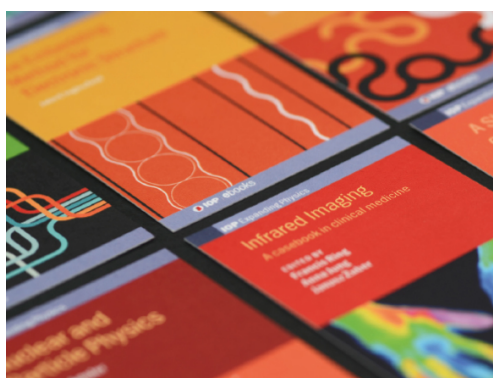


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To cite this article: A V Bagde *et al* 2021 *J. Phys.: Conf. Ser.* **1779** 012080

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# Exploring sustainable transportation development in Penang: stakeholders' perspectives of the Penang Transport Master Plan

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**Abstract.** Transportation is associated with all aspects of the nation's growth. Nowadays, sustainability is one of the primary goals of many urban transportation systems. Over the past, many innovative initiatives have been undertaken to achieve a safe, efficient, and sustainable transport system. Besides, natural environment, social wellbeing, and economic prosperity depend on sound transportation systems. In Malaysia, Penang is well-known as an industrial and medical hub. In recent years, the state has experienced rapid economic growth. However, without proper development planning for the transportation system and infrastructure, the growth for sustainable development will be jeopardised. Heavy congestions due to increasing car dependency lead to psychological stress for the travellers. There are limited studies on sustainable transportations in Penang. Therefore, this study will explore the current transportation system in Penang, including the Penang Transport Master Plan. To address the aim of the research, we adopt an inductive cross-organisational semi-structured interview to explore the current level of sustainability within Penang transportation system. From this case study, the initial findings indicate Penang is in dire need for a robust, sustainable transport system which can include rail transports and integration of different modes of transport. Moreover, the result also shows that the behaviour and attitude of Penangites towards public transportation needs to be changed. This study suggests a series of long term and short term solutions to enhance the performance of the transportation system in Penang. The balance alignment between the economic, social and environmental themes of sustainability will overcome the issues faced by the current transportation system in Penang.

## 1. Introduction

In today's world, climate change has become a global concern. Realising the dependency of humans on the biosphere, the United Nations' World Commission on Environment and Development (WCED) came up with the sustainable development concept [1]. The development should not harm or deploy any parts of social, environment, and economics. The important subtopic in sustainable development is sustainable transportation. It can be defined as –affordable, operable efficiently and fairly, with a choice among transport mode, supportive towards the economy and balances regional development without deploying any environmental, social or economic dimension [2] [3] [4]. The rapid urbanisation has created migration of people from the rural areas towards the urban areas. Additionally, the rate of increase in the number of vehicles is faster than population growth [5] [6] [7]. One contributing factor is car ownership is a symbol of pride in many developing countries.



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Eventually, this rapid stress in the existing transport system puts tremendous pressure on current public transportation. This paper will explore sustainable transportation development in Penang, specifically the Penang Transport Master Plan (PTMP) from the stakeholders' perspectives. The results will contribute to the improvement of the current transportation system, and other development approaches towards sustainable transportation objectives.

This paper is organised as follows; Section 2 explores frameworks, policies and methods for the development of sustainable transportation internationally. Section 3 reviews the study area and issues in the transportation systems. Section 4 gives an overview of the study method and methodology employed. Section 5 is the analysis and discussion of the findings of our study. Section 6 provides recommendation and the study is concluded with Section 7.

## 2. Sustainable Transportation

There are various definitions of sustainable transportation as illustrated in Table 1.

**Table 1.** Various definitions of Sustainable transportation

Author	Definition
Black, 1996	“Transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs.” [8]
Pearch, et al., 1993	“Transport and mobility with non-declining capital, where capital includes human capital, monetary capital, and natural capital.” [9]
Bell, et al., 1997	“A more sustainable transportation system” as “one which provides affordable access to freight and passenger service and does so in an environmentally sound and equitable manner.” [10]

Table 1 states some of the definitions of sustainable transportation. This paper defines sustainable transportation as “the ability to meet the needs of the society to move freely, communicate, gain access, trade and establish relationships without sacrificing other essential human or ecological values today or in the future” [11]

Daly (1992) enlists three parameters for defining sustainable transportation [12]. These parameters are 1) the use of renewable resources shall not exceed the rate of its regeneration, 2) the use of non-renewable sources shall not exceed the use of its substitute, and 3) pollution emission shall be bounded to the assimilative capacity of the environment [13]. The Canadian Centre for Sustainable Transportation further states that sustainable transportation shall grant the basic needs of human to be met safely, operates efficiently, shall be affordable, offers various modes of transportation, supports a vibrant economy and limits the carbon emissions and waste within the earth capability to absorb [13].

Public transportation or mass transportation is one of the modes that can offer sustainable transportation. It allows carrying a higher number of passengers as compared to private vehicles. This type of transportation includes bus, rail, and tram. With the increase in fuel prices and air pollution, mass transportation can help mitigate problems related to high congestion and carbon emission. Congestion increases not only cost fuel consumption but also increases the level of pollutions, which poses a danger to the public and environment [14].

The motivations behind sustainable transportation are increase users' satisfaction, increase in regular customer, increase in transportation efficiency, systematic accessibility of transportation, and maintain the relationship between buyers and suppliers [15].

**Table 2.** Various sustainability mobility initiatives

<b>Initiatives</b>	<b>Region</b>	<b>Aim</b>
Comprehensive Sustainable Transportation Indicators	Canada	The aim is to measure sustainable mobility as comprehensively as possible, taking into account all sustainability goals and objectives regarding transportation.
Gröna Bilister (Green Drivers in Swedish)	Sweden	The aim was to create a Swedish nationwide assessment scheme that measured the progress towards reducing the environmental effects of car use in municipalities.
HASTA	Sweden	HASTA aim is to aid municipalities to make progress towards sustainability at present and to construct a policy that motivates investments for sustainability today and in the near future.
Indicators for the Integration of Environmental Concerns Into Transport Policies	OECD member countries	The aim of the Environmentally Sustainable Transport is to identify tools and strategies in the long term to achieve sustainability for the transport sector.
Indicators to Assess Sustainability of Transport Activities	European Union	The institute for environment and sustainability (IES), a scientific institute within the European Commission's Joint Research Centre (JRC), set up the scheme.
Kommunvelometern (Swedish for Municipality Velometer)	Sweden	The aim is to highlight and rank municipalities' performance as bicycle-friendly cities by looking at the network coverage and efforts that aim to increase the bike share as a mean of transport.
Non-motorized transport performance indicator	United States	The indicator listing stands as a small part of a larger report, which aim is to create a user guide to developing pedestrian and bicycle master plans.
Performance Indicators for Transport	An initiative of the World Bank	The aims to supply indicators that can measure the sustainability for the four main modes of transport: road, air, rail and maritime.
SHIFT	European Union	The function of SHIFT is to allow cities to evaluate the sustainability of their transport system. City management, travel behaviour, environmental impacts are some of the factors that are regarded by the program. Cities that perform well are awarded a label.
Siemens Complete Mobility Index	Germany	It aims to evaluate the sustainable mobility level of a city and compare it with best practices.
STPI (RAJAT)	Canada	The aim of the project was the development of listing sustainable transportation performance indicators.

Table 2 shows major sustainable initiatives taken by different countries and authorities worldwide in the social, environmental and economic context. The initiatives share a common first step that is they study the travel demand management to develop various modelling and initiatives [13]. Demand management is the key to start an exploration of problems in transportation systems [16] [17]. Successful sustainable public transport service needs high movement modal sharing with a seamless service of two or more than two modes of transportation. Sabeen et al. (2012) propose the following policies for public transport in Malaysia [18]:

i) Promote the use of electric vehicles which serve as a “National Green Technology Policy” to minimise carbon emission. The policy encourages the production of electric and hybrid vehicles along with the relevant infrastructure development.

ii) Promote the practice of cycling. Although cycling is environmental friendly, it is only applicable for short distances. Many people can use this mode for their short distance journeys. Moreover, nowadays, there are numerous services for renting cycles.

iii) Avail mass transport to avoid driving stress, emission load, and to save money. Tseu (2006) states that both accessibility and mobility should be provided with the same importance [19].

Furthermore, sustainable transport requires the development of indicators corresponding to the three dimensions of sustainability; social, economic and environmental. The “Sustainable Urban Mobility in Asia” (SUMA) project appraise various indicators like safety, access, clean air, environment, social and economical for the promotion of a sustainable transportation system. The project clusters modifies and adapts more than three hundred indicators to assess the layers of the sustainable transportation system. In the Bangkok Declaration 2020, seventy-five indicators are shortlisted for the adaptation to improve transportation systems [20].

**Table 3.** Sustainable transportation Indicators

<b>Objectives</b>	<b>Indicators definition</b>
Economic	
Accessibility –land use mix	Several job opportunities and commercial services.
Accessibility –smart growth	Implementation of policy and planning practices that lead to more accessible, clustered, multi-modal development
Affordability	A portion of household expenditure devoted by transport
Commute access	Average commute travel time
Facility costs	Per capita expenditure on roads, traffic services, and parking facilities
Freight efficiency	Speed and affordability of freight and commercial transport
Planning	The degree to which transport institutions reflect least-cost planning and investment practices
Transport diversity	Mode split: walking, cycling, rideshare etc.
Social	
Citizen involvement	Public involvement in transport planning process
Community livability	Degree to which transport activities increase community livability
Equity –disabilities	Quality of transport facilities and services per people with disabilities
Equity –fairness	Degree to which prices reflect full costs unless a subsidy is specifically justified
Equity –non-drivers	Quality of accessibilities and transport services for non-drivers
Health & fitness	Portion of population who regularly walks or cycles
Non-motorized transport planning	Degree to which impacts on the non-motorized transport are considered in transportation modelling
Environment	
Climate change emission	Per capita fossil fuel consumption, CO <sub>2</sub> , another change emission
Habitat protection	Preservation of wildlife habitat
Land use impact	Per capita land devoted to transport facility
Noise pollution	Portion of population exposed to high level of traffic noise
Other air pollution	Per capita emission of “conventional air pollutants”
Resource efficiency	Non-renewable resource consumption in the production and use of vehicles and transport facilities
Water pollution	Per capita vehicle fluid losses

*Source: Litman (2007)*

Table 3 shows the three sustainable parameters, the indicators for each parameters and the measurement of the critical indicators for successful sustainable transport systems [21].

### 3. Study location: Penang

Penang is Malaysia's second-largest state the most developed area in Malaysia after Kuala Lumpur [22]. It is the major employer to people from around the neighbouring nations [23]. It has the highest population density than other states in the country, and the current population is about 1.78 million [7]. Penang is also a World Heritage site which attracts tourists from all over the world. Penang Island's urban modes of transportation include land, air, and water [23].

The current urban transport problems in Penang include the rapid growth in personal car ownership and usage, high dependency on private vehicle, less usage of public transport, increase in traffic congestion, high rate of traffic accidents, insufficient facilities for non-motor users, and impacts on the environment [23] [5] [6].

The requirement and problems of pedestrians, cyclists and bus users are rarely taken into account in domestic and state transport plans and policies [23]. Mobility-impaired and vulnerable groups such as disabled individuals and the elderly, as well as vulnerable groups such as kids and the poor, are almost always overlooked.

Considering the effects discussed in Section 2, the Penang State Government have established a plan called the Penang Transport Master Plan (PTMP), which aims to build an integrated transport system for the city by 2030. PTMP will include ferry, roads, rail, sky, cab and tram networks. The scope of this plan is to mitigate congestion problems, to improve livability and to enhance accessibility for moving people so that they can avail alternate modes of integrated transport [24] [25].

### 4. Qualitative research method

This paper analyses sustainable transportation projects in Penang. The data is collected in two stages. In the first stage, secondary information is obtained from various sources of available literature, such as academic journal articles, textbooks, and reports to form a frame for the research. The second stage involves collecting primary data through semi-structured interview method. In total there are five interviews with stakeholders from state government (R1), city council (R2), expert in transportation studies (R3), and two end-users of public transportation (R4 and R5).

### 5. Initial Finding Analysis and Synthesis

The purpose of the study is to explore sustainable transportation development in Penang from the perspectives of the stakeholders. Table 4 summarises the findings and is followed by a more in-depth analysis.

**Table 4.** Summary of Findings

Objective	Summary
The performance level of the transportation system in Penang	Management of demand and capacity for vehicles and roads is crucial, which is not focused and results in adverse effects on traffic flow.
Driving force for Penangites to use public transport	Education, changing current policies, taxes and providing efficient, affordable and accessible public transportation.
Robust sustainable transportation model in Penang	State government PTMP plans are on track to build a robust transportation system for Penang. For a transportation model to be sustainable, high investments plan is not always necessary.

The existing transportation system in Penang includes taxi, Rapid bus, Rapid ferry and air mode for domestic and international travels [18]. All interviewees concur that the most used public transport is the bus, i.e. Rapid Penang. It provides affordable tickets and has multiple bus-stops covering the significant areas in Penang from Bayan Lepas to Komtar. The interviewees prefer to drive rather than taking the ferry as the ferry takes longer time. The reason behind this excessive commute time to reach

the ferry docks is congestion in the city. Additionally, the buses have no special provision or lanes to boost the commute time on the main highways and adjoining roads. Congestion affects every citizen due to the weak public transportation or mass transportation system. Furthermore, congestion also occurs due to private vehicle dependency. To boost the Malaysian economy, the Government subsidizes the price of petrol and encourages people to buy Malaysian made private vehicle by keeping the costs low with low or zero percent and easy vehicle loans.

The primary responsibility of public transportation is to relieve the country from cars as their leading cause of traffic congestion [26]. If public transportation is effective, accessible, efficient, scheduled, and maintained, then people will choose public transport more than their private vehicles. While about 8% of the population use public transportation, R1 expects the new transport plan will increase the number to 40% by 2030. The expected increase is, according to R1 and R3, due to people's perception of buses (negative) as compared to rail (positive).

Motivating and encouraging public through education about the benefits of using public transports, campaigns for awareness of public transport with zonal management might convert users from private to public transportation. Other methods include enforcing strict policies and regulations in road usage and pricing of cars to discourage people from using their private vehicles [27] [28].

Additionally, the city can also be sustainable by embracing the key challenges and goals through minor changes such as improving the existing bus service, controlling congestion, soft teachings, or exerting pressure on the public to shift towards public transportation [29]. These changes do not require huge investments for new projects.

Consequently, the existing transportation system is not performing at the level where it can manage the demand and provide capacity for the. Investments in projects now will have impacts on the future which will boost the economy by creating green jobs, improving energy security, reducing congestion and health costs, as well as increasing other economic benefits [30].

The findings clearly show that the Government plays a central role in making or reforming policies for the projects in the city. PTMP has many benefits for the future but is facing financial problems due to poor planning. Planning is the first stage for any system considering transportation is always changing and must continually adapt to cater the changing needs [13].

## **6. Recommendations**

There are various ways which can help the development of Penang's current transportation system. The recommendations can be divided into two categories: short term solutions and long-term solutions.

### *6.1. Long-Term solutions*

#### *6.1.1 An alternative mode of public transport*

Penang needs an alternative mode of public transportation as a central mass transportation system since many people have an aversion of using buses for their daily commute. A different mode, such as the Light Rail Transit (LRT) can serve as the city's public transportation. Light rail provides more extensive accessibility, numerous stations and can reach the city centre faster and is also practical in small cities [31]. LRT can be a backbone for the entire transportation in Penang.

#### *6.1.2 Taxation and Pricing Policies*

Taxation and pricing policies can be adopted as a forcing method which includes congestion-free pricing, congestion-free areas, parking charges, fuel taxes and pollution taxes [13]. All the categories mainly deal with strict actions to be used by the government to push people towards public transportation. Stringent measures includes charging a fee for road usage, making reforms in congestion prone areas, increasing the parking charges which in turn increases the cost of overall trip, raising the fuel taxes, and vehicle emissions pollution fines.

### 6.1.3 Integrated Planning

The new designs of the plans must consider pedestrians, cyclists, and mobility-impaired persons. Different speed lanes, private lanes for bus, and bus stop at 10 -15 minutes walking distance and green lanes for cyclists in the heritage area must be considered in the designs [5] [23]. Additionally, projects must also integrate different modes of transport including LRT, feeder bus, and congestion alleviation bus [21].

### 6.1.4 Travel demand management

Study shows that if the capacity of roads is increased than the demand, i.e. people's needs, the demand (people with private vehicles) reaches and exceeds the capacity in some considerable amount of time where strategic demand management is necessary to build new policies and planning [13]. Building more highways is not a solution as this will encourage people to buy a car or use their vehicles [16] [17] [R3]. Carpooling, car-sharing, free buses, transit vouchers and vehicle replacement are some essential solutions which can help the travel demand management [13]. By increasing taxation and fines, the authorities can provide public transport transit vouchers for the difference in increased cost and encourage people to use public transport.

## 6.2 Short-Term Solutions

### 6.2.1 Education for Change

Education for change is necessary to achieve the targets for sustainable development. Education on the environment and climate change must be introduced in schools, offices, and clubs. The information can also through brochures, televisions, social media, and specialised workshops. The merits of bicycles, ridesharing, usage of public transport and transport subsidies must be included in the education syllabus [13] [5] [23]. The main intention of stakeholder engagement is to educate the stakeholders about developments and megaprojects and their benefits to society [32]. Disputes based on falsification or rumours can be resolved by educating stakeholders.

### 6.2.2 Changes in Regulatory restrictions

One way to reduce the congestion problem is regulatory restrictions. Regulatory limits on cars usage effectively address the congestion problem. Restrictions such as odd-even rule where only odd number car will be allowed on the road on only odd days of the calendar and even number car will be on even dates of the calendar reduce the vehicle population on the road significantly [31]. Similarly, the system of "three in one" as used in Jakarta, can be implemented in Penang. The system requires a car to have a minimum of three persons during peak hours. However, the three-in-one system failed in Jakarta and therefore, has been changed to the odd-even system [33].

### 6.2.3 Integrating Technology

Intelligent transport systems (ITS), E-hailing, smart mobile applications and alternative fuels are some technologies which can be combined with the current system to address the environment and congestion problems faced by the current transportation in Penang. In the short term, ITS can help improve mitigation measures by analysing the traffic at specific times of the day. Additionally, ITS can also control the transportation system in the long term by using its advance technologies of controlling, regulation, monitoring live transportation, monitoring emissions from vehicles and various other applications [34]. Intelligent transport systems involve constant communication of the vehicle, roads and information processing systems [35] [36]. ITS uses sensors, the internet, control systems and informative feedback for the driver. ITS has been used in major developed cities such as London, Singapore, and New York. ITS technology helps in advance traffic management system, advance vehicle information system, advanced vehicle control systems [37]. The main application which is needed in Penang is the Advanced Public Transportation Systems (APTS). The APTS uses advanced technologies to improve the 'attractiveness' and 'economics' of public transit operations [38]. These technologies help both vehicles and drivers in coordinating operations such as maintaining the speed limit, tracking of low traffic areas, etc. E-hailing taxi is currently in public demand because of the convenience and limitations on parking space [39] [40]. But an increase in the number of taxi can again lead to congestion. Therefore, control over the taxi service is also essential. Moreover, the



service offered must mainly be a carpooling system so that it gives the benefits of taxi while saving costs and contributing to fewer emissions.

Alternative fuels are one of the best solutions for the reduction in environmental impact and progressing towards sustainability [13] [41] [42] [43]. Using vehicles with compressed natural gas, electric, electric-gas hybrid can help significantly. The government must provide benefits to users of alternative fuel vehicles to promote and encourage more citizens to buy these types of vehicles.

## 7. Conclusion

This study explores sustainable transportation development in Penang from the perspectives of the stakeholders. Sustainable transportation can be achieved if the urban planning and governance work together in the integration of new plans, systems, policies and reforms. Misinformation and miscommunication between the government and the stakeholders result in some resistance to the PTMP. Changing the perception of people about public transport is the key to shift from private vehicles to public transportation. To achieve sustainable transportation goals, another essential factor is the degree of involvement of the stakeholders (Government, consultants, and end-user- public). If all stakeholders work hand-in-hand, rapid progress towards the goals can be accomplished. Further research involving other stakeholders is required to get a holistic view of the proposed reforms.

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