level, both the University of Mauritius (UoM) and the University of Technology Mauritius (UTM) offer both undergraduate and postgraduate level degree programs relating urban transport sustainability. The Multidisciplinary Centre of Excellence Transport (MCE), set up at the UoM conducts research activities mainly targeting at solutions to transport problems in Mauritius. The Mauritius Research Council carries out studies on energy efficiency and renewable energy, which helps in devising sustainable transport energy options. It is government's policy to undertake a research-oriented approach towards sustainable solutions to urban transport problems. The government supported 'Mauritius Transport Consensus Forums', consisting of both local and global experts, conducts research works to device workable options for Mauritius urban transport sustainability.

IX. RESULTS AND DISCUSSION

This section discusses the results of the BSC performance for sustainability of Mauritius's urban transport. The scores of each indicator, as obtained from review of literature, field interview and expert judgment, as well as its overall score have been presented in Table 2. From Table 2, it is noticeable that, out of the 22 major user experience related indicators, 19 were underscored by users, as compared to scores obtained from both literature review and expert judgment. This may indicate that, users yearn for a better and more user-friendly urban transport. However, for all indicators, the scores obtained from expert judgment and literature review are generally consistent. It is also noticeable that, there are significant differences in performance

among different indicators and themes. Among the 45 indicators of BSC, 23 have performed moderate and 22 have performed poor. From Fig. 8, it is noticeable that, among the 10 themes of BSC, 6 have performed moderate and 4 have performed poor; and, among the 5 perspectives of BSC, 4 have performed moderate and 1 has performed poor. The overall score of BSC is 2.6, depicting a marginally moderate performance. The consistency of the performance obtained from literature review, field interview and expert judgment indicates the validity of the obtained results. The following sub-sections discuss important findings of this case study.

IX.1. Social Perspective

The overall performance of the social perspective is moderate, scoring 2.65. Among the indicators, the 'safety enhancement' and 'social equity and coherence' have performed the best, both with moderate performance, scoring 3.00. These are mainly due to Mauritius's initiatives to enhance safety as well as to provide equitable transport services to all levels of population through initiatives including fare concessions, new elder-friendly bus fleets etc. The worst performing is the 'level of service and comfort', scoring 2.10 and depicting a poor performance, mainly due to the slow, old fleeted, uncomfortable, poorly maintained, infrequent and overly crowded transport services. The indicators 'affordability' and 'employment growth' have performed moderate. However, the indicator 'accessibility, connectivity and travel time' has performed poor, mainly due to poor connectivity of transport infrastructure with major traffic generators as well as increased travel delay due to congestion. The indicator 'security enhancement' has also performed poor, mainly because of high rate of security breaches, including theft of automobiles as well as theft of personal belongings while travelling.

IX.2. Environmental Perspective

The environmental perspective has performed moderate, with a score of 2.71. Among the indicators, the 'impact on global environment' has performed the best, with a moderate performance, scoring 3.15. This is mainly due to Mauritius's efforts to restrict the per capita carbon emission from transport as well as having a global average per capita ecological footprint. The indicators 'impact on local noise level', 'sustainable energy consumption' and 'sustainable waste management' have performed moderate. The worst performing is the 'impact on local air quality and ecology', scoring 2.37 and depicting a poor performance, mainly due to increasing local air pollutions from transport.

Table 2: Balanced Scorecard for Sustainable Urban Transport in Mauritius

Persp.	Theme	Indicator	Imp. (AD)	Score				Theme Over.	Persp. Over.
				Indicator					
				LR	FI (CoV)	EJ (AD)	Over. (AD)		
Social	Social sustainability	Accessibility, connectivity and travel time*	4.76 (0.04)	2.4	2.3 (0.19)	2.4 (0.18)	2.37 (0.04)	2.65	2.65
		Affordability*	4.64 (0.04)	2.9	2.8 (0.14)	3.0 (0.11)	2.90 (0.07)		
		Level of service and comfort*	4.32 (0.02)	2.1	2.0 (0.20)	2.2 (0.18)	2.10 (0.07)		
		Safety enhancement*	4.85 (0.03)	3.1	2.9 (0.12)	3.0 (0.11)	3.00 (0.07)		
		Security enhancement*	4.25 (0.05)	2.4	2.4 (0.21)	2.5 (0.18)	2.43 (0.04)		
		Social equity, culture and coherence*	4.51 (0.03)	3.1	2.9 (0.16)	3.0 (0.11)	3.00 (0.07)		
Environ.	Environmental sustainability	Employment growth*	4.22 (0.02)	2.7	2.6 (0.18)	2.7 (0.07)	2.67 (0.04)	2.71	2.71
		Impact on global environment	4.49 (0.05)	3.2	n.a.	3.1 (0.16)	3.15 (0.05)		
		Impact on local air quality and ecology*	4.86 (0.03)	2.4	2.3 (0.21)	2.4 (0.13)	2.37 (0.04)		
		Impact on local noise level*	4.54 (0.04)	2.5	2.5 (0.20)	2.5 (0.13)	2.50 (0.00)		
		Sustainable energy consumption	4.62 (0.02)	2.7	n.a.	2.8 (0.18)	2.75 (0.05)		
Econ.	Economic sustainability	Sustainable waste management	4.15 (0.03)	2.8	n.a.	2.8 (0.13)	2.80 (0.00)	2.74	2.74
		Revenue enhancement	4.55 (0.06)	3.1	n.a.	3.2 (0.20)	3.15 (0.05)		
		External cost savings	4.60 (0.03)	2.6	n.a.	2.5 (0.13)	2.55 (0.05)		
		Mobility and economic growth	4.71 (0.05)	3.3	n.a.	3.3 (0.11)	3.30 (0.00)		
Process	Built environment and land-use	Congestion and travel demand management*	4.79 (0.05)	2.1	1.9 (0.23)	2.0 (0.13)	2.00 (0.07)	2.40	2.40
		Land-use and transport integration	4.81 (0.04)	2.3	n.a.	2.2 (0.13)	2.25 (0.05)		
		Management of transport infrastructure*	4.73 (0.05)	2.5	2.4 (0.21)	2.6 (0.11)	2.50 (0.07)		
	Management of transport modes	Management of parking facilities*	4.42 (0.06)	2.5	2.4 (0.20)	2.5 (0.16)	2.47 (0.04)	2.43	2.43
		Promotion of public transport*	4.93 (0.02)	2.4	2.2 (0.21)	2.3 (0.13)	2.30 (0.07)		
		Control over private vehicles	4.9 (0.03)	2.3	n.a.	2.2 (0.18)	2.25 (0.05)		
		Promotion of non-motorized transport*	4.51 (0.04)	2.0	1.9 (0.21)	2.1 (0.13)	2.00 (0.07)		
		Integration among passenger modes*	4.62 (0.02)	2.5	2.4 (0.20)	2.5 (0.13)	2.47 (0.04)		
		Efficiency of commercial goods transport	4.66 (0.03)	2.8	n.a.	2.7 (0.11)	2.75 (0.05)		
	Management of user behaviour	Promotion of green vehicles	4.58 (0.02)	2.8	n.a.	2.8 (0.18)	2.80 (0.00)	2.38	2.38
		Promotion of vehicle sharing practices*	4.22 (0.06)	2.5	2.4 (0.20)	2.5 (0.16)	2.47 (0.04)		
		Awareness, education and transition*	4.41 (0.04)	3.0	2.9 (0.12)	3.0 (0.16)	2.97 (0.04)		
	Operational efficiency	Legislation and enforcement*	4.83 (0.06)	2.4	2.3 (0.19)	2.4 (0.13)	2.37 (0.04)	2.25	2.25
		Smart infrastructure technologies	4.56 (0.04)	2.3	n.a.	2.2 (0.07)	2.25 (0.05)		
		Smart vehicle technologies	4.55 (0.03)	2.3	n.a.	2.4 (0.18)	2.35 (0.05)		
Smart road pricing		4.42 (0.04)	2.1	n.a.	2.0 (0.11)	2.05 (0.05)			
Smart fare collection*		4.38 (0.02)	2.7	2.7 (0.18)	2.8 (0.11)	2.73 (0.04)			
Advanced traveller and goods information*		4.61 (0.04)	2.3	2.2 (0.19)	2.3 (0.16)	2.27 (0.04)			
Smart congestion and incident management*		4.52 (0.02)	2.0	1.9 (0.19)	1.9 (0.18)	1.93 (0.04)			
Operator capability		4.85 (0.06)	2.2	n.a.	2.1 (0.09)	2.15 (0.05)			
Supplier capability		4.67 (0.03)	2.4	n.a.	2.2 (0.20)	2.30 (0.10)			
Organization and Innovation	Institution and leadership	Institutional coverage and integration	4.83 (0.04)	2.5	n.a.	2.5 (0.13)	2.50 (0.00)	2.63	2.63
		Leadership and political dynamics	4.8 (0.03)	2.7	n.a.	2.8 (0.07)	2.75 (0.05)		
		Effective investment	4.78 (0.04)	2.8	n.a.	2.7 (0.13)	2.75 (0.05)		
	Capability and welfare	Information and performance management	4.65 (0.03)	2.5	n.a.	2.5 (0.13)	2.50 (0.00)	3.02	3.02
		Skill development and training	4.66 (0.05)	2.8	n.a.	2.8 (0.11)	2.80 (0.00)		
	Learning and innovation	Employee welfare	4.27 (0.04)	3.2	n.a.	3.3 (0.20)	3.25 (0.05)	2.36	2.36
		Local and global feedback*	4.54 (0.04)	2.3	2.2 (0.21)	2.3 (0.07)	2.27 (0.04)		
		Innovations and good practices	4.76 (0.06)	2.3	n.a.	2.3 (0.13)	2.30 (0.00)		
Research and development	4.71 (0.04)	2.5	n.a.	2.5 (0.11)	2.50 (0.00)				

Note:

1. An asterisk (*) denotes an indicator with major user-experience
2. LR: literature review, FI: field interview, EJ: expert judgment
3. CoV: coefficient of variation, AD: average deviation

IX.3. Economic Perspective

The overall performance of the economic perspective is moderate, scoring 2.74, and it is the best performing among all perspectives, mainly due to a high level of contribution of urban transport to Mauritius’s rapid economic growth. Among the indicators, the ‘mobility and economic growth’ has performed the best, with a moderate performance,

scoring 3.30. This is mainly due to increased impact urban transport to trade, opportunities and economic development of the country. The indicators ‘revenue enhancement’ and ‘external cost savings’ have also performed moderate. The worst performing is the ‘congestion and travel demand management’, scoring 2.00 and depicting a poor performance, mainly due to severe traffic congestion during morning and evening peak hours.

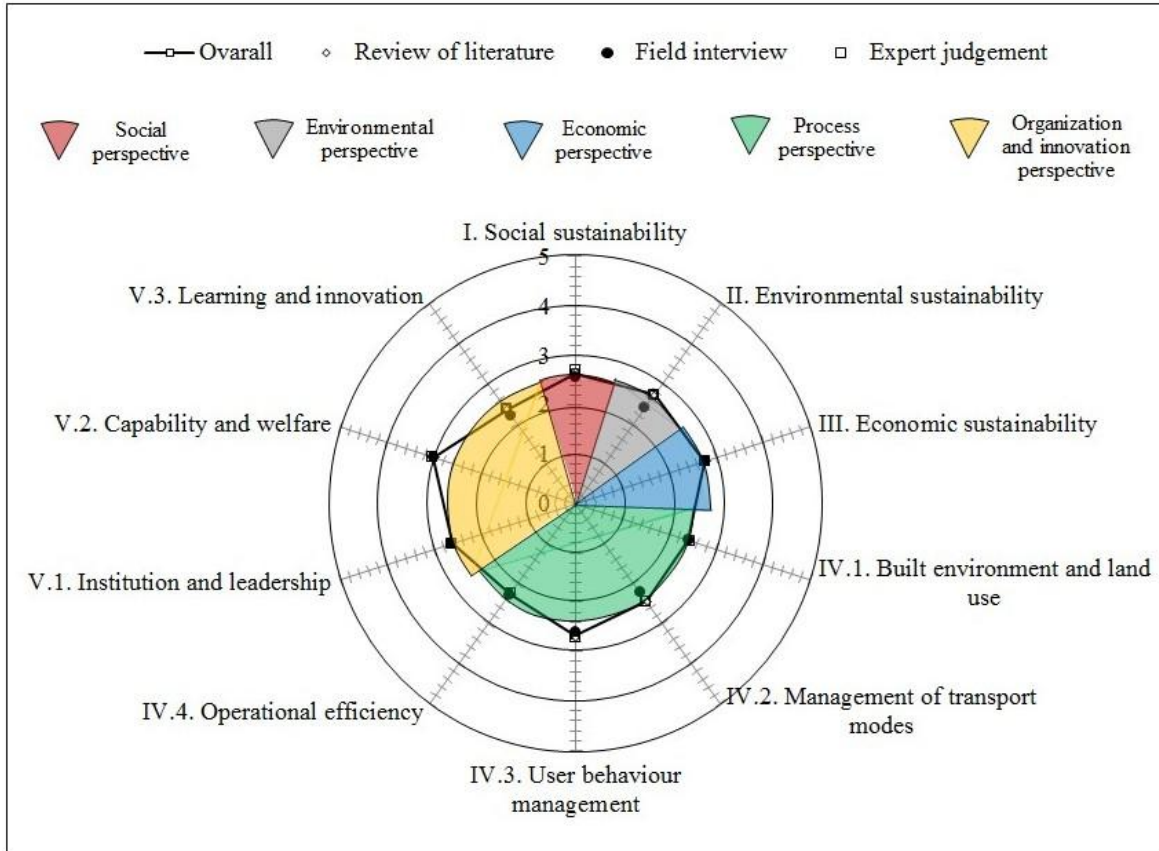


Figure 8: Scores of BSC Themes and Perspectives

IX.4. Process Perspective

The overall performance of this perspective is poor, scoring 2.38, and it is the worst performing among all perspectives. The theme ‘built environment and land use’ has performed poor with a score of 2.40. Among indicators of this theme, the ‘management of transport infrastructure’ and ‘management of parking facilities’ have performed moderate. However, the ‘land use and transport integration’ has performed poor, mainly due to poor integration of sustainable transport planning principles with the land use as well as a poor level of decentralization, which have resulted in a huge traffic pressure on Port Louis. The

theme ‘management of transport modes’ has also performed poor, scoring 2.43. Among its indicators, the ‘integration among passenger modes’, ‘efficiency of commercial goods transport’, ‘promotion of green vehicles’ and ‘promotion of vehicle sharing practices’ have performed moderate. However, the ‘promotion of public transport’ has performed poor, mainly because of a poor modal share coupled with inadequate, poorly maintained, old fleeted, infrequent and overcrowded public transport services. The ‘control over private vehicles’ has also performed poor, resulting from the fact that, private vehicle population is rapidly increasing and current government initiatives are inadequate to restrict

private motorization. The worst performing is the 'promotion of non-motorized transport', scoring 2.00 and depicting a poor performance, mainly due to uncomfortable and difficult pedestrian flows in urban areas as well as insufficient and poorly maintained footpaths and cycling facilities.

The theme 'management of user behavior' has performed moderate, scoring 2.65. Among the indicators, the 'awareness, education and transition' has performed moderate. However, the 'legislation and enforcement' has performed poor, mainly due to high occurrences of traffic violations, e.g., illegal parking, as well as inadequate technology and staffing for enforcement. Finally, the theme 'operational efficiency' has performed poor with a score of 2.25, and it is the worst performing among all themes of BSC, mainly due to a poor level of technological deployment in improving operational efficiency. The indicator 'smart infrastructure technologies' has performed poor, because of a lack of technology deployment in urban transport infrastructures. The 'smart vehicle technologies' has also performed poor, as a result of poor technological deployment in vehicles. The 'smart road pricing' has performed poor, because of the absence of an electronic road pricing mechanism. The 'smart fare collection' has performed moderate. The 'advanced traveller and goods information' has also performed poor, reflecting inadequate provision of facilities for advanced information to travellers. The worst performing is the 'smart congestion and incident management', scoring 1.93 and depicting a poor performance, mainly because of a general lack of advanced surveillance and positioning technologies in congestion and incident detection as well as post-occurrence management.

IX.5. Organization and Innovation Perspective

The overall performance of this perspective is moderate, scoring 2.62. The theme 'institution and leadership' has performed moderate with a score of 2.63. All of the indicators of this perspective have performed moderate. The theme 'capability and welfare' has performed moderate with a score of 3.02. Both of the indicators 'skill development and training' and 'employee welfare' have performed moderate, mainly due to government efforts to enhance skill development and welfare of transport industry employees. The theme 'learning and innovation' has performed poor with a score of 2.36. Among indicators of this theme, the best performing is the 'research and development', scoring 2.5 and depicting a moderate performance. The worst performing is the 'local and global feedback', scoring 2.27 and depicting a poor performance, mainly

because of a poor level of citizen participation in decision making, as well as a lack of public feedback facilities. The 'innovations and good practices' has performed poor, reflecting an inadequate level of innovation and learning from global benchmarking practices.

X. CONCLUSIONS

In this study, the sustainability of Mauritius's urban transport was evaluated using a Balanced Scorecard. Results show that, there are significant differences in performance among different indicators and themes. The major moderate performing areas include affordability, safety, social equity, employment growth, impact on global environment, energy consumption, revenue enhancement, economic growth, efficiency of commercial goods transport, promotion of green vehicles, awareness and education, leadership and policy, effectiveness of investment, and skill development and training. In addition, the marginally moderate performing areas, where improvements are highly necessary, are noise control, external cost savings, management of transport infrastructures and parking facilities, integration among passenger modes, and promotion of vehicle sharing practices. On the other hand, indicators that have performed poor, requiring immediate improvement, include level of service, air pollution, congestion management, integration of land-use and transport, integration among institutions, promotion of public and non-motorized transport, control over private vehicles, impact on local air quality and ecology, public participation, innovation, and technological deployment in infrastructures, vehicles, congestion and incident management, road pricing and traveler information. The overall performance of sustainability in Mauritius's urban transport is moderate. Results also indicate that, users are keen for a more user-friendly urban transport. The specific contribution of this study inheres, firstly, in reviewing the sustainability of Mauritius's urban transport with an integrated balanced framework using BSC, which is an outset initiative in the case of Mauritius; and secondly, in evaluating the sustainability performance of Mauritius's urban transport using the performance of its indicators. The results of this study may be useful for policy makers; firstly, to achieve an integrated and balanced understanding of sustainability performance, and secondly, to easily identify areas that need prioritized attention to improve. Further, with these results and understanding, effective policies can be set off and initiatives can be undertaken in order to achieve long term sustainability in Mauritius's urban transport.

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