Sustainable Urban Transportation Systems

An Overview

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

CITYNET

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BACKGROUND

As cities are growing in terms of population and physical size, their contributions to national GDP are also increasing due to increased economic activities in urban areas. Now in many countries the contribution of cities to national GDP is 80 percent or more of the total GDP[1]. With this greater role of the urban sector, the demand for urban transportation – passenger and freight has increased many folds in the recent years.

With the growth or urban economies, the living conditions and lifestyles of the city people are also changing. As income of the upper and middle class people in the city is increasing, the ownership of private vehicles is increasing rapidly. For example in Bangkok, the registered motor vehicles rose from 4,163,000 in 1999 to 5,614,294 in 2007 which is a 35 percent increase in only 8 years[2]. The Asian cities which do not have any growth management plan for controlling this rapid increase in personal vehicles are experiencing severe traffic congestion and other problems including air pollution, loss of personal and corporate productivity, high cost of transport and poor quality of life.

Traffic congestion and air pollution have a negative impact on GDP as it imposes a significant cost in terms of both health and productivity. The Executive Secretary of the United Nations Framework Convention on Climate Change, Christiana Figueres, in a statement made at the UN Commission on Sustainable Development on May 2011, noted that in Shanghai 10 percent of the GDP is lost due to traffic congestion while in Bangladesh 1.5 percent of the country's GDP is lost due to traffic congestion[3].

The traditional way of solving traffic congestion is to increase capacity of the road network. However, experience has shown that this solution only works as a temporary fix because developers build new commercial and residential developments where new lanes are added to an existing road network or where new roads are built. Consequently, after a few years, these roads become congested again. Most large cities in Asia have come to a stage where adding lanes or building new roads is not possible anymore due to scarcity of land. In addition, due to the increase in the price of construction materials it has become very expensive for cities to increase the capacity of the existing road network.

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1. UN HABITAT, 2010, *The State of Asian Cities 2010/11*.

2. UNHABITAT, 2008, *Bangkok's Strategy to Tackle Air Pollution, State of the World Cities 2008/2009, Nairobi, Kenya*. Available from www.unhabitat.org/downloads/docs/presskitsowc2008/Bankok%20strategy.pdf (accessed 9 September 2010).

3. Christiana Figueres, Executive Secretary of the United Nations Framework Convention on Climate Change, statement to the UN Commission on Sustainable Development, New York, 2-13 May 2011. Available from http://unfccc.int/files/press/statements/application/pdf/110511_speech_csd.pdf.

Thus, adding lanes to cope with traffic congestion is not a financially feasible option for many cities anymore. Adding capacity is also not environmentally sustainable because as the amount of roads increases, the amount of green space decreases. Building more roads has an adverse environmental impact.

Increasing capacity on the roadway induces an increase in vehicles, which in turn leads to an increase in the rate of accidents[4]. An increase in the rate of accidents is not desirable because apart from the social cost of human pains and sufferings and loss of lives, fatality, injury or property damage, resulting from accidents create a negative impact on the economy. The estimated economic costs of road crashes in Asian countries are about 2-5 percent of their GDP[5].

Although vehicle ownership in Asian cities is increasing, providing additional road space to increase their 'mobility' may benefit only a small percentage of the urban population. In most Asian cities the vast majority of the urban population does not have access to personal vehicles and thus, a vast majority of the population may not benefit much from this approach. The traditional approach of increasing mobility by providing more road space is therefore neither economically productive and environmentally sustainable nor equitable.

In order to meet the transport demand for their ever growing urban population and freight, the Asian cities will have no other choice but to consider developing a sustainable transportation system. Having a sustainable transportation system is not just an option but a necessity for Asian cities to meet the growing demand as well as to maintain the quality of living for the city residents.

4. Tokue Shibata. "Social Costs of Traffic Congestion in Developing Metropolises", Tokyo Keizai University. Available from www.tku.ac.jp/~koho/kiyou/contents/economics/257/079_shibatatokue.pdf (accessed 9 September 2010).

5. UNCRD. *Sixth Regional EST Forum in Asia.* Available from http://www.uncrd.or.jp/env/6th-regional-est-forum/doc/Concept-Note-6th-Regional-EST-Forum.pdf (accessed April 15, 2012).

INTRODUCTION

The World Commission on Environment and Development defines sustainable development as, "Development which meets the needs of the present without compromising the ability of future generations to meet their own needs"[6]. Adopting the above definition of sustainable development, the CAI-Asia defines sustainable transportation as, "…a set of transport activities together with relevant infrastructure that collectively does not leave problems or costs for future generations to solve or bear present builders and users of the system should pay such costs today. These costs are not limited to environmental externalities, but also include social and other economic impacts caused by transportation"[6]. Sustainable transportation provides access to all groups of people in the city in a manner that is within the environmental carrying capacity of the city and is affordable to both the providers and the users of the system. The system has low impact on the environment, encourages transit oriented development, green vehicles, car sharing, fuel-efficient transport systems, and non motorized modes of transportation such as walking and biking. A sustainable transportation system is essential as it is an important aspect of a liveable city, a city that provides a high quality of standard of living.

The concept of sustainability has three main components: social, economic and environment. The goals of sustainable transportation, some of the aspects of sustainable transportation and how they support the three components of sustainability are discussed below.

The development of a sustainable transportation system starts with the organization of urban space. The main objective is to reduce the demand for transportation by reducing the number of trips and the length of travel distance. The organization of urban space helps in reducing the distances between places and people and as a result people travel less to obtain goods and services. Reducing the transportation demand reduces the use of scarce resources and produces less adverse impact on the environment and economy.

The transportation system needs to be integrated and balanced to avoid any 'transportation gaps'. This concept of 'transportation gap' was first introduced by Gabriel Bouladon[8]. Bouladon provided a notion of inherent service capability and compared service capability to demand. For instance, there are places that people travels to, but are too far to walk or too close to drive. In these instances, other types of transportation services should be available that enables the user not to take either of the extreme modes – that is walk or drive. Filling

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6. World Commission on Environment and Development, 1987. Our Common Future, Oxford University press, London.

7. World Resources Institute, *Sustainable Urban Transportation in Asia*. Available from http://pdf.wri.org/sustainable_urban_transport_asia.pdf (accessed 11 September 2010).

8. David Levinson's Networks, Economics and Urban Systems Research Group, *Overview Looking Around*. Available from http://nexus.umn.edu/Books/TTE-Introduction.pdf (accessed on 16 March 2011).

the transportation gaps can help make the transportation system more balanced and integrated and can meet the diverse range of travel needs of different groups.

A sustainable transportation system also requires the provision of a diverse, integrated and balanced public transportation services. The transportation needs of different groups are different due to the distances they need to travel, their trip purpose, income, age, gender, physical ability etc. A wide range of public transit services has a better capability to meet the diverse range of travel needs of different groups. A sustainable transportation system also requires the provision of a public transit system that provides good connections with the major activity areas.

A sustainable transportation system should ensure efficient use of scarce resources. This may be achieved, by promoting fuel-efficient and green vehicles, car sharing and encouraging the use of non motorized transportation. By promoting public transportation and non motorized transportation the transportation system is made more efficient to both the providers and the users. As less people uses personal vehicles, the lower is the level of traffic congestion and demand for new roadways.

Transportation is not just about moving people but it also involves the movement of goods. A recent study shows that 10 to 18 percent of trips in an urban area involve the movement of goods[9]. Freight traffic in urban areas is increasing because of the increase in urban economic activity and growing population in the cities. Even though, about 10 percent of the total traffic is freight traffic, an estimated 40 percent of the pollution caused by the transport sector in an urban area is caused by the urban freight transport. Some of the freight transport is done by using large trucks which have greater turning radius compared to most vehicles in the city. Furthermore, the freight delivery vehicles require considerable time for loading and unloading of goods at different points of the city. In dense part of the cities, all these contribute to traffic congestion.

As it is not a realistic idea to prevent freight transport from entering the city, a sustainable transportation system minimizes the amount of freight traffic in the city as much as possible by improving the efficiency of the freight transport operations through facilities such as consolidation centers or freight villages and through the use of web-based technology and Intelligent Transport System (ITS)[10].

Other than optimizing the use of scarce resources, reducing traffic congestion and air pollution there are other important benefits of a sustainable transportation system. The CIA-Asia Program mentions that there is a direct relation between a sustainable urban

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9. Wisinee Wisetjindawat. “Review of Good Practices in Urban Freight Transportation”, presentation prepared for the EGM Meeting in ESCAP, Bangkok, Thailand, March 2010. Available from ww.unescap.org/ttdw/common/TPT/egm_eco_efficiency/dr_wisinee.pdf.

10. Ibid.

transportation system and poverty reduction[11]. Poverty is still a major issue in many countries in Asia. In the Asia-Pacific region 30-35 percent of the people in the urban areas live in slums[12].

Thus, having a sustainable transportation system for Asia is very important as it will reduce the poverty level in the region bringing economic prosperity to all the citizens. Access to affordable transportation for everyone is a key to improved health, education and social empowerment. Access to affordable transportation for everyone can ensure that everyone is able to get to work at a place of their choices. A sustainable transportation system may also work as a catalyst in the development process. A city with a sustainable transport system can easily attract new businesses and other activities. Thus, the benefits of having a sustainable transportation system is not limited to mitigating traffic congestion and improving air quality only but it also helps to reduce poverty and brings economic prosperity to the city.

From the discussion presented in the above paragraphs, it can be stated that, the main objectives of a sustainable transportation system are to:

(i) Reduce the travel demand, particularly by motorized modes by reducing the number of trips and trip lengths
(ii) Greater use of truly sustainable modes (i.e. walking and other non-motorized transport)
(iii) Efficient use of existing systems and reducing the use of all resources – natural, physical and financial
(iv) Increasing energy efficiency and emission standards of motorized vehicles.

These objectives can be achieved through the following measures:

(i) Organization of urban space – land use planning and finding better solution to meet the needs through action in other areas
(ii) Making services and opportunities accessible by walking and non-motorized transport
(iii) Development of a balanced integrated transport system that ensures efficient travel using multiple modes
(iv) Technological standards (vehicle, fuel, emission etc.) and
(v) Improvement in efficiency of urban freight logistics through organization of freight distribution and delivery facilities and services.

In this paper, the issues in sustainable transportation, areas of actions their importance and the policy, infrastructure and other interventions required to achieve the objectives are discussed. In addition, a set of indicators are suggested to measure the progress of achieving the objectives.

11. Ibid.

12. Ibid.

IMPORTANCE OF INDICATORS

The importance of having a sustainable transportation system and some measures that may be considered to achieve the objectives of a sustainable transportation are discussed in this paper. However, it is not enough just to learn about the importance and approaches to achieve a sustainable transportation system. A mechanism is needed to determine if the transportation system is progressing towards sustainability. The main objective of this paper is to suggest a set of indicators to assess progress in development of a sustainable urban transportation system. The suggested indicators may serve many other purposes including:

(i) benchmarking
(ii) monitoring progress towards sustainable development over time
(iii) comparing between cities
(iv) evaluating effectiveness of policies and actions.

INDICATORS TO ASSESS PROGRESS IN DEVELOPMENT OF SUSTAINABLE URBAN TRANSPORTATION SYSTEM

To achieve a sustainable transportation system, it is important that sustainable transportation is comprehensively mentioned in the transportation planning. In addition, there must be an institutional mechanism to implement the sustainable transportation system. Urban land use and transportation planning is integrated which is why organization of urban land use greatly impacts the sustainability of a transportation system. One of the goals of sustainable transportation is to enhance the public transit system and to reduce the usage of personal vehicles. This is why transit system and usage of personal vehicle are important aspects of sustainable urban transportation system. Safety and security is also essential for a transportation system as accidents have socio-economic impact. Transportation is not only about moving people but it also involves the movement of goods which is why freight transport is another area of sustainable transportation. Transportation is one of the major emitters of CO_2 and other Green House Gas (GHG). As a result, environment is another area of sustainable transportation.

Based on the previous paragraph, seven areas are identified for this study that are key to the development of a sustainable urban transportation system. Each of these areas has several subareas. The framework in Figure 1 provides these areas and the subareas. This section discusses the issues and importance of these areas, the objective, some suggested actions and policy considerations required to promote sustainable transport development and the indicators to measure the progress in development. This structure is important as any entity interested in sustainable urban transportation system will be able to identify the issues and importance of each areas of sustainable transportation. Then they will be able to learn about the objectives of that particular area of sustainable transportation. After that they will also get an overview of some suggested actions and policy considerations to meet the objectives. Finally, they will also be able to determine if the suggested actions and policy considerations are helping to reach the objectives by the indicators that are provided. The suggested indicators were developed considering the following:

(i) definition of sustainability
(ii) the objectives of sustainable transportation development as discussed in the previous section and
(iii) the good examples of sustainable transportation development from cities around the world.

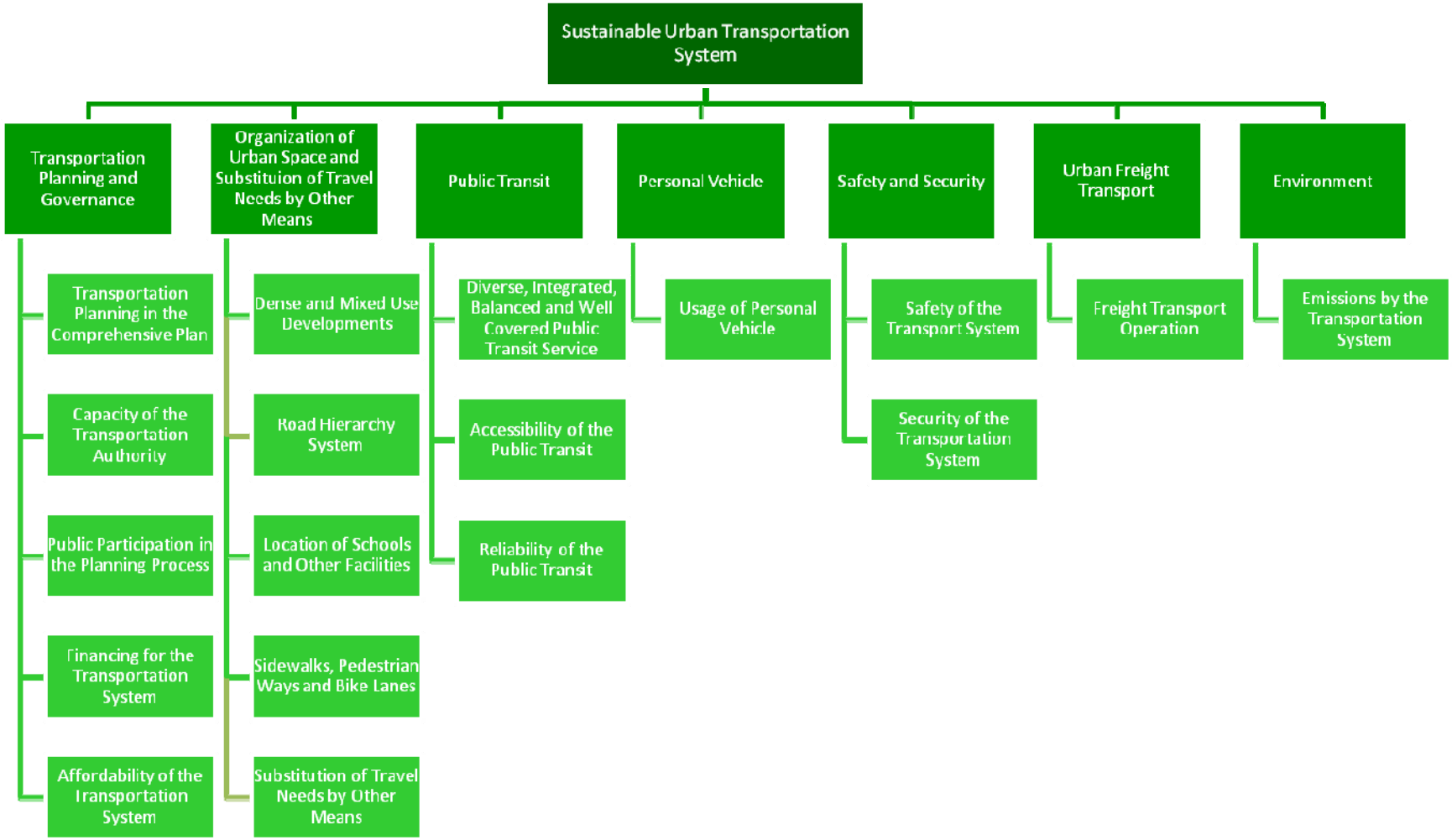

Figure 1 Areas and Subareas of Sustainable Urban Transportation System

TRANSPORTATION PLANNING AND GOVERNANCE

Transportation Planning in the Comprehensive Plan

Issues and Importance

A comprehensive plan is a long term plan which outlines the vision, goals and objectives and the approaches that a city can take to have that vision come true. As transportation service is a key component related to quality of life, it is not possible to improve the quality of life without improving the transportation system. The comprehensive plan should consider transportation planning adequately. It should mention the direction in which the transportation system should be developed. It should identify the future transportation demands and based on that consider sustainable transportation development plans (short-term, medium-term and long-term) that the city may implement to meet those demands.

If transportation planning is not well covered in the comprehensive plan then it generally means that the city has no concrete plans for the transportation system and that in the long run the transportation system will most likely be developed without any overall guiding direction.

Objective

Transportation planning in the comprehensive plan indicates the goals, objectives and approaches to develop a sustainable transportation system.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Identification of future transportation demands of the city using demographic and other economic and social data on a regular basis
- Provisions to include sustainable transportation development in the comprehensive plan such as public transit, network of pedestrian sidewalk and bike lanes

Indicators

The suggested indicators are:

- Adequate consideration of future strategic directions of transportation development in the comprehensive plan
- Sustainable transportation development plans, policies and projects exist in the comprehensive plan

Capacity of the Transport Authority

Issues and Importance

The transportation authority should have the necessary capacity and resources to estimate the present and future transportation demands, and consider the appropriate policy decisions that may be taken to meet the existing and future demands. It is also important that their actions

meet the expectations of the people. Often, the transportation authorities do not have qualified staff with the required experience and expertise that are capable of assessing the transportation demands and needs of the people and consider alternative policy actions and their suitability.

There is also a need that there is an institutional mechanism for collaboration and cooperation with other agencies involved in city development including the relevant agencies of the national government.

Objective

The transportation authority has the necessary number of qualified professionals who have the experience and expertise to provide a quality and safe transportation system that meets the transportation needs of all users.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Availability of the required number of professional and other staff

Indicator

The suggested indicators are:

- The number of qualified personnel required to run the transportation system and the existing number of qualified personnel in the transportation system

Public Participation in the Planning Process

Issues and Importance

Since planners have the professional background and experience in planning, there is often a belief that they would be able to consider and decide the best option that can meet people's real needs and satisfy them. However, even though a planner has the experience in planning, it is not possible for them to know the specific transport needs of a locality. This is why public participation is very important in any type of planning process as it increases the likelihoods that actions that are taken or services that are provided by public agencies more adequately reflect the needs of the general public[13].

There are three main reasons of public participation. First, the involvement of all stakeholders including the general public is needed to bring qualitative improvement in planning and decision-making. Second, public participation in planning can deal with the various issues of cross-cutting nature. Third, the main element of any transport system is its users. Involving the public in the decision making process provides a better chance of determining the needs

13. United Nations Economic and Social Commission for Asia and the Pacific, *A Guide to the Application of Public Participation in Planning and Policy Formulation Towards Sustainable Transport*. Available from http://www.unescap.org/ttdw/publications/TPTS_pubs/pub_2308/pub_2308.pdf (accessed 25 May 2012)

of the general public especially the disadvantaged group. If these groups are not involved then an important of social equity may remain ignored[14].

Benefits of Public Participation

The benefits of public participation have made public participation a part of the planning process. In some countries it is even required by law. A study by TRANSPLUS identifies the following benefits of active public participation:

- Clearer identification of problems
- Improving the quality of the resulting plans
- Developing a common basis for action program
- Raising awareness and encouraging changes in behavior
- Overcoming conflicts and streamlining implementation
- Initiating social empowerment of participants[15]

Objective

Presence of a participatory approach in the planning process using a bottom up approach where every participant's perspective is given due importance.

Actions and Policy Interventions

The suggested actions and policy considerations are:

- Train professional staff in participating approaches to planning and development
- Training professional staff in undertaking public participation and consultation
- Include stakeholder participation in the planning process
- Establish a mechanism for public participation
- Set up an institutional mechanism for consultation with all relevant agencies

Indicators

The suggested indicators are:

- Recognition and practice of public participation in the planning and service delivery process
- Availability of trained man power in participatory approach to planning and development

14. Ibid.
15. Knowledge on Sustainable Urban Land Use and Transport, University of Leeds, *Participation*. Available from http://www.konsult.leeds.ac.uk/public/level1/sec05/index.htm (accessed on 25 May 2012).

- Existing institutional mechanism for public participation and consultation

Financing for the Transportation System

Issues and Importance

Funding is a key issue for the development of a transport system for an urban city of the developing country. A city needs adequate funding to develop, operate and maintain the transport system and to implement future projects. Traditionally, budgetary resources are the main source of funding for transport development. Often, the required amount of funding is not available for the development of public transit systems, provision of adequate infrastructure facilities and/or upgrading of existing facilities. Resources are also required for the maintenance of facilities. In the absence of adequate funding from traditional sources, there is a need to mobilize additional resources from available alternatives.

Objective

Availability of funds to upgrade and replace existing transport systems and to implement future transportation projects to meet the present and future transportation demands.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Consider capturing of land/rental value appreciation due to major transportation projects
- Consider alternative funding sources such as increasing the fuel/gas tax, vehicle registration fee, increase the road fees (toll price) or selling bonds if existing funding is not sufficient to meet the needs
- Implement public transportation projects using cross-subsidy from other urban development projects
- Involve the private sector in the delivery of transport services at a greater scale
- Consider sustainable transport development projects through funding from various low-carbon development financing mechanism (LCDF, GEF, CTF etc.)

Indicators

The suggested indicators are:

- Percentage of funding needs that are met
- Availability funding from the private sector
- Innovative funding mechanism including low-carbon financing mechanism are used
- Availability of funding support from the national government

Affordability of the Transportation Services

Issues and Importance

For people to be able to use the transport system to meet other people and get access to goods employment and services, the transport services have to be affordable to the people. The affordability of the transport users is very important for the success and sustainability of a transportation system.

The Mesquite Group, whose purpose is to help people understand and manage personal finances, suggests that the ideal budget for transportation for a person is 15 percent of that person's total income[16]. To make the transport system economically viable and socially inclusive, the city has to determine what the city can afford to construct and operate and what the public can afford to pay for the services. The city also has to determine how much of the total income people are spending on transportation. If people are required to spend more than 15 – 20 percent of their total income on transportation then, using the transport service may become a burden for people, which would then adversely affect their welfare.

Objectives

The percentage of total income that people spent on using the transport system should be less than 15 – 20 percent; the cost of travel using a public transit should be much lower than the cost of using a personal transport.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Consider various options for improving the efficiency of public transport operations and other means so that the cost of using a public transport service is much lower than using a private transport
- Regulate pricing of transport services
- Apply innovative pricing of transport services to increase public transport patronage
- Consider providing subsidy to groups of people with special needs
- Consider increasing the cost of using personal vehicle by increasing the gas/fuel tax, parking fee, toll prices etc.

16. The Mesquite Group. "Dedicated to helping you survive and thrive in today's difficult financial climate", 2010. Available from http://www.themesquitegroup.org/MG/MesquiteGroup.nsf/byid/Home.html (accessed on February 24, 2012)

Indicators

The suggested indicators are:

- Percentage of income that people spend on transportation
- Cost of travel by using public transit (cost/ km)
- Cost of public transit compared to cost of public transit with comparable cities (percentage of cost of the public transit of the comparable cities)

ORGANIZATION OF URBAN SPACE AND SUBSTITUTION OF TRAVEL NEEDS BY OTHER MEANS

Dense and Mixed Use Developments

Figure 2 Mixed Use Development in Shanghai

Figure 3 Dense Development in Singapore

Issues and Importance

One of the major goals of sustainable transport is to reduce the travel demand, particularly by motorized modes through the reduction of number of trips and trip lengths. The way developments are organized in a city impacts the trip lengths and number of trips that the city dwellers need to make to get access to people, goods, opportunities and services. Organization of the urban space can greatly help in travel demand management.

The trip lengths and number of trips in a dispersed sprawled city with low density development and with no spatial growth boundary will be much higher than in a city that is dense, has mixed use developments and some form of a spatial growth boundary. In the first type of development, city dwellers will greatly depend on their personal vehicles for mobility while in the latter type of development city dwellers may not need to depend on their personal vehicle so much as most of the destinations may be made accessible by walking or other non-motorized modes. To a great extent, the mobility needs can be satisfied by non-motorized transport in this type of dense and mixed use developments.

Even if for some reason one decides to drive, it will still reduce the per capita distance traveled by vehicle. Dense developments can increase the transit ridership making the transit systems more viable. In addition, dense developments make it easier for public transit service providers to increase the percentage of people that they are able to serve. Dense and mixed

use developments also increase the chance of chaining trips of different purposes. This also reduces the total amount of travel per capita.

Dense developments and mixed use developments are key to designing livable communities. Livable communities improve the quality of life because people walk and bike more making them healthy. It decreases total vehicle traveled miles, decreasing traffic congestion and air pollution. It decreases the amount of time people spend for travelling to go to work or other purposes. People can spend the saved time with their family or for recreation purposes. People are able to socialize with their neighbors more and help one another. This makes the city more vibrant and increases the social unity among residents.

Objective

Land use planning policies promote dense and mixed use developments.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Develop a zoning map to increase the area for dense and mixed use developments and to reduce the number of low density development in the city
- Outline a spatial growth boundary of the city to prevent the city from sprawling and getting dispersed
- Provide incentives to developers for developing dense and mixed use developments
- Increase property tax for low density developments to discourage people from living in such developments
- Conduct campaigns through mass media and social media to demonstrate the benefits of living in dense and mixed use developments
- Provide facilities and amenities in mixed-use development to make the areas more attractive compared with low-density zone marked areas

Indicators

The suggested indicators are:

- Existence of policies to promote high density mixed use land developments
- Density of development (persons/hectare)
- Percentage of area designated for dense and mixed use developments

Road Hierarchy System

Issues and Importance

The major functions of urban roads are to provide access, circulation of local and through traffic, and environmental improvement. It is not necessary for a particular road to perform

all these functions. Depending on the purpose a road will serve, roads have a hierarchy system (i.e. neighborhood roads, collector roads, arterial). For example, some types of roads are used for accessibility such as neighborhood roads but some roads are used for mobility such as arterials or freeways. In order to make roads safe and efficient, roads should be designed considering their main function and classification in a hierarchy of road systems. Thus, before designing a roadway, planners and engineers have to first determine the purpose that the roadway will serve and based on that design the roadway.

Objective

Provide the required amount of roads and the required type of road to maintain an acceptable level of service on the road considering the travel demand, mode of travel, density of development and classification of roads.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Consider establishing a hierarchy of road system and classify roads accordingly
- Redesign, modify the existing roads, as necessary, according to their respective category
- Ensure that roads are serving the purpose that it was originally supposed to serve by eliminating conflicting demands of road uses as much as possible
- Provide street furniture and lighting according to classification category of roads

Indicators

The suggested indicators are:

- Level of service of the roads
- Classification of roads according to its main purpose
- Roads function according to their classification category
- Absence of through traffic on residential and minor roads

Location of Schools and other Facilities

Issues and Importance

In the peak hours, school trips constitute a major part of all trips[17]. Although, the number of school trips cannot be reduced, the school trip lengths and the number of school trips made by motorized modes can be reduced through proper spatial distributions of schools throughout the city. Adequate number of primary schools, however, should be located within

17. Grace Corpus, "Analysis of Peak Hour Travel Using the Sydney Household Travel Survey Data" in *29th Australasian Transport Research Forum.*

each locality.

If each residential area of a city provides quality primary schools that are able to serve the school going children in that area and if the policy is such that children are only allowed to attend schools in their own locality, then the school trips will be distributed evenly throughout the city without causing less pressure on the city's main transportation system. Students of higher classes may however attend schools at other parts of the city.

Similar to providing schools in each locality, each locality can also provide shops and other facilities that serve common necessities such as convenience stores, pharmacy, clinics, barber shops, post office, banks etc. This will on one hand reduce the use of personal vehicles or other motorized transport and on the other hand make the lives of the residents much easier by reducing their travel time to do small yet important daily chores.

Benefits of Neighborhood Schools

A study conducted by the Environmental Protection Agency, USA examined the transport mode share for a school centrally located surrounded by development and for a school located at the edge of an urbanized area amidst undeveloped land. The findings conclude that the school centrally located had 85 percent of the students using auto to commute to school while the school surrounded by undeveloped land had 100 percent of the students using auto to commute to school. This study also determined that neighborhood schools would produce a 13 percent increase in walking and biking and a reduction of at least 15 percent in emissions[18].

Objective

Children are attending schools in their own locality and that each locality has the necessary shops and facilities that serve the daily and common necessities.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Provide quality public schools in each locality that has the capacity to serve the school goers in each locality
- Maintain the quality and a common standard for the schools so that parents are comfortable in sending their children to schools in their locality
- Formulate policies that permits parent to send children to public schools in their locality only
- Provide shops and facilities that serve daily necessities of the people in each locality

18. United States Environmental Protection Agency, *Travel and Environmental Implications of School Siting*. Available from http://www.epa.gov/dced/pdf/school_travel.pdf (accessed May 26, 2012).

Indicators

The suggested indicators are:

- Average distance to primary and high schools
- Percentage of children attending schools in their own localities
- Percentage of children walking or using non-motorized transport to go to school
- Percentage of people walking or using non-motorized transport to access daily necessities and service delivery points

Sidewalks, Pedestrian Ways and Bike Lanes

Issues and Importance

One of the major goals of a sustainable transportation system is to reduce the number of trips and trip lengths by motorized modes. Dense and mixed use developments alone may not increase the use of non-motorized transport if there are no good sidewalks or bikeways to walk or bike. In addition to dense and mixed use developments, safe and comfortable infrastructure and facilities such as sidewalk, pedestrian ways and bike lanes/paths for walking and other types of non-motorized transport would be required to increase walking and non-motorized trips.

Vehicle friendly cities are designed by providing priority to vehicles. Safety of pedestrians and people in non-motorized modes are hardly considered in such types of cities. This discourages people to walk or bike. For safety reasons people are forced to use personal vehicles. To reduce the number of trips made by personal vehicles, cities should be designed by focusing on designing the urban space for people rather than for vehicles. Transport infrastructure and facility should be designed by considering the people rather than vehicles. This will encourage people to walk and use other non-motorized modes of transport, reducing the number of trips made my personal motorized vehicles.

Objectives

Increase the share of walking and other non-motorized modes of transport.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Provide continuous and interconnected sidewalks and bike lanes accessible by everyone by designing it using the universal access design
- Separate sidewalks from the roadway using barrier, on street parking or by landscaping between the sidewalk and the roadway to increase the safety of pedestrians
- Ensure safety of pedestrians at intersections through clearly marked crosswalks, foot over bridges or underpasses
- Relocate vendors from pedestrian areas to alternative locations

- Provide traffic signs and markings using the proper standards and guidelines
- Provide lighting at the sidewalks to ensure safety of pedestrians in the dark
- Provide pedestrian signals to increase the safety of pedestrians at the crosswalk
- Separate bike lanes from the vehicle lanes using a barrier to increase safety of bikers
- Provision of covered walkway and planting trees along with sidewalks and walkways and provide street furniture and fixtures to make them aesthetically pleasing and attractive to use
- Build trails through parks to improve the experience of pedestrians and bikers
- Provide safe bike stands at major activity areas

Figure 4 Sidewalk Separated from the Roadway by Landscaping in Singapore

Figure 5 Barrier Separated Bike Lane in South Korea

Indicators

The suggested indicators are:

- Length of walk ways
- Level of service on sidewalks in major activity areas
- Share of walking and other non-motorized transport
- Quality and aesthetic appeal of sidewalk and walkway pavement and furniture
- Share of walking and other non-motorized transport
- Connectivity between major activity areas through sidewalks and pedestrian ways
- Connectivity between important locations through bike lanes and bike paths
- Availability of safe bike stands

Substitution of Travel Needs by Other Means

Issues and Importance

Travel is a derived demand and as such the need for travel to some extent can be substituted by other means. The application of information and communication technologies can play a major role in this respect. In fact such applications have already reduced the necessity of urban travel to some extent. Greater use of the internet service in providing many public services can reduce the need for travel to an office to get that service. The public and private sector can make use of e-governance and e-commerce to deliver many services and thereby reduce the need for travel to get those services.

Objectives

Reduce travel demand through the use of information and communication technologies.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Formulate public policies on greater use of e-governance and e-commerce modulation for the delivery of public and private services
- Encourage services providers to deliver services taking the advantage of ICTs as much as possible
- Generate awareness among people for greater use of e-governance and e-commerce facilities
- Encourage policies on tele-commuting and work-from-home policies as applicable

Indicators

The suggested indicators are:

- Proportion of work force on tele-commuting and work-from-home scheme
- Usage indices of e-governance and e-commerce
- Number of service that are available through the internet and other means that do not require any actual travel
- Usage of shopping parcel delivery services

PUBLIC TRANSIT

Diverse, Integrated, Balanced and Well Coverage Public Transit Service

Issues and Importance

The availability of a wide variety of public transit services is a major element of developing a sustainable transport system. Public transit is more efficient compared to private transport in terms of energy and road space use, user cost and emission production. Most of the urban

passenger travel needs can be efficiently provided by public transit services. However, the travel demand of the citizens varies based on their income, trip purpose and the distance they need to travel. Thus, just by having one type of public transit service is not sufficient as it cannot serve the transport needs of everyone and for all purposes.

A balanced public transit system is important to satisfy different types of transport demands. To ensure a balanced public transit, cities can have commuter and other rail-based services to serve people who are travelling long distances, and have a variety of bus and other paratransit services to serve people who are travelling shorter distances, have lower income or have special requirements. The provision of appropriate types, availability and frequency of services by different public transit modes is important to develop a balanced system.

In addition, to making the transit services diverse and balanced, it also has to be integrated at three levels: operational, physical and institutional system. Operational integration involves the coordination of routes, schedules and frequencies. Physical integration occurs by making transfers among transit systems more efficient. Institutional integration has different aspects. One common aspect involves the use of a common fare ticketing system, and the provisions of discounts or free transfers between different transit modes. Integration improves the efficiency from a user's perspective as it reduces the time they need to spend to transfer between modes and make the transfer more convenient and safe. Integration also allows for a better route planning, as services could be optimized reducing the cost of operation of the system. Transit system integration however, is not common in developing cities because of lack of coordination among the different transport service providers due to institutional, legal and financial barriers.

The coverage of the public transit should extend to as many parts of the city and serve as many users as possible. A diverse, balanced and integrated system that has well coverage across the city has the capacity to maximize the number of users of the transit system.

Objective

Development of a diverse, balanced, integrated public transit that has a well coverage to provide service to as many areas and people as practically possible.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Implement a diverse, integrated and balanced public transit system that meets the transportation needs of everyone in the city
- Improve the coordination among the transit service operators to integrate the public transit system in terms of physical, operational and ticketing system
- Build the necessary infrastructure and facilities to extend the coverage of the transport system in the city

- Provide incentives to transit service operators for offering services on the not so profitable routes provide
- Give priority to road based public transit modes to other modes especially cars
- Make major activity centers and work places easily accessible by public transit

Indicators
The suggested indicators are:

- Modal share of public transit (by different types of services)
- Integration of public transit services
- Existence of a common ticketing system
- Percentage of city covered by public transit service
- Percentage of population covered by public transit service

Quality of the Public Transit

Issues and Importance

The quality of service is the most important aspect of public transit to attract people. It depends on:

(i) reliability of the public transit
(ii) the time that it will take a person to go to one place using public transit compared with personal vehicles or mother modes of transport
(iii) availability of seats, the number of people inside the bus or train per unit area, the design of the seats and facilities for the standees, the cleanliness, temperature and also the air quality inside the public transit

On time performance is one of the factors that determines the reliability of a public transit. On time performance of a public transit during the peak hours especially during the morning peak hours when people go to work is very important. If the train or bus does not arrive at the stations at the scheduled arrival time then passengers will consider using other alternatives including personal vehicles.

Poor reliability has adverse effect on passenger waiting time and load factor and as such is a major determinant of the quality of public transit service. Poor reliability results from: (i) uneven headway due to irregular dispatch (ii) en-route traffic congestion (iii) lack of consciousness of the drivers to maintain the schedule.

'Bunching' is the symptom of an irregular service. Poor reliability occurs when two or more buses of same route travelling at headways less than what is planned.

Objective

The quality of transit services is satisfactory to users and comparable to alternative modes of travel.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Journey time and the level of service by public transit modes are comparable to alternative modes of travel
- Consult of the transit operator with the city before making changes to the transit routes and schedule
- Improve the quality of transit services to meet the expectation of the majority riders
- Provide incentives to the public transit operators for operating a reliable service of choice to riders
- Penalize or disqualify the transit operators from operating the service if they fail to provide a reliable and quality service on a regular basis

Indicators

The suggested indicators are:

- On-time performance
- Excess waiting time (proportion of passengers subject to longer than average waiting time)
- On-board level of service (load factor, availability of seats, low-floor/level platform boarding)
- Cost of service
- Environmental condition (clean vehicle, air condition etc.)

Accessibility of the Public Transit

Issues and Importance

Accessibility of a public transit depends on the distance to transit station/stop, the ease of accessing or boarding the transit and the waiting time to access or board the public transit. In terms of distance to access the public transit, the transit stop/station should be within the distance that people are willing to walk. A research conducted by Victoria Transport Policy Institute (VTPI) found that people were willing to walk a quarter mile to a bus stop and half a mile to a train stop[19]. However, there are other factors that may impact the distances that transit rider would be willing to walk.

One of the factors that may impact the distances that people are willing to walk is whether the transit rider is a captive rider or a choice rider. Captive riders will generally walk further than

19. Todd Litman, *Land Use Impacts on Transport* (Victoria Transport Policy Institute, 2010). Available from www.vtpi.org/landtravel.pdf.

choice riders. To attract a choice rider the distance to a transit stop has to be within limit such as suggested by VTPI.

Another factor that may impact the distances people are willing to walk to access transit stops are the walking conditions to the transit stops. There has to be good connectivity to the transit stops from residential or commercial developments through proper sidewalks (i.e. without obstructions) and crosswalks that offers safe and secure walking conditions and attractive landscaping.

A public transit system should provide universal access in terms of boarding and riding the transit to ensure that everyone especially people with special needs are able to board the transit easily and safely. Universal access design standards and guidelines should be followed while designing the transit stops and the transit systems.

Objective

The public transit should be easily accessible and provide access to everyone in terms of boarding and riding the transit system.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Determine of activity areas that requires public transit stops and review the existing location of existing stops
- Follow the universal access design standards while designing the transit system (i.e. transit stops, transit vehicles)
- Follow the universal access design and guidelines while designing the infrastructure facilities that connect between major activity areas and transit stops

Figure 6 Shaded Bus Stop in Shanghai

Indicators

The suggested indicators are:

- The distance people need to walk to access the public transit
- The design of the transit stop, transit system and other infrastructure and facilities related to the public transit
- Quality of access infrastructure

PERSONAL VEHICLE

Usage of Personal Vehicle

Issues and Importance

One of the key elements of a sustainable urban transportation system is to increase the share of non-motorized and public transit modes and to decrease the number of trips by personal vehicles including motorcycles.

A standard size bus (length of a bus is about 10-12 meter) occupies the same amount of space on the road as about two cars (length of a sedan is about 5 meter). However, a bus can carry about 50 – 80 persons. In order to carry the same number of people by car (about 3 people per car), 16-27 cars, occupying about 8 – 14 times more road space than by the bus would be required. Public transit has a lower carbon footprint as the average energy efficiency of public transit modes is higher.

The Vasconcellos Rule

The 6-4.2 rule in Vasconcellos suggests that a standard 45 seat diesel bus with six passengers, occupies per person less road space than a car with an occupancy of 1.5 people; the same bus with four passengers uses less energy per person than a car with an occupancy of 1.5 people; and the same bus with two passengers emits less CO, CO_2 and hydrocarbons, per person than a car with an occupancy of 1.5 people[20].

Objective

Reduce the modal share and trip lengths by personal vehicles.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Traffic demand management policies that can reduce number of trips by personal vehicles such as:
    - Congestion pricing during peak hours to make use of personal vehicles more costly and reduce traffic congestion
    - High Occupancy Vehicle (HOV) lanes during the peak hours to increase personal vehicle occupancy rate
    - Parking policies in the CBD area (number of parking space and parking pricing policies should discourage making a trip by personal vehicle)
    - Restriction on on-street parking that restrict car ownership

20. Eduardo A. Vasconcellos, Urban Transport, Environment and Equity: The Case for Developing Countries, Earthscan, London.

- Promotion of car-pooling for work trips
- Introduction of school bus system
- Raising price of fuel used by cars/personal vehicles

- Vehicle growth management policies

Congestion Pricing in London

Prior to the congestion pricing scheme, it was estimated that in London delays were costing people and businesses £4 million (US $7 million) to £6 million (US $10 million) per week in time and money. The congestion pricing scheme in the city decreased the number of vehicles entering the city by 25 percent and the amount of circulating traffic fell by 15 percent[21].

Indicators

The suggested indicators are:

- Modal share of personal vehicle compared
- Average occupancy rate personal/private vehicles
- Modal share of school trips by personal vehicles
- Number of trips by personal vehicle trips compared to other transport modes
- Trip lengths by personal vehicle compared to other transport modes
- Parking space per 1000 sq. m or per 1000 jobs in the CBD (should be minimum)
- Parking price (should be higher)

SAFETY AND SECURITY

Safety of the Transport System

Issues and Importance

Safety is an important issue of transportation service. Accidents may lead to loss of life, injury or property damage and none of these are acceptable. In addition, accidents also have an economic cost. As mentioned earlier, the economic cost of road crashes including both urban and national in Asian countries are about 2-5 percent of their GDP[22]. For this reason it is important to have a safe transportation service. Safety of a transportation system can be

21. Federal Highway Administration, U.S. Department of Transportation, *International Scan: Reducing Congestion and Funding Transportation Using Road Pricing*. Available from http://international.fhwa.dot.gov/pubs/roadpricing/roadpricing.pdf (accessed May 26, 2012)

22. Ibid.

divided into three areas which are road safety, pedestrian safety and public transport safety.

Total Fatality Number in Developed and Developing Countries

The total fatality number is the number of fatalities per 10,000 vehicles. In motorized countries the total fatality number is around than 2. In USA the total fatality number is 2.0 and in UK it is 1.4 whereas in Bangladesh the total fatality number is 45. The fatality index is the deaths divided by total casualties expressed as a percentage. In Dhaka this is 40 percent which is amongst the highest in the developing countries[23].

The number of road accidents increases as the traffic volume increases. The rapid growth of urban population and number of vehicles in urban areas is becoming a growing concern in many Asian cities.

One of the common types of accidents that are caused by vehicles is vehicle to pedestrian accidents. It is important not only to ensure the safety of vehicular traffic but also to ensure the safety of pedestrians. Basic measures such as taking some low cost treatments can reduce traffic accidents. Some of the things that a city can do to reduce traffic accidents include provision of safe cross-walks and other pedestrian infrastructure, high standards of driver training for public transit drivers, compliance of safe operation procedures, safety audit of road network and dedicated lanes for public transit buses.

Objectives

Reduce the accidents caused by the transportation sector.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Undertake a road safety audit of all major roads and intersections
- Implement policies to design all the roadways, intersections, sidewalks and bike lanes using the road and highway design guidelines
- Provide traffic signs and markings using the proper standards and guidelines
- Enforce the traffic law and penalizing the violators
- Increase awareness of traffic law among the general public especially public transit operators by using the social and mass media Special driver training for public transit systems

23. Hasib Ahsan and Mohammed Hoque. “Traffic Safety in Dhaka City: Key Issues and Countermeasures”, *Journal of Civil Engineering The Institution of Engineers, Bangladesh*, vol. CE 30, No. 1 (2002). Available from www.jce-ieb.org.bd/pdfdown/ce300102.pdf.

- Regular vehicular inspection and maintenance program

Indicators

The suggested indicators are:

- Accident rates (per 100,000 population, per 10,000 vehicles etc.)
- Number of accidents
- Fatality rate (total)
- Accident rates rate by mode of transport and VRUs (Vulnerable road user groups)
- Total fatality number
- Economic cost of crashes as a percentage of the GDP

Security of the Transport System

Issues and Importance

The security of the users of the transport service has to be ensured to make a transportation system sustainable. Security of a transportation system includes security of the people while they are travelling on the road, sidewalks, bike paths and as well as when they are using the transit system. The users of a transport system need to be protected against all sorts of criminal activities, such as mugging, robbing, harassing or other acts.

Although, security is important for all, it is especially important for women, children, elderly and people with special needs because they have higher risks of being the victim. If a city cannot provide security to the transportation users especially to the above mentioned groups, then they may be reluctant to travel, which may affect their well-being.

Objective

Having a transport system that ensures security to all of its users.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Provide sufficient lighting at all roads and sidewalks, walking trails at nighttime and install CCTV cameras at transit stops and at other places which have a poor safety record
- Post security guards and security check points as needed
- Ensure coordination of the law enforcement agencies with the transportation agencies

Indicators

The suggested indicators are:

- Number of criminal incidents (mugging, harassment etc.) while people are using the transportation system
- Number of criminal incidents on public transit services

URBAN FREIGHT TRANSPORT

Freight Transport Operation

Issues and Importance

As mentioned earlier, although only 10 percent urban traffic is related to freight, freight traffic is responsible for 40 percent of the air pollution caused by the transportation sector in the urban areas. As the population of Asian cities are increasing, the consumption of goods and services is increasing, which in turn causing an increase of freight traffic in urban areas. If the freight traffic is not managed properly, the quality of the urban environment will deteriorate due to increased level of congestion, air pollution and the obtrusive nature of freight traffic. Also, freight traffic operations are not often carried out efficiently. The efficiency of freight operations can be significantly improved through consolidation of freight deliveries, reduction of empty haulage and other measures. Consolidation centers allow delivery vehicles to be more fully loaded, serve multiple customers in a single trip, and provide on-time service[24]. Improvements in urban freight logistic operations can reduce freight traffic and trip length and also help to reduce the cost of freight transport.

London Construction Consolidation Center (LCCC)

Consolidation Center was established in London for construction materials. Some of the benefits the traffic and environmental benefits of this consolidation center are:

- 68 percent reduction in construction vehicles for deliveries to sites served by consolidation center
- Better control over sizes of vehicles entering City of London
- About 75 percent reduction of CO_2 emissions for deliveries from consolidation centre to sites
- 120 minutes average reduction in journey time for contractors[25]

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24. Metrolinx, An Agency of the Government of Ontario, *GTHA Urban Freight Study* (2011). Available from http://www.metrolinx.com/en/regionalplanning/goodsmovement/GTHA_UFS_Final_DRAFT.pdf (accessed May 15, 2012)

25. South East Scotland Transport Partnership, *Freight Consolidation Center Study Final Report*. Available from http://www.sestran.gov.uk/uploads/Freight%20Consolidation%20Centre%20Study%20-%20Final%20Report.pdf?phpMyAdmin=36eb3a8adbf8de84465f6d90a254a337 (accessed May 24, 2012)

Objective

Manage the volume of freight traffic in urban areas to reduce its adverse impact on the quality of urban environment and to increase the efficiency of freight operation.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Design standards for large freight vehicle passage routes that meet their safe maneuvering requirements
- Ban large freight vehicles during the daytime in the downtown and other congested areas to prevent traffic congestion
- Design and implement a designated large freight vehicle road network with designated parking and loading/unloading areas
- Establish consolidation centers or freight villages at suitable locations and encourage suppliers to use these centers for consolidation of their deliveries
- Relocate whole-sale centers so that movement of freight vehicles can be easily managed
- Provide incentives to trucking companies to travel in the off peak periods in the city
- Providing incentives to trucking companies to use modern technology such as GPS to improve their efficiency of operation
- Provide incentives to the trucking companies such as tax breaks for operating environmental friendly vehicles

Indicators

The suggested indicators are:

- Freight ton-km per unit of GDP
- Freight ton-km per 10,000 urban people
- Fuel consumption and GHG emission by freight transport
- Distance over which freight is moved
- Proportion of freight traffic that neither have origin or destination in the city through which they are passing

ENVIRONMENT

Emissions by the Transportation Sector

Issues and Importance

Green House Gases (GHGs), suspended particulate matter and lead are some of the major sources of air pollution. The main GHGs are carbon dioxide, methane, nitrous oxide, and fluorocarbons[26]. Of these GHGs, the emission of carbon dioxide is the one that people are usually more concerned about as it is believed to be the main reason for global warming[27].

The sectors that are responsible for CO_2 emissions are power generation and energy, transportation, industry, residential and agriculture. Figure 7 taken from an International Transport Forum (ITF) report demonstrates the shares of CO_2 emissions for different sectors for 1990 and 2007 and also provides the estimated CO_2 taken from an International Transport

Forum (ITF) taken from an International Transport Forum (ITF) report demonstrates the shares of CO_2 emissions for different sectors for 1990 and 2007 and also provides the estimated CO_2 emissions for 2020 and 2030[28].

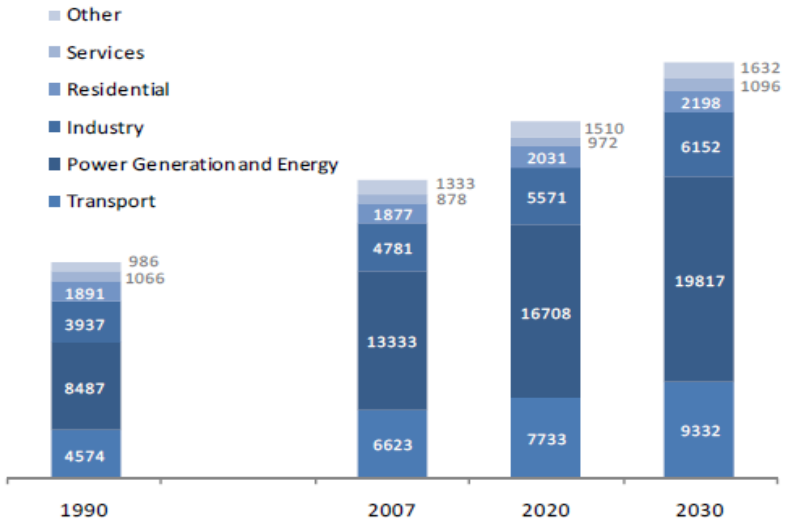

Figure 7 World Energy-related CO_2 Emissions (Mt)

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26. University of Michigan, "Greenhouse Gases and Society". Available from www.umich.edu/~gs265/society/greenhouse.htm (accessed September 11, 2010).

27. Union of Concerned Scientists, "Global Warming FAQ", 14 July 2009. Available from www.ucsusa.org/global_warming/science_and_impacts/science/global-warming-faq.html.

28. International Transport Forum, *Reducing Transport Greenhouse Gas Emissions* (2010). Available from www.internationaltransportforum.org/Pub/pdf/10GHGTrends.pdf.

The above graph demonstrates that in the past, worldwide, the transportation sector was the second largest source of CO_2 emissions and is also projected to remain the second largest source of CO_2 emissions in the future.

For the transportation sector this is even a greater concern as global CO_2 emissions from transport have grown by 45 percent between 1990 and 2007[29]. It is estimated that in 2005, 59 percent of the CO_2 emissions was caused by the combustion of fossil fuel and the transportation sector had a significant share of the global fossil fuel combustion-related CO_2 emissions. Table 1 provided by Timilsina and Shreshtha in their research demonstrates the amount of CO_2 emissions for the year 1980 and 2005 by different sectors in some of the Asian countries[30].

Table 1 suggests that for many countries in Asia the transportation sector is the second largest emitter of CO_2. Since fossil fuel is mainly consumed by transport vehicles, a significant amount of the CO_2 emissions caused by the transportation sector is from the road sector.

The World Health Organization has suggested levels for the green house gases and particulate matter that should be maintained to limit the adverse impact of air pollution on human health.

Table 1 CO_2 Emission Mix by Sector

Country	1980					2005				
	Total	Power	Industry	Transportation	Other	Total	Power	Industry	Transportation	Other
	(Mt of CO2)	(%)	(%)	(%)	(%)	(Mt of CO2)	(%)	(%)	(%)	(%)
Bangladesh	7	21	41	14	24	36	35	29	12	24
China	1,403	20	51	6	23	5,060	48	37	7	9
India	292	26	39	19	16	1,147	52	30	8	10
Indonesia	69	10	39	26	26	341	28	39	22	11
Korea	122	20	32	12	37	449	35	31	19	15
Malaysia	23	32	34	28	6	138	33	35	28	3
Mongolia#	12	48	25	11	16	10	70	8	12	10
Pakistan	26	16	37	25	22	118	30	37	22	11
Philippines	32	27	39	15	18	76	37	19	37	7
Sri Lanka	4	8	22	55	16	12	28	16	45	11
Thailand	34	33	23	28	16	214	30	37	26	7
Vietnam	14	24	36	14	26	80	24	37	25	14

Note: 1985 data are used instead of 1980 for Mongolia. Other includes residential, commercial and agricultural sectors.

29. Ibid.

30. David Greene and others, "Reducing Greenhouse Gas Emissions from U.S. Transportation, (Pew Center on Global Climate Change, 2003). Available from http://www.pewclimate.org/docUploads/ustransp.pdf.

Objective

Reduce the adverse environmental impact caused by the transportation sector.

Actions and Policy Considerations

The suggested actions and policy considerations are:

- Formulate and implement emission standards for all classes of vehicles
- Set targets to reduce air pollution in five, ten and twenty years time from the urban transport sector
- Encourage modal shift to more energy efficient and low-carbon modes

Indicators

The suggested indicators are:

- Aggregate GHG emissions and other air pollutants caused by the transportation sector compared to other sectors
- Composite emission/veh-km
- Percentage of vehicles using environment friendly and renewable energy
- Usage of low-carbon vehicles
- Energy efficiency of vehicles (km/lit)

CONSOLIDATED LIST OF INDICATORS TO ASSESS PROGRESS TOWARDS DEVELOPMENT OF A SUSTAINABLE URBAN TRANSPORTATION SYSTEM

In the above section, objectives of a sustainable urban transportation system, some suggested policy and infrastructure interventions to achieve these objectives and indicators for a sustainable transportation system have been identified. The table below provides a consolidated list of indicators to determine a sustainable urban transportation system by categorizing the indicators in the seven areas of sustainable urban transportation system. In addition, the table provides the objectives and the suggested actions and policy considerations required to achieve the objectives. For some of the indicators the standards that are generally used are also provided.

Table 2 Indicators to Assess Progress Towards Development of a Sustainable Urban Transportation System

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
Transportation Planning and Governance	Transportation Planning in the Comprehensive Plan	-Transportation planning in the comprehensive plan indicates the goals, objectives and approaches to develop a sustainable transportation system	-Identification of future transportation demands of the city using demographic and other economic and social data on a regular basis -Provisions to include sustainable transportation development in the comprehensive plan	-Adequate consideration of future strategic directions of transportation development in the comprehensive plan -Sustainable transportation development plans, policies and projects exist in the comprehensive plan	
	Capacity of the Transport Authority	-The transportation authority has the necessary number of qualified professionals who have the experience and expertise to provide a quality and safe transportation system that meets the transportation needs of all users	- Availability of the required number of professional and other staff	- Number of qualified personnel required to run the transportation system and the existing number of qualified personnel in the transportation system	
	Public Participation in the Planning Process	-Participatory approach in the planning process which gives due importance to every participant's perspective	-Train professional staff in participating approaches to planning and development -Training professional staff in undertaking public participation and consultation -Include stakeholder participation in the planning process -Establish a mechanism for public participation -Set up an institutional mechanism for	-Recognition and practice of public participation in the planning and service delivery process -Availability of trained man power in participatory approach to planning and development -Existing institutional mechanism for public participation and consultation	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			consultation with all relevant agencies		
	Financing for the Transportation System	-Availability of funds to upgrade and replace existing transport systems and to implement future transportation projects to meet the present and future transportation demands	-Consider capturing of land/rental value appreciation due to major transportation projects -Consider alternative funding sources such as increasing the fuel/gas tax, vehicle registration fee, increase the road fees (toll price) or selling bonds if existing funding is not sufficient to meet the needs -Implement public transportation projects using cross-subsidy from other urban development projects -Involve the private sector in the delivery of transport services at a greater scale Consider sustainable transport development projects through funding from various low-carbon development financing mechanism (LCDF, GEF, CTF etc.)	-Percentage of funding needs that are met -Availability funding from the private sector -Innovative funding mechanism including low-carbon financing mechanism are used -Availability of funding support from the national government	
	Affordability of the Transportation Services	-Percentage of total income that people spent on using the transport system should be less than 15 – 20 percent; the cost of travel using a public transit should be much lower than the cost of using a personal	-Consider various options for improving the efficiency of public transport operations and other means -Regulate pricing of transport services -Apply innovative pricing of transport services to increase public transport patronage	-Percentage of income that people spend on transportation -Cost of travel by using public transit (cost/ km) -Cost of public transit compared to cost of public transit with comparable cities (percentage of	-Percentage of total income spent on transportation is not more than 15-20 percent

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
		transport	-Consider providing subsidy to groups of people with special needs -Consider increasing the cost of using personal vehicle by increasing the gas/fuel tax, parking fee, toll prices etc.	cost of the public transit of the comparable cities)	
Organization of Urban Space and Substitution of Travel Needs by Other Means	Dense and Mixed Use Developments	-Land use planning policies promote dense and mixed use developments	-Develop a zoning map to increase the area for dense and mixed use developments and to reduce the number of low density development in the city -Outline a spatial growth boundary of the city to prevent the city from sprawling and getting dispersed -Provide incentives to developers for developing dense and mixed use developments -Increase property tax for low density developments to discourage people from living in such developments -Conduct campaigns through mass media and social media to demonstrate the benefits of living in dense and mixed use developments -Provide facilities and amenities in mixed-use development to make the areas more attractive compared with low-density zone marked areas	-Existence of policies to promote high density mixed use land developments -Density of development (persons/hectare) -Percentage of area designated for dense and mixed use developments	
	Road Hierarchy	-Provide the required amount of roads and the	-Consider establishing a hierarchy of road system and classify roads	-Level of service of the roads	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
	System	required type of road to maintain an acceptable level of service on the road considering the travel demand, mode of travel, density of development and classification of roads	accordingly -Redesign, modify the existing roads, as necessary, according to their respective category -Ensure that roads are serving the purpose that it was originally supposed to serve by eliminating conflicting demands of road uses as much as possible -Provide street furniture and lighting according to classification category of roads	-Classification of roads according to its main purpose -Roads function according to their classification category Absence of through traffic on residential and minor roads	
	Location of Schools and Other Facilities	-Children are attending schools in their own locality and that each locality has the necessary shops and facilities that serve the daily and common necessities	-Providing quality public schools in each locality that has the capacity to serve the school goers in each locality -Maintaining the quality and a common standard for the schools -Implementation of policies that permits parent to send children to public schools in their locality only -Providing shops and services that serves daily necessities in each locality	-Average distance to a primary school and high school -Percentage of children attending schools in the neighborhood -Percentage of children walking or using non-motorized transport to go to school -Percentage of people walking or using non-motorized transport to access daily necessities	
	Sidewalks, Pedestrian Ways and Bike Lanes	-Increase the share of walking and other non-motorized modes of transport	-Provide continuous and interconnected sidewalks and bike lanes accessible by everyone by designing it using the universal access design -Separating sidewalks from the roadway using barrier, on street parking or by	-Length of walk ways -Level of service on sidewalks in major activity areas -Share of walking and other non-motorized transport	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			landscaping between the sidewalk and the roadway -Ensure safety of pedestrians at intersections through clearly marked crosswalks, foot over bridges or underpasses -Relocate vendors from pedestrian areas to alternative locations -Provide traffic signs and markings using the proper standards and guidelines -Provide lighting at the sidewalks to ensure safety of pedestrians in the dark -Provide pedestrian signals to increase the safety of pedestrians at the crosswalk -Separate bike lanes from the vehicle lanes using a barrier to increase safety of bikers -Provision of covered walkway and planting trees along with sidewalks and walkways and provide street furniture and fixtures to make them aesthetically pleasing and attractive to use -Build trails through parks to improve the experience of pedestrians and bikers -Provide safe bike stands at major activity areas	-Quality and aesthetic appeal of sidewalk and walkway pavement and furniture -Share of walking and other non-motorized transport -Connectivity between major activity areas through sidewalks and pedestrian ways -Connectivity between important locations through bike lanes and bike paths -Availability of safe bike stands	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
	Substitution of Travel Needs by Other Means	-Reduce travel demand through the use of information and communication technologies	-Formulate public policies on greater use of e-governance and e-commerce modulation for the delivery of public and private services -Encourage services providers to deliver services taking the advantage of ICTs as much as possible -Generate awareness among people for greater use of e-governance and e-commerce facilities -Encourage policies on tele-commuting and work-from-home policies as applicable	-Proportion of work force on tele-commuting and work-from-home scheme -Usage indices of e-governance and e-commerce -Number of service that are available through the internet and other means that do not require any actual travel -Usage of shopping parcel delivery services	
Public Transit	Diverse, Integrated, Balanced and Well Coverage Public Transit Service	-Development of a diverse, balanced, integrated public transit that has a well coverage to provide service to as many areas and people as practically possible	-Implement a diverse, integrated and balanced public transit system that meets the transportation needs of everyone in the city -Improve the coordination among the transit service operators to integrate the public transit system in terms of physical, operational and ticketing system -Build the necessary infrastructure and facilities to extend the coverage of the transport system in the city -Provide incentives to transit service operators for offering services on the not so profitable routes provide -Give priority to road based public	-Modal share of public transit (by different types of services) -Integration of public transit services -Existence of a common ticketing system -Percentage of city covered by public transit service -Percentage of population covered by public transit service	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			transit modes to other modes especially cars -Make major activity centers and work places easily accessible by public transit		
	Quality of the Public Transit	-The quality of transit services is satisfactory to users and comparable to alternative modes of travel	-Journey time and the level of service by public transit modes are comparable to alternative modes of travel -Consult of the transit operator with the city before making changes to the transit routes and schedule -Improve the quality of transit services to meet the expectation of the majority riders -Provide incentives to the public transit operators for operating a reliable service of choice to riders -Penalize or disqualify the transit operators from operating the service if they fail to provide a reliable and quality service on a regular basis	-On-time performance -Excess waiting time (proportion of passengers subject to longer than average waiting time) -On-board level of service (load factor, availability of seats, low-floor/level platform boarding) -Cost of service -Environmental condition (clean vehicle, air condition etc.)	
	-Accessibility of the Public Transit	-The public transit should be easily accessible and provide access to everyone in terms of boarding and riding the transit system	-Determine of activity areas that requires public transit stops and review the existing location of existing stops -Follow the universal access design standards while designing the transit system (i.e. transit stops, transit vehicles) -Follow the universal access design and	-The distance people need to walk to access the public transit -The design of the transit stop, transit system and other infrastructure and facilities related to the public transit -Quality of access infrastructure	-A quarter mile to a bus stop and a half a mile to a train stop

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			guidelines while designing the infrastructure facilities that connect between major activity areas and transit stops		
Personal Vehicle	-Usage of Personal Vehicle	-Reduce the modal share and trip lengths by personal vehicles	-Traffic demand management policies that can reduce number of trips by personal vehicles such as: o Congestion pricing during peak hours to make use of personal vehicles more costly and reduce traffic congestion o High Occupancy Vehicle (HOV) lanes during the peak hours to increase personal vehicle occupancy rate o Parking policies in the CBD area (number of parking space and parking pricing policies should discourage making a trip by personal vehicle) o Restriction on on-street parking that restrict car ownership o Promotion of car-pooling for work trips o Introduction of school bus system o Raising price of fuel used by cars/personal vehicles	-Modal share of personal vehicle compared -Average occupancy rate personal/private vehicles -Modal share of school trips by personal vehicles -Number of trips by personal vehicle trips compared to other transport modes -Trip lengths by personal vehicle compared to other transport modes -Parking space per 1000 sq. m or per 1000 jobs in the CBD (should be minimum) -Parking price (should be higher)	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			-Vehicle growth management policies		
Safety and Security	Safety of the Transport System	-Reduce the accidents caused by the transportation sector	-Undertake a road safety audit of all major roads and intersections -Implement policies to design all the roadways, intersections, sidewalks and bike lanes using the road and highway design guidelines -Provide traffic signs and markings using the proper standards and guidelines -Enforce the traffic law and penalizing the violators -Increase awareness of traffic law among the general public especially public transit operators by using the social and mass media -Special driver training for public transit systems -Regular vehicular inspection and maintenance program	-Accident rates (per 100,000 population, per 10,000 vehicles etc.) -Number of accidents -Fatality rate (total) -Accident rates rate by mode of transport and VRUs (Vulnerable road user groups) -Total fatality number -Economic cost of crashes as a percentage of the GDP	
	Security of the Transport System	- Having a transport system that ensures security to all of its users	-Provide sufficient lighting at all roads and sidewalks, walking trails at nighttime and install CCTV cameras at transit stops and at other places which have a poor safety record -Post security guards and security check	-Number of criminal incidents (mugging, harassment etc.) while people are using the transportation system -Number of criminal incidents on	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			points as needed -Ensure coordination of the law enforcement agencies with the transportation agencies	public transit services	
Freight Transport	Urban Freight Transport Operation	-Manage the volume of freight traffic in urban areas to reduce its adverse impact on the quality of urban environment and to increase the efficiency of freight operation	-Design standards for large freight vehicle passage routes that meet their safe maneuvering requirements -Ban large freight vehicles during the daytime in the downtown and other congested areas to prevent traffic congestion -Design and implement a designated large freight vehicle road network with designated parking and loading/unloading areas -Establish consolidation centers or freight villages at suitable locations and encourage suppliers to use these centers for consolidation of their deliveries -Relocate whole-sale centers so that movement of freight vehicles can be easily managed -Provide incentives to trucking companies to travel in the off peak periods in the city -Providing incentives to trucking companies to use modern technology such as GPS to improve their efficiency	-Freight ton-km per unit of GDP -Freight ton-km per 10,000 urban people -Fuel consumption and GHG emission by freight transport -Distance over which freight is moved -Proportion of freight traffic that neither have origin or destination in the city through which they are passing	

Areas of Sustainable Urban Transportation System	Subareas of Sustainable Urban Transportation System	Objective	Actions and Policy Considerations	Indicators	General Standards and Practices (if available)
			of operation -Provide incentives to the trucking companies such as tax breaks for operating environmental friendly vehicles		
Environment	Emissions by the Transportation Sector	-Reduce the adverse environmental impact caused by the transportation sector	-Formulate and implement emission standards for all classes of vehicles -Set targets to reduce air pollution in five, ten and twenty years time from the urban transport sector -Encourage modal shift to more energy efficient and low-carbon modes -Implementation of mandatory policies for the transport sector to observe the trends of GHG emissions and other air pollutants by the transportation sector and other sectors as well -Setting targets to reduce air pollution within a certain period of time such as 5-10 years -Implementation of plans and policies to help countries reach their targets on emission reduction	-Aggregate GHG emissions and other air pollutants caused by the transportation sector compared to other sectors -Composite emission/veh-km -Percentage of vehicles using environment friendly and renewable energy -Usage of low-carbon vehicles -Energy efficiency of vehicles (km/lit)	

CONCLUSION AND RECOMMENDATIONS

As transportation is related to everyone's daily life, transportation service is one of the variables on which the quality of life of residents in a city depends. A sustainable transportation system can ensure access to goods, people, opportunities and services in a safe, efficient and equitable manner without putting a burden to the environment. The main benefit of a sustainable transportation is that it is an aspect of liveability and thus a sustainable transportation improves the quality of life in a city.

A sustainable urban transportation system can be achieved through (i) organization of urban space – land use planning and finding better solution to meet the needs through action in other areas, (ii) making common services and opportunities accessible by walking and non-motorized transport by reducing adverse impact on the environment, (iii) development of a balanced integrated transport system that ensures efficient travel using multiple modes, (iv) technological standard and (v) organization of freight distribution and delivery facilities and services.

One of the major goals of sustainable transportation is to reduce the travel demand, especially reduce the trips made by motorized transport, which includes not only private vehicles but also motorized public transport and to increase the amount of nonmotorized transport such as biking and walking. To achieve this, cities should start diverting from designing car oriented cities to pedestrian and bicycle friendly cities. The usage of non-motorized transportation can be promoted by designing compact mixed use developments in the city. It is also very important for cities to integrate transportation planning and land use planning.

In this study the objective of a sustainable transportation system, policy and infrastructure interventions to achieve these objectives and indicators to assess progress in development of a sustainable urban transportation system were discussed. However, not all indicators that were provided are of equal importance. A future study is suggested to develop an aggregate index of sustainability considering the importance of each individual indicator to reflect the present condition in that area.