Sustainable Transport Initiatives in Sri Lanka

SAMAN BANDARA
UNIVERSITY OF MORATUWA

Capacity Building Workshop on Sustainable Urban Transport Index

30th October 2017
Introduction

- Decision-makers are becoming more aware of the need to implement solutions that promote the achievement of sustainable transportation.
- However, in Sri Lanka, no comprehensive tool has been developed to monitor the progress of transportation systems towards or away from sustainability.
- There is a need to explore concepts related to the definition of sustainable transportation and the selection of indicators suitable for Sri Lanka.
- This presentation focuses on the initiatives that have been taken to move towards achieving sustainable targets in transport and methodologies developed in monitoring and evaluating possible performance indicators.
Sustainable Development Goals - Transport

- **Goal 3.6** - By 2020, halve the number of global deaths and injuries from road traffic accidents
- **Goal 7.3** - By 2030, double the global rate of improvement in energy efficiency
- **Goal 9.1** - Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
- **Goal 11.2** - By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
Goal 12.c - Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.
Indirect

- Agricultural productivity (Target 2.1),
- Air pollution (3.9),
- Access to safe drinking water (6.1.),
- Sustainable cities (11.6),
- Reduction of food loss (12.3),
- Climate change adaptation and mitigation (13.1)
Proposed Indicators

- 3.6.1 - Death rate due to road traffic injuries - Per 100,000 population
- 7.3.1 - Energy intensity measured in terms of primary energy and GDP - Megajoules per USD constant 2011 PPP GDP
- 9.1.1 - Proportion of the rural population who live within 2 km of an all-season road
- 9.1.2 - Passenger and freight volumes, by mode of transport - Freight volume (tonne kilometres) by road transport, Passenger volume (passenger kilometres) by road transport, Freight volume (tonne kilometres) by rail transport, Freight volume by air transport, Freight volume (tonne kilometres) by air transport, Mail volume (tonne kilometres) by air transport, Passenger volume by air transport, Passenger volume (passenger kilometres) by air transport
11.2.1 - Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities

12.c.1 - Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels
Issues

- Data Availability
- Establishing baselines
- Identifying trends
- Predicting problems
- Assessing options
- Setting performance targets
Initiatives

- Improved accident database
- Walkability Index
- Driving cycle for Sri Lanka
- Center for Intelligent Transport Systems
- Use of Big Data
Sri Lanka Accident Data Management System (SLADMS)

- SLADMS was first introduced in 2013 to replace the existing MAAP application used by Sri Lanka Police.
- MAAP application’s technology was outdated by that time and the system could be no longer maintained.
- The project of developing SLADMS’s standalone version (was started in University of Moratuwa in 2012) as a solution to overcome the inefficiencies and difficulties associated with MAAP application.
- As a result the SLADMS system was deployed and police officers were trained to manage the system.
- The performance and feature enhancements (including a sophisticated visualization tools such as the Map module) made it possible to lead accident data analysis in a novel approach.
Walkability Index

- Walkability - Extent to which the built environment is friendly to the presence of people living, shopping, visiting, enjoying or spending time in an area
Global Walkability Index
Holly Krambeck (1996)

Pedestrian facilities are evaluated under nine elements qualitatively

- Walking path modal conflict
- Security from crime
- Crossing safety
- Motorist behavior
- Amenities (Cover, benches, public toilets, street lights)
- Disability Infrastructure and Sidewalk Width
- Maintenance and Cleanliness
- Obstructions
- Availability of Crossings
## Global Walkability Index

**Field Data Collection**

<table>
<thead>
<tr>
<th>Survey Area Name</th>
<th>Survey Area #</th>
<th>Peak Hour</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Survey Team Names: ____________________________________________________________

### Surveyed Road Stretch

<table>
<thead>
<tr>
<th>Surveyed Road Stretch</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>(Σ(x<em>length</em>10*count))/#)/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Walking Path Modal Conflict</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Security from Crime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Crossing Safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Motorist Behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Amenities (Cover, benches, public toilets, street lights)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Disability Infrastructure and Sidewalk Width</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Maintenance and Cleanliness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Obstructions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) Availability of Crossings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10) Pedestrian Count</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Length of Surveyed Stretch (km)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unweighted Average: __________________________

### Notes

______________________________
**Disability Infrastructure**

The following diagrams provide some guidance on how to judge disability infrastructure provision. Acoustic pedestrian signals might also be considered.

1. No infrastructure for disabled persons is present.
2. Limited infrastructure for disabled persons is available, but is not in usable condition.
3. Infrastructure for disabled persons is present but in poor condition and not well placed.
4. Infrastructure for disabled persons is present, in good condition, but poorly placed.
5. Infrastructure for disabled persons is present, in good condition, and well placed.
Type an address to get your Walk Score

Address: 

Go

What is Walk Score?

We help you find a walkable place to live by calculating a Walk Score for any address.

Walk Score Ranks 40 Largest U.S. Cities

As suburban home prices decline, there's never been a better time to live in a walkable neighborhood.

We rank 2,508 neighborhoods to help you find a walkable place to live.

Public Transit On Your Site

Add Transit Score™ and nearby public transportation to

Outdoor electronic sirens

High quality outdoor sirens 121dB(A) / 30m

(100ft)
Walk Score Methodology

We like to be transparent about how Walk Score works — and we love hearing your feedback.

The Walk Score Algorithm

Walk Score measures how easy it is to live a car-lite lifestyle—not how pretty the area is for walking.

Walk Score uses a patent-pending system to measure the walkability of an address. The Walk Score algorithm awards points based on the distance to amenities in each category. If an amenity is within .25 miles (or .4 km), we assign the maximum number of points. The number of points declines as the distance approaches 1 mile (or 1.6 km)—no points are awarded for amenities further than 1 mile. The points are summed and normalized to yield a score from 0—100. The number of nearby amenities is the leading predictor of whether people walk.¹

For a sneak peek at the future of Walk Score, read our blog post. Your Walk Score may change as our data sources are updated or as we improve our algorithm.

How Walk Score Doesn’t Work

There are a number of factors (pedestrian design, safety, etc.) that contribute to walkability but are difficult to measure with an algorithm. Read how Walk Score doesn’t work.
How It Doesn’t Work: Known Issues with Walk Score

We’ll be the first to admit that Walk Score is just an approximation of walkability. There are a number of factors that contribute to walkability that are not part of our algorithm:

- **Street width and block length**: Narrow streets slow down traffic. Short blocks provide more routes to the same destination and make it easier to take a direct route.
- **Street design**: Sidewalks and safe crossings are essential to walkability. Appropriate automobile speeds, trees, and other features also help.
- **Safety from crime and crashes**: How much crime is in the neighborhood? How many traffic accidents are there? Are streets well-lit?
- **Pedestrian-friendly community design**: Are buildings close to the sidewalk with parking in back? Are destinations clustered together?
- **Topography**: Hills can make walking difficult, especially if you’re carrying groceries.
- **Freeways and bodies of water**: Freeways can divide neighborhoods. Swimming is harder than walking.
- **Weather**: In some places it’s just too hot or cold to walk regularly.

As MarionBain said, “You should use the Web 3.0 app called going outside and investigating the world for yourself” before deciding whether a neighborhood is walkable! And if you can’t go there in person, Walk Score includes Google Street View so you can use your own eyes to evaluate the walkability factors that our algorithm doesn’t yet include.

**Walk Score Improvements**

We are developing a “Street Smart” Walk Score that takes walking distances, intersection density, block length, etc into account when calculating Walk Scores.

Walk Score now shows Transit Score and public transit where public Google Transit feeds are available.

Visit WalkScore.org to discuss other Walk Score improvements.

**Other Issues**

**International Support**: Walk Score is officially supported in the United States, Canada, Australia, and New Zealand. We’ve heard from our users that the Google data we rely on is less accurate outside of the United States. We are looking for open source developers to help add support for other countries. Visit WalkScore.org to learn more.
Need For Improvements

Existing walkability measures either

- Rank roads based on a level of service criteria using qualitative measures that are very subjective or
- Uses few land use parameters only, disregarding the quality of the facilities available.
Walkability Scorecard Model

- A model capable of pedestrian facilities in road links to compare different road links and to identify deficiencies in a given road.
- In the proposed model, a score as a percentage is finally obtained from the evaluation.
- Where, 100% means a perfect road to walk and 0 means the worst condition for walking.
- This could be used in detail to compare two or more roads.

(A score card to evaluate pedestrian safety in urban environments using walkability measures, I Dias & S Bandara - Injury prevention, 2012)
Parameters considered

1. Presence and continuity of sidewalks
2. Effective width of sidewalks
3. Surface condition of sidewalks
4. Albedo (solar reflection ability)
5. Modal conflict
6. Availability of crossings
7. Delay at crossings
8. Amenities & aesthetics
9. Disability infrastructure
10. Pedestrian security
A Model to Prioritize Pedestrian Facilities Requirements in an Urban Area

- A study to developed a model to prioritize road links for provision of pedestrian facilities in small and medium cities.
- The model developed with three basic parameters namely:
  - Pedestrian demand
  - Connectivity
  - Evaluation of existing pedestrian facilities
- Finally a point scoring frame work was developed for prioritization of road links with an evaluation of existing pedestrian facilities
Driving Cycle Development

- This Study proposed an economical, practical, accurate methodology for the development of driving cycles, including the development of a driving cycle for Colombo, Sri Lanka.
- The proposed methodology captures regional traffic and road conditions and selects a model that represents the collected data sample with minimum available traffic-related information.
- Route selection was done by dividing routes into links using nodes or physical junctions to minimize the number of trips required for data collection.
- Speed–time data for respective links were used to reconstruct speed–time profiles of identified origin–destination pairs.
- The on-board method was used for data collection, and the Markov chain theory was used to develop a transition probability matrix of state changes.
Driving cycle concept to evaluate fuel efficiency of existing roads

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Road Group 1</th>
<th>Road Group 2</th>
<th>Southern Expressway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Speed (kmph)</td>
<td>25.50</td>
<td>17.90</td>
<td>80.65</td>
</tr>
<tr>
<td>Average Running Speed (kmph)</td>
<td>32.28</td>
<td>24.52</td>
<td>80.65</td>
</tr>
<tr>
<td>Average Acceleration (kmh(^{-1}) s(^{-1}))</td>
<td>1.87</td>
<td>2.36</td>
<td>1.63</td>
</tr>
<tr>
<td>Average Deceleration (kmh(^{-1}) s(^{-1}))</td>
<td>1.79</td>
<td>2.59</td>
<td>0.89</td>
</tr>
<tr>
<td>Acceleration Proportion</td>
<td>0.33</td>
<td>0.36</td>
<td>0.21</td>
</tr>
<tr>
<td>Deceleration Proportion</td>
<td>0.31</td>
<td>0.34</td>
<td>0.23</td>
</tr>
<tr>
<td>Idling Proportion</td>
<td>0.21</td>
<td>0.27</td>
<td>0.00</td>
</tr>
<tr>
<td>Cruising Proportion</td>
<td>0.15</td>
<td>0.03</td>
<td>0.56</td>
</tr>
<tr>
<td>PKE (kmh(^{-1}) s(^{-1}))</td>
<td>1.15</td>
<td>2.15</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Publications


Center for Intelligent Transport Systems

Main objective of this center is to facilitate inter-disciplinary research in the focus area of Intelligent Transport Systems (ITS) and become the primer research institute for ITS studies in the South Asian Region.

Secondary objectives are:

- Contribute towards improving transport services in the country and the region using new technologies to achieve comfortable, safer, environment friendly and fuel efficient transport operation
- Increase inter-disciplinary research initiatives and dissemination of knowledge in the study area in terms of research publications, research degrees, training programmes, conferences and workshops
- Seek external funding for collaborative work in the area of ITS.
On-going activities

- Vision based traffic monitoring and control
- Improvements to Sri Lanka Accident Data Management System
- Development of Automated Traffic Violation Detection and Fine Collection System
- V2x Communications for alleviating traffic congestion and enhancing road safety
- Evaluation of Road conditions and correlations with travel patterns for different types of roads and vehicle categories
- Big data for Transport modelling, Project Evaluations & Land use Planning
Vision-based techniques are becoming increasingly popular in traffic monitoring mainly due to the accuracy it can deliver over the other techniques tested to date. One drawback however in vision is its computational intensity and therefore the slow processing speed, which makes it unfit for real-time deployment. In this research, the main focus is to trade vision processing complexity with accuracy so that vision processing can be speeded up to the level of real-time deployment while maintain a reasonable level of accuracy in traffic sensing. Using general purpose embedded cameras such as raspberry pi, vehicle shapes can be identified by simple edge-detection. Road can be segmented and the edge pixel density in each segment can be calculated. The chronological variation of the edge pixel in segments would probably be a useful indicator of the flow. If this method is accurate enough, then traffic monitoring process can be made fast enough for real-time traffic monitoring.
Figure below shows some preliminary results in that one segment of the road is processed for vehicle edge-detection.
Improvements to Sri Lanka Accident Data Management System

- The proposed system is about expanding the features associated with previous SLADMS system through a web based unified platform and introducing more sophisticated tools into accident data analysis.
- Also this new web based system eliminates the difficulties and inefficiencies in data transfer naturally arise from a standalone application.
- Advanced visualization modules and statistical modeling related to decision making will be introduced in Future.
- Also supportive standalone software which can be used to accelerate data collection will be introduced in this phase.
- The next phases would be integrating road accident records in hospitals into the SLADMS.
- This will allow further evaluations to be carried out with respect to accident related injuries and costs.
Development of Automated Traffic Violation Detection and Fine Collection System

- Traffic violations have been identified as a major reason for unnecessary traffic congestions and deteriorating road safety standards.

- There is a need to research into optimizing the resources that could be used for both traffic management and violation detection.

- Improving an integrating existing data bases on vehicle registration, driver licensing, police detections and fines issued and to facilitate the proposed (already in effect but not yet implemented) driver improvement point system.

- Connecting these databases to accident database and fine collection mechanism through post offices, mobile phones, internet etc. and technologies to be used will also be looked into.
V2x Communications for alleviating traffic congestion and enhancing road safety

- DSRC (Dedicated Short Range Communications) enable a variety of Vehicle to Vehicle/ Infrastructure/ Pedestrian (V2x) applications, and is expected to play a major role in ITS in future.

- Next generation mobile phones are expected to have built-in DSRC capability, which would no doubt accelerate the adoption of DSRC in ITS.

- Our current work in the area of ITS includes setting up of an open source simulation framework, VEINS, which bidirectionally couples a vehicular traffic simulator (SUMO) and a communications network simulator (OmNet++).

- Through this versatile simulation framework, performance of basic autonomous vehicle applications implemented with DSRC can be evaluated.
- Poor visibility of roadside traffic signs has been identified as a major cause for accidents as well as inadvertent traffic violations.

- To address this problem, driver assistance systems supported by DSRC-enabled static and dynamic roadside traffic signs are proposed to be studied for their performance.

- Suitable communications protocols to enable fast acquisition of data packets broadcast from roadside infrastructure by passing vehicles will be designed and their performance studied through simulations.

- Real-life experiments will be carried out via prototype DSRC hardware to further establish the practical applicability of these applications and their effectiveness in improving safety on the road.

(in collaboration with University of Bremen, Germany)
Evaluation of Driver Behaviour & Road conditions

- Knowledge on road conditions is important information for road maintenance planning, vehicle operating costs, route planning etc.

- Road condition surveys using accurate equipment is time consuming and expensive and not practical to get information at frequent interval and to cover roads at all levels.

- Developing correlations between road condition, geometry and travel time using mobile applications and Google data and maintaining road condition database for the entire road network will be very useful to the road users and road authorities.

- It is proposed to research into use of mobile applications to evaluate road conditions using smart phone or less expensive on-boards equipment that could collect other vehicle performance information and to develop a database structure so that data could be shared with relevant stakeholders.
IoT & Data Analytics Based Architecture

Real-time analysis
- Driving anomaly detection
- Fuel fraud
- Geo fencing
- Vehicle fault detection

Historical analysis
- Driver profiling
- Driver coaching
- Predicting sensor failure
- Case analysis
OBD2 Based Analysis

OBD – On Board Diagnostics
- Available in many vehicles since 1996
- OBD2 – In most vehicles since 2005
- Speed, RPM, Odometer, Coolant Temperature, Pedal Position, Oxygen, Mass Air Flow, etc.
Driver Profiling

Reckless driving detection via accelerations & deceleration

Anomaly Detection
Preventive Maintenance

Mass Air Flow (MAF) sensor failure prediction
Fuel Consumption Prediction of a Long Distance Bus

Actual Fuel Consumption: 84.08L
Predicted Fuel Consumption: 91.77L
Error: 9.1%
On Going Work

- Driver profiling & feedback
  - Beyond acceleration profile
  - Correlating with location, time, traffic, & weather

- Descriptive & Predictive Analysis of RMC delivery
  - GPS, OBD2, & fuel sensor data

- Process re-engineering
  - Automated driver scheduling for Vehicle Delivery
  - Automated RMC delivery scheduling with multiple plants
  - Automated heavy-goods delivery scheduling with multiple plants
Publications


Main Issue- Lack of funding for maintenance and resources

In Sri Lanka planning decisions on maintenance are mostly taken based on subjective judgment/ad-hoc decisions without a consistent objective basis

Fund allocation can be optimized if the decision making can be supported by up to date information of the road network condition
Roughness Measurement

Road Roughness is very useful for road agencies because it can be used to assess the road condition and be used in decision making process for maintenance planning and programming.

But existing measurement technologies used in Sri Lanka like Profilometer are very expensive.
Roughness Measurement Using Smartphones

- A 3-Axis accelerometer is one of the most common sensors found in a modern smartphone.
- The Objective is to demonstrate how Androsensor application can be used for the measurement of roughness.
- The smart phone apps based method is classified as a Class 3 measurement method. Compared to Class 1, 2 it has less accuracy and precision.
- However it is comparatively low cost.
Data Collection & Methodology Used

- IRI readings from Profilometer
- Accelerometer readings – Using Androsensor app for the same road section
- A 4WD cab is used as the experimental vehicle
- Smartphone fixed vertically on the windshield of the vehicle in a steady position.
- Then drive the vehicle with normal driving condition along many roads that have different surface conditions
- Regression analysis - To find a relationship between accelerometer readings and IRI from profilometer
Data Analysis Results

20 km/h <Speed< 40 km/h

\[ y = 1.5537x - 15.218 \]
\[ R^2 = 0.7667 \]

40 km/h <Speed< 60 km/h

\[ y = 1.4945x - 14.275 \]
\[ R^2 = 0.8486 \]

Speed>60 km/h

\[ y = 0.93x - 8.3395 \]
\[ R^2 = 0.7547 \]
Comparison of IRI Values

<table>
<thead>
<tr>
<th>IRI</th>
<th>Road Type</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.35</td>
<td>Asphalt Rd</td>
<td>Good</td>
</tr>
<tr>
<td>3.08</td>
<td>Concrete Rd</td>
<td>Fair</td>
</tr>
<tr>
<td>3.87</td>
<td>Asphalt Rd</td>
<td>Bad</td>
</tr>
<tr>
<td>10.65</td>
<td>Gravel Rd</td>
<td>Poor</td>
</tr>
</tbody>
</table>
Use of Big Data

Three methods of data gathering using Google Maps APIs and Facebook Graph API, in which the analysis is based on machine learning principles and natural language processing.

Four case studies based on

i). Google traffic data to evaluate road performance,
ii). Google traffic data to monitor transport projects
iii). Google places data for identification of dynamic land use performance
iv). Facebook comments to evaluate public opinion to evaluate projects

The proposed methodologies performed well within an experimental workbench and the application to real project scenario is expected to perform.
Collecting Data From Google Traffic Layers
Evaluation of Road Performance with Google Traffic Data

- Evaluate Long term changes
- Evaluate Short term local incidents
- Identify low performing links
- Identify daily variations
- Identify impact of events
Identification of Bottlenecks of a road network

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Moratuwa- Rathmalana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Arterial Road</td>
</tr>
<tr>
<td>Location</td>
<td>Downtown</td>
</tr>
<tr>
<td>Length</td>
<td>5130m</td>
</tr>
<tr>
<td>Study Time</td>
<td>3 Months</td>
</tr>
<tr>
<td>TT Segments</td>
<td>6</td>
</tr>
<tr>
<td>TT Frequency</td>
<td>4 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Segment</th>
<th>Start</th>
<th>End</th>
<th>% Effect</th>
<th>TTI</th>
<th>IF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>KJ-M1</td>
<td>7:16 AM</td>
<td>5.7%</td>
<td>1.95</td>
<td>0.395</td>
</tr>
<tr>
<td>S1</td>
<td>Kj-KM5</td>
<td>7:08 AM</td>
<td>29.2%</td>
<td>2.02</td>
<td>0.194</td>
</tr>
<tr>
<td>S3</td>
<td>KM4-KM3</td>
<td>7:48 AM</td>
<td>28.8%</td>
<td>2.23</td>
<td>0.322</td>
</tr>
<tr>
<td>S4</td>
<td>KM3-KM2</td>
<td>6:40 AM</td>
<td>37.0%</td>
<td>1.78</td>
<td>0.599</td>
</tr>
<tr>
<td>S5</td>
<td>KM2-KM1</td>
<td>6:56 AM</td>
<td>12.7%</td>
<td>2.27</td>
<td>0.654</td>
</tr>
</tbody>
</table>
Evaluation of Restaurant Popularity in Colombo
Evaluation of train station popularity in Colombo
Bus information system

SEE-GO is a Mobile Bus Tracking Application which provides Real Time Data and Traffic Analysis for Passengers, Bus Owners and Regulatory bodies in order to facilitate quality and comfort in Public Bus Transportation.
Measuring Particulate Matter

Development of a low cost portable device

Reduce the adverse per capita environmental impact of cities

Reduce the number of deaths and illnesses due to Air Quality

Integrate climate change measures into national policies

Promote sustainable construction and infrastructure
Legal Framework

Mandatory requirement in Environmental Impact Assessment (EIA) reports.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Avg. Time</th>
<th>Maximum Permissible Level (μgm)</th>
<th>Method of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter- Aerodynamic Diameter is less than 10μm in Size</td>
<td>Annual</td>
<td></td>
<td>Hi-volume sampling and Gravimetric or Beta Attenuation</td>
</tr>
<tr>
<td>(PM$_{10}$)</td>
<td>24 Hrs</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter- Aerodynamic Diameter is less than 2.5μm in Size</td>
<td>Annual</td>
<td>25</td>
<td>Hi-volume sampling and Gravimetric or Beta Attenuation</td>
</tr>
<tr>
<td>(PM$_{2.5}$)</td>
<td>24 Hrs</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
Existing Situation

Air Quality Measuring Vehicle

Cost - $7,000 per session

Dust Monitoring Devices

Dust Monitor DustTrak DRX TSI 8533
Price - $10,950.00

TSI 8534 Handheld DustTrak DRX
Price - $9,350.00
Basic Concept

Real Time data Collection
Solidworks® Model Of Final Product

Estimated Product Cost – 40,000 LKR
Thank you