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ORIGINAL ARTICLE

Application of School Bus Routing Problem in GIS to Organize School Buses in Kandy City, Sri Lanka

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ABSTRACT

Generally, Kandy city and traffic congestion go hand in hand. This situation becomes worse during school time. The geographical location of the city, the limited number of entrances and the large number of schools located within a small area are contributing to this condition. This study attempts to propose a new model to reduce school time traffic congestion using School Bus Routing Problem (SBRP) method. Network analysis in GIS facilitates the build of this system. SBRP seeks to plan an efficient schedule for school buses to pick up students from a bus stop and drop them to school by satisfying various constraints like; school time window, maximum walking distance and riding time, and the traffic. SBRP selects the nearest bus stops, generates suitable bus routes and visualizes traffic congestion on roads in Kandy city. Vehicle Routing Problem (VRP), closest facility, and location-allocation tools identify GIS-based solutions to SBRP. The proposed model selected suitable bus stops to drop students to a school and to generate the fastest bus route for the school buses. Visualizing a 12-hour daytime traffic in Kandy City, all schools are covered by the 56 fastest bus routes. The maximum riding time and distance limits to 59 minutes and 16 km respectively. Historical traffic data identifies 6.00 am to 8.00 am and 12.00 pm to 2.00 pm as the most traffic-congested time in the city. Finally, all problems of SBRP are solved and a systematic method is introduced to transport school students by optimizing the traveling time of students with existing traffic congestion.

1 Introduction

Student transport is the transportation of children and teenagers to and from schools and school events, and can also be undertaken by school students themselves (Darrelljon, 2017). They use different transportation modes; walking, cycling, buses, and cars. Using general-purpose public transport is the most common means of student transport in some countries including Sri Lanka. Sometimes the parents or the students get reimbursed when they buy public transport tickets. According to a 1994 report based on Australian road safety statistics, Hasler (2013) found that traveling to school by bus is: 7 times less likely to cause serious injury or death than being driven in a family car, 31 times less likely to cause the same than walking, 228 times less likely to cause the same than cycling. Officials of the National Transportation Safety Board in the USA say school buses are safer than cars, even if they are not fitted with seat belts (Darrelljon, 2017). Therefore, the safest mode of school transportation is the bus.

In Sri Lanka, public transportation is used in rural areas to transport students to schools but the majority of urban areas use private vehicles. This, in turn is affecting to increase the traffic congestion on roads in urban areas. Kandy City has this problem during school time. The School Bus Routing Problem (SBRP) method is a good solution to overcome this problem, and yet, no city in Sri Lanka uses it. The main target of this research is to use SBRP to find a solution for traffic congestion during school time in Kandy City based on Geographical Information System (GIS). The main objective of this study is to create a method to assign each student to a particular bus that must be routed in an efficient manner in Kandy City using SBRP. The specific objectives are to visualize the 12-hour daytime traffic of Kandy City, to select suitable bus stops to drop students to a school and to generate the fastest bus route for the school buses.

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A GIS is an organized collection of computer hardware, software, geographic data, and personnel, designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (Chou, 1995). GIS, as a fast-growing technology, provides strong decision support for users in searching for optimal routes, finding the nearest facilities and determining the service areas.

Kandy is the main city of the Kandy district located in the Central Province which was initially built as a fortress city. There are four main entrances to Kandy City (Fig. 1); from the north Katugastota road, east Thannekumbura road and west Peradeniya and Gannoruwa roads which cross the Mahaweli River. This limited number of entrances cause heavy traffic during peak hours to enter and exit the city.

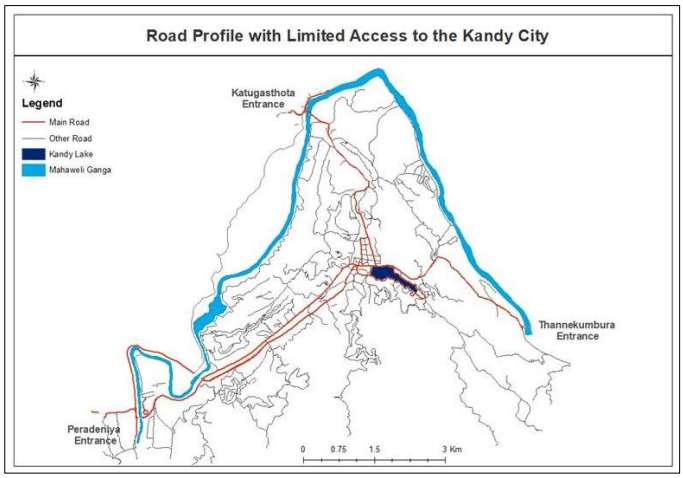

Fig. 1: Main Roads in Kandy City.

According to Kandy Transport Improvement Program (KTIP) (SLSCPD, 2014), around 325,000 people enter Kandy City during the 12-hour day time of a weekday, of which around 90,000 arrive for employment and 63,000 for education. A huge amount of vehicles carrying these people use the limited number of entrances into the city causing traffic congestion. KTIP reported that the buses entering the city are estimated to make 5,000 trips carrying 200,000 passengers. At the same time, there are around 1,000 school vans entering the city on school days carrying over 16,000 passengers. The balance is made up of nearly 45,000 private vehicles that dominate the traffic flow, and carry around 100,000 passengers into the city. The train service available is used only by very few passengers due to the unreliability of the services.

There is a traffic problem with school vehicles and school passengers during school time. Totally 63,387 students and 2,875 teachers are engaged in 40 schools including 23 major schools. This study selected the most popular 26 schools and additionally, there are government, semi-government and private schools but the majority are government schools. These 26 schools are consisting of a combination of girls' colleges, boys' colleges and mixed schools. Fig. 2 presents the locations of these schools and the bus stops. According to these factors, during the student pick-up time in the morning and afternoon, school vehicles create traffic congestion. This study is an attempt to propose a model to reduce traffic congestion due to school time using GIS.

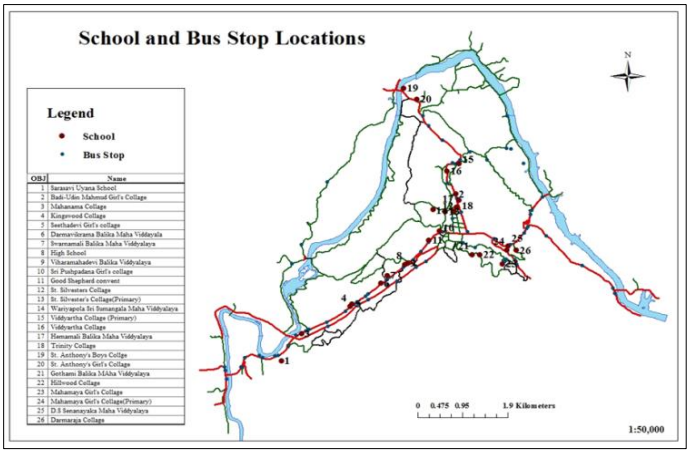

Fig. 2: Schools and Bus Stops in Kandy City.

When considering the historical evidence it must be needed to give attention to the nature of school transportation, problem-solving methodologies, GIS-based analysis and related algorithms and some other applications. Most of the research enhances school transportation as a problem and they give special attention to it. Nayati (2008) said school bus routing and scheduling are major problems in society because school bus transportation needs to be safe, reliable, efficient and systematic. Therefore they find different solutions using new technology.

In computer science, routing is a process of forwarding the data from a known source to the destination. In this process, the data may travel through several intermediate paths and need to select the best possible optimal nodes to forward the data. This optimal selection of nodes will enable to achieve high performance in the network. A large amount of work has been carried out to find the optimal path in the network routing to improve its efficiency and remove congestion problems (Sharma and Khurana, 2013). Routing algorithms are supported to solve that type of problems. There exist different routing algorithms which have been developed for specific kinds of networks as well as for general routing purposes such as Vehicle Routing Problem (VRP) Genetic Algorithm, Greedy Algorithm, Simulated Annealing, Floyd-Warshall's Algorithm and Dijkstra's Algorithm

Network analysis in GIS provides strong decision support for users in searching for optimal routes, finding the nearest facility and determining the service area. Searching for an optimal path is an important advanced analysis function in GIS (Delavar et al., 2004). Additionally, GIS has tools and utilities available to help increase the efficiency of the transportation office and the drivers that are driving the routes (ESRI, 2010). Network analysis in GIS has different usages. It can be used for utility networks like water mains, sewage lines, and electrical circuits. These networks are generally directed. Transportation networks

include roads, railroads, and flight paths. These networks are generally undirected. The School transportation can be considered as road network analysis.

Network analyst in GIS has three different availabilities namely the Route, Closest Facility, and Origin-Destination (OD) Cost Matrix solvers. These functions are based on Dijkstra's algorithm for finding the shortest paths. Each of these three solvers implements two types of path-finding algorithms. The first type is the exact shortest path, and the second is a hierarchical path solver for faster performance. The classic Dijkstra's algorithm solves a shortest-path problem on an undirected, non-negative weighted graph. To use it within the context of real-world transportation data, this algorithm is modified to respect user settings such as one-way restrictions, turn restrictions, junction impedances, barriers, and side-of-street constraints while minimizing a user-specified cost attribute. The performance of Dijkstra's algorithm is further improved by using better data structures such as d-heaps. In addition, the algorithm needs to be able to model the locations anywhere along an edge, not just on junctions (ESRI, 2010).

Nayati (2008) created a GIS-based school transport management system. It has designed bus stop allocation, the fastest and safest bus routes with an Automatic Vehicle Location facility. Delavar et al. (2004) used GIS to search the optimal route, the nearest facility and the determined service area. Searching for an optimal path is an important analysis function in GIS. Kang et al. (2015) cover the issue of establishing plans to efficiently transport students distributed across a designated area to the relevant schools using defined resources. As with a similar VRP, the SBRP may have diverse constraints such as heterogeneous vehicles, the allotted time window and multiple depots.

Park and Kim (2010), provide a comprehensive review of the school SBRP. It seeks to plan an efficient schedule for a fleet of school buses where each bus picks up students from various bus stops and delivers them to their designated schools while satisfying various constraints such as the maximum capacity of a bus, the maximum riding time of a student in a bus, and the time window of a school. This class of problem consists of different sub-problems involving data preparation, bus stop selection, bus route generation, school bell time adjustment, and bus schedules. Different researchers use various assumptions, constraints, and solution methods to solve SBRP (Khader, 2008).

The SBRP by Arias-Rojas et al. (2012) seeks to plan an efficient schedule of a fleet of school buses that must pick up students from various bus stops and deliver them by satisfying various constraints: maximum capacity of the bus, maximum riding time of students, and the time window to arrive at school. In that research, they considered SBRP for a school in Bogotá, Colombia. The problem is solved using the Ant Colony Optimization (ACO) method. Eldrandaly and Abdallah (2012) found a GIS-based solution for SBRP. According to them, SBRP is a central issue in transportation planning and optimization systems. SBRP seeks to plan an efficient schedule for a fleet of school buses where each bus picks up students from various bus stops and delivers them to their designated schools while satisfying various constraints such as the maximum capacity of buses, and the time window of a school. Due to its inherent complexity, many heuristics have been proposed to solve this combinatorial problem in an effective way. In that study, a novel GIS-based decision-making framework that combines GIS, clustering techniques, network cutting techniques, and a hybrid ACO metaheuristic with the iterated Lin–Kernighan local improvement heuristic is proposed for solving the SBRP as a split delivery VRP.

The bus stop selection step seeks to select a set of bus stops and assign students to these stops. In general, students who are in rural areas are picked up at their home and in urban areas, allowed to walk to a bus stop from their home and take a bus at the stop. Many studies assume that the locations of bus stops are given. Heuristic solution approaches are classified into two sections, Location-Allocation-Routing (LAR) strategy and the Allocation-Location-Routing (ALR) strategy (Park and Kim, 2010).

A main criterion of the bus stop selection is the maximum walking distance since student transportation policy and regulations define the maximum walking distance of students. The Student Transportation Policy and Regulation of the US define junior and senior kindergarten - 0.5 km, grades 1 to 8 inclusive – 1 km and secondary students - 1.6 km within the urban areas (WRDSB, 2023). Additionally, the student transportation of Edmonton of Canada considered kindergarten, grade 1 and 2 – generally, within 300 m of their residence, grades 3 to 6 – generally within 500 m of their residence, and grades 7 to 12 – generally within 700 m of their residence as the maximum walking distance (Conseil-Scolaire-Center-Node, 2013).

According to the historical evidence, SBRP is the suitable method to build a model to school transportation of Kandy City. That method has five steps and (Park and Kim, 2009), provides a comprehensive review about SBRP. By means of that review, most of the researchers follow these five steps. Some studies avoid the bus stop selection step and also the school bell time adjustment. It depends on the objectives of the study. However, Desrosiers et al. (1981) and Park and Kim (2010) followed all five steps. They have followed the LAR strategy to select bus stops. ArcGIS is supportive software to get the result. The closest facility in the network analysis can be used to select a bus stop. The ‘‘cluster-first, route-second” approach follows to generate routes. This study considers multi schools to generate the route. Therefore, it needs to consider the school bell time to schedule a route but in this study, the bell time adjustment has been avoided and a single time window is applied to all. VRP and closest facility algorithms are used to get the result of bus stop selection, bus route generation and route scheduling.

2 Data and Methodology

2.1 Road Network of the Study Area

According to the geographical location, Kandy City appears as a major transportation hub on the island and it is the gateway to the central highland.

Table 1: Main Entrances to Study Area (*Source*: Kandy Transport Improvement Program).

Road	Road Distance (km)	Average Day-Time Speed (km/h)
A1: Peradeniya to Clock Tower (SBM)	6.2	21.5
AB42: Peradeniya to Clock Tower (WGM)	6.2	24.1
A9: Clock Tower Junction to Katugastota Junction	4.4	19.4
A26: Clock Tower Junction to Tennekumbura Junction	7.7	24

For transportation, there are multimodal systems and road networks including primary and secondary roads and railway lines. A number of "A" class roads begin from Kandy to every direction of the country. From north the A9 Kandy- Jaffna road, to east the A26 Kandy – Padiyathalawa road via Mahiyanganaya, to west the A1 Kandy – Colombo road and to South the A5 Kandy – Chenkalady road via Badulla. The A10 road connects Putthlam with Kandy via Kurunagala and Katugasthota. The B413 Raja Mawatha provides access from Badulla to Kandy City which is connected to A26 Road at Thannekumbura. A9 and A10 roads run out from the city crossing the Katugasthota bridge. A1 and A5 roads fall across the Peradeniya bridge while the A26 road travels on the Thannekumbura bridge. According to the KTIP report, there are three major nodes in the national road network in the periphery to enter the core area known as Preadeniya, Katugasthota and Thannekumbura and the average distance between these three nodes is less than 9 km (Table 1).

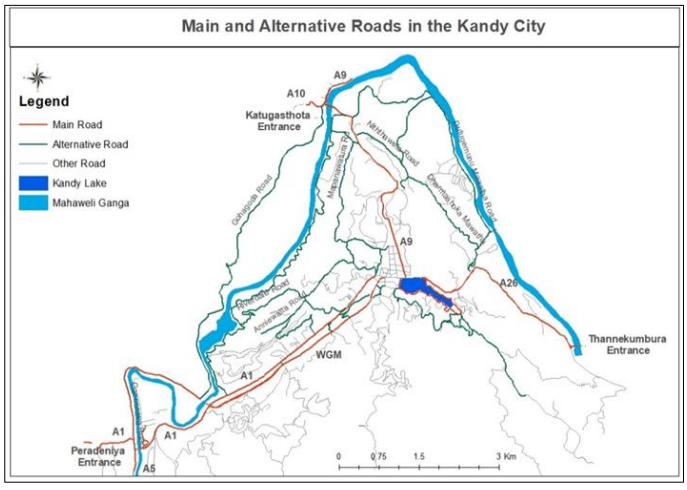

Fig. 3: Alternative Roads in KMC.

Due to the high traffic congestion, people tend to use alternative paths. For example, within Kandy Municipal Council (KMC) area, there are alternative bypass routes between these three nodes to avoid the city center. Bridge at Gohagoda makes it easier for passengers to travel between nodes without entering to the core area. Fig. 3 and Table 2 show alternative bypass routes located in KMC.

Table 2: Node Connections of Bypass Road and Distance (*Source*: Kandy Transport Improvement Program).

Node Connection	Distance Through City	Alternative Bypass Road
Getambe - Katugastota	8.9 km	B 365 Gohagoda road
Katugasthota - Thannekumbura	8.9 km	B069 Buwelikade to Lewella and B550 -Dharmasoka Mawatha, from Lewella to Nittawela of the intermediate lane
		B069 Buwelikade to Lewella and Dutugemunu Mawatha (KMC road) along the right-hand bank of the Mahaweli River to Mawilmada and then a municipal road to Nittawela
Tannekumbura - Getambe	9.3 km	No attractive routes available due to the adverse terrain and geography, but can still avoid the core area through Katugasthota.

2.2 School Bus Routing Problem

SBRP has been constantly studied since the appearance of the first publication by Newton and Thomas (1969), where SBRP was made out of a collection of five problems. Each problem should be taken individually and solving methodology could be different, but it has an interrelationship with each other. However, these five problems can be considered as solving the key factors of SBRP, and according to Park and Kim (2010), these are;

I. Data preparation
II. Bus stop selection
III. Bus route creation
IV. School bell time adjustment
V. Route scheduling

Out of this, school bell time adjustment and route schedules are necessary for multi-school. Multi-school means different school students are on the same bus at the same time. The collection of all required data and the preparation of it for the analytic stage are called data preparation which consists of a network data set creation, identification of school and bus stop location, and preparation of the cost matrix. Bus stop selection determines the location of a suitable bus stop and assigns students to each bus stop depending on the location of the school they attend. Bus route generation constructs the route of the bus and the scheduling, which specifies the exact starting and ending time of the route.

2.2.1 ArcGIS for School Bus Routing Problem

GIS is a powerful tool used for computerized mapping and spatial analysis. Network analysis is one of the extensions used in ArcGIS. It models the real-world network and can be used for transportation network analysis. It is used with other ArcGIS applications such as ArcMap, geoprocessing, and so on (ESRI, 2010). Network analysis extension can be used to find the best route, closest facility, service area, and Origin-Destination (OD) cost matrix, has a Vehicle Routing Problem (VRP) tool, and The Traveling Salesmen Problem tool. Route solver finds the route that minimizes travel costs through a series of stops. Optionally it is generating cost attributes (mile, minute, rush hour time), best order, time window, and cost on stop and driving directions. The closest facility finds the minimum travel cost between incidents and multiple facilities. Additionally to the above mentioned alternatives, the closest facility generates a number of facilities to find, cutoff value, cost on the incident, and facilities. VRP, closest facility, and location-allocation tools in ArcGIS 10.5 are used in this study. Google Earth is used to verify the accuracy of results and to identify locations.

2.3 Data Preparation

Network data set creation is the main task of data preparation. Three different types of data had been selected; spatial data, historical traffic data, and road details. Spatial data is geospatial data that identifies the geographic location of features and boundaries on Earth. Kandy City boundary, road network, school, and bus stop locations are identified as spatial data. City boundaries and road networks are created as line shape files using the data from the Survey Department of Sri Lanka. It consists of all roads in Kandy City but only primary and secondary roads are selected in this study. Bus stop locations and school locations are presented as a point feature, and are mapped from Google Earth. Polygon feature classes have not been used in this network data set.

Traffic data provide information about how travel speed on road segments changes over time. The average travel speed of each road segment is extracted from the historical traffic data. The section between two nodes is known as a segment. Traffic data is taken from the Feasibility Study to Investigate Existing Proposal and to Propose Appropriate Transport Solutions for Kandy City to Enhance the Efficiency of the Transport Infrastructure Program; governed by RDA (RDA, 2017). Speed is measured at 30-minute intervals. Generally, five minutes interval speed is more useful to show traffic congestion. However, due to a lack of data availability, a 30-minute interval has been considered. Accordingly, the time interval has been created as a scale factor for each road segment using travel speed and free-flow speeds. The scale factor is limited to a range of zero to one as tabular data. Zero represents the high density of the traffic and one represents the low density of traffic. In this study, one represents the free-flow speed of the road and zero represents the high traffic condition.

2.3.1 Network Data Creation

2.3.1.1 Street Feature Creation

The street feature class is the main requirement of a network data set which is a line feature class. Specialty is, all lines are needed to connect with each other. Therefore, topology-building rules are used to identify digitizing errors.

The geographic coordinate system is the projected coordinate of this feature class. Creating a network data set requires special attributes with existing street attributes. Those are important to build a network data set and use it for a different purpose. Table 3 describes the attribute fields, data type and application.

Table 3: Street Attribute Details.

Field	Data Type	Application
One-way	Text	To help determine one-way streets
Length	Double	To calculate the shortest routes
Travel Time	Double	To calculate the fastest routes
Speed	Integer	Sometimes used to calculate travel time
Street Name	Text	To define direction

2.3.1.2 One Way Road Creation

According to the requirement, any road in the road network can be defined as a one-way road. In the network, the data set is defined as an attribute in the attribute table of the street feature class. The field name must be written as “Oneway “or “oneway”. It is easy to detect as a restriction field during the network-building process. Otherwise, we need to introduce it manually. The middle of Kandy City has one-way streets. Fig. 4 shows the one-way roads and arrows show digitized directions. ‘FT’ (From-To) means travel is allowed only in the digitized direction. ‘TF’ (To–From) would be permitted against the digitized direction.

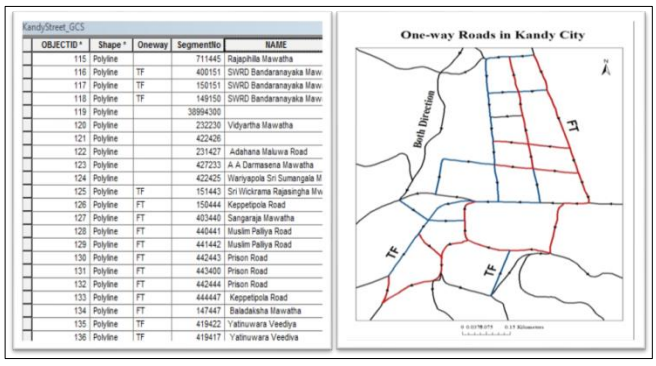

Fig. 4: One-way Roads -A Screenshot.

2.3.1.3 Travel Time Calculation

Travel time can be calculated using distance and traveling speed. The attribute table of the street feature class has a shape length field. It is representing the length or distance of the street segment as a meter. Free-flow speed of the road conceded as travel speed.

2.3.1.4 Turning Restriction Feature Class

Turning restriction is not a one way restriction. No vehicle can have access to the road with the turning restriction. It can be added at any time due to different reasons. Kandy network has only one restricted road (Fig. 5). It is the Temple Street and is located in front of Temple of the Tooth.

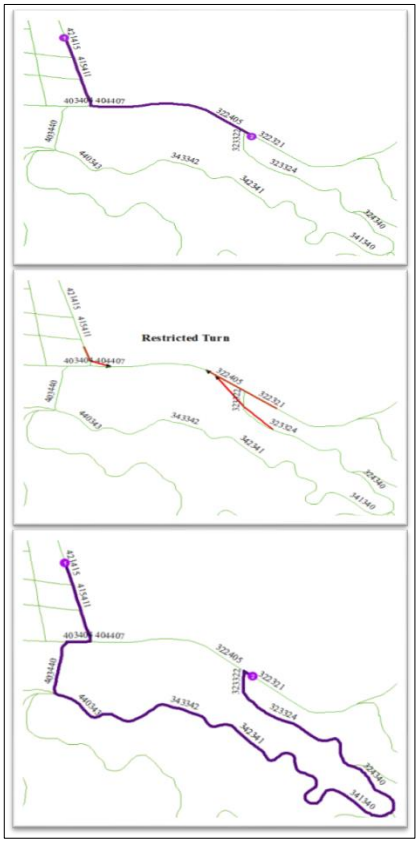

Fig. 5: Shortest Path Finding Before and After Introducing Turning Restriction - A Screenshot.

2.3.1.5 School and Bus stop Locations

School locations and bus stop locations are identified from Google Earth. The file from Google Earth is of "kml" type and these files are converted to the shape file format.

2.3.1.6 Creating Historical Traffic Data

Storing historical traffic data in a network data set is important to identify a series of costs for each road. The costs would represent traffic speeds at different times of the day, applied over the course of a week. Historical traffic data is presented as a profile table and a street profile join table in ArcGIS. These cost attributes are stored using a normalized model. The normalized model minimizes the size of the traffic data. Cost attribute is recorded as scale factors of the free-flow speeds. It is limited to a range of zero to one and recorded in a profile table. That profile represents the speed variation throughout the day. The scale factor is calculated according to the equation given below.

$$Scale\ factor = \frac{Travel\ speed\ \ of\ road}{Free\ flow\ speed\ of\ road}$$

2.3.1.7 Street Daily Profile Table

Free-flow speed of the road and the travel speed are needed to design the street daily profile table. Free-flow speed is the speed that occurs when the traffic density is zero. That speed depends upon different factors such as weather conditions, terrain, and material of the road, and therefore, 40 km/h is taken as the free-flow speed. Travel speed means the actual traveling speed on the road during the considered time interval. It can be obtained through observation during a traffic survey. Traffic data are representing 30-minute intervals; therefore traffic changing duration is a 30-minute interval. 48 values are required to represent 24-hour traffic congestion on a single road segment. It is called the "profile" of that road segment. Generally, two-way roads have two profiles, one for the "From-To" direction and another one for the "To-From" direction. Scale factors were created from 5.30 am to 6.00 p.m. because school transportation has no influence from the nigh-time traffic. Therefore, night-time travel speed is assigned as free-flow speed.

2.3.1.8 Street- Profile Join Table

The street-profiles join table consists of street features, their free-flow travel speeds (or travel times) and related traffic profiles for each day of the week. Street feature and profile table link to this table using the object ID number and there is no need to build any relationship classes. Fig. 6 defines the relationship of all tables used for traffic visualization.

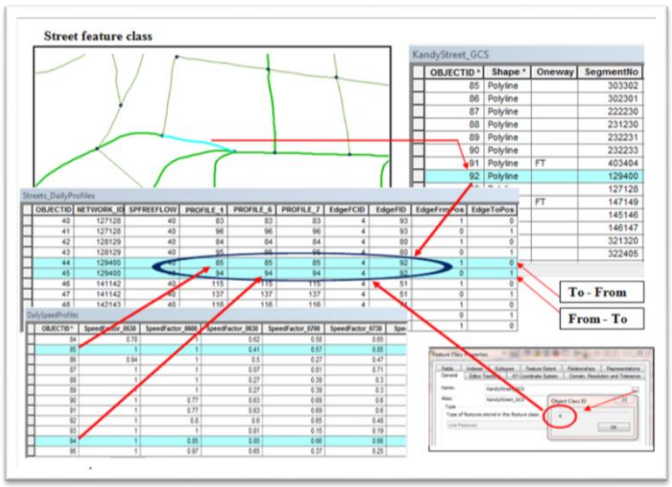

Fig. 6: Relationship of Attribute Tables for Traffic Visualization.

2.3.1.9 Bus Stop Selection

The bus stop selection step seeks to select a set of bus stops and assign students to these stops. In general, students in rural areas are picked up from their homes and in urban areas, students walk to a bus stop from their home. The selected study area is also well-urbanized and allows students to walk to the bus stop.

LAR strategy first determines the set of bus stops for school and assigns students to these stops. Bus routes generated for vehicles that come from the outer side to the study area and within the study area are considered separately. Bus stop selection is also considered separately. One of the assumptions made for outer side vehicles is that they will not pick up any student within the study area. Therefore; they only need bus stops near the school. LAR strategy was applied for this selection. School services which started within the study area stop at all the existing bus stops and pick up students and drop them to the school.

The main criterion of the bus stop selection is the maximum walking distance of students from the bus stop to school. According to literature, the maximum walking distance depends on the age of the students, and is between 500 m to 800 m. Generally, this distance can be completed within 5 - 10 minutes. Student walking distance in this study was decided based on student transport systems in other countries. It is limited to less than 800 m. This criterion is defined as a constraint, in the closest facility analysis tool. The network analyst window of the closest facility has six network analysis classes, namely facilities, incident, route, point barrier, line barrier and polygon barrier. In this scenario, bus stops are the facilities and schools are the incidents. There are 40 bus stops and 26 schools. Selected 26 bus stops are the closest to the schools. The closest facility tool can be used to select the nearest bus stop among the existing bus stops. To find the new bus stops location-allocation tool was used. Enter the new and existing bus stop locations as the point feature for the facilities class and introduce schools for the demand class and it will generate the nearest bus stop for a particular school.

2.3.1.10 Route Scheduling

Route scheduling specifies the exact starting and ending time of the route. Different criteria can be used to schedule a route. The number of schools is the main criterion of this study. 26 schools which are selected for this study are located in front of main roads that have high traffic congestion. These schools can be taken as the most popular schools in Kandy. As such, some students are coming from faraway places such as Mawanella, Mawathagama, Gampola, Matale and the Mada-Mahanuwara, and therefore, school services are started from these areas as well. This study considered that and generated routes separately.

2.3.1.11 Bell time Adjustment

The next route scheduling criteria is the school bell time adjustment. This problem has occurred with the selection of multiple schools. Generally in Sri Lanka, all government schools are started at 7.30 a.m. and end at 1.30 p.m. but primary sections end before 1.30 p.m. Majority of the selected schools in the study area started at 7.30 a.m. and end at 1.30 p.m. Table 4 defines other selected criteria to schedule a route.

Table 4: Route Schedule Criteria.

Criteria	Considerations	Selected
Number of schools	Single school	Multiple School
	Multiple schools	
Surrounding of services	Within the study area	Both
	Outside the study area	
	Both	
Problem scope	Morning	Both
	Afternoon	
	Both	
Mix load	Not allowed	Allowed
	Allowed	
Fleet mix	Homogeneous fleet	Heterogeneous fleet
	Heterogeneous fleet	
Constraint	School Time window	7.30 a.m. and 1.30 p.m.
	Walking Distance	500 m – 800 m
	Maximum riding time	Around 1 hour

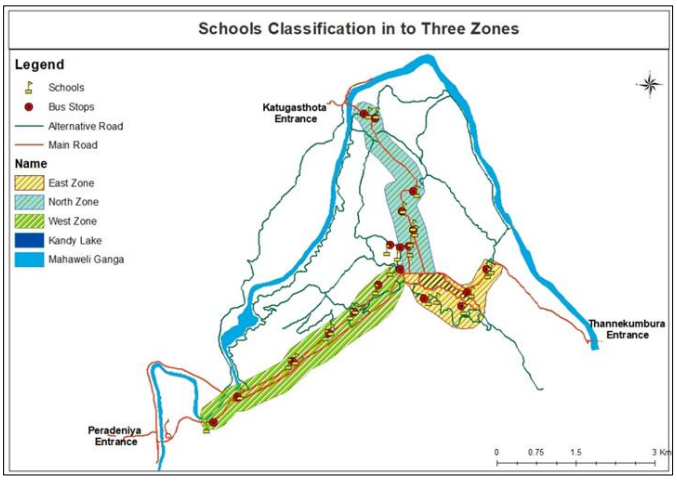

Fig. 7: Three Main Zones and Related Schools.

Selected schools are located all over the area, and therefore; route scheduling is very difficult and takes more time for one route. As a solution, all schools are categorized into three zones. It is based on three main entrances. Mainly A9 Katugasthota to Kandy City as a north zone, A1-SBM from Peradeniya to Kandy City as a west zone and A26 Sangaraja Mawatha area as an east zone. All main zones are

divided into subsections as I and II based on the traveling time. Fig. 7 shows three main zones and Table 5 lists out related schools.

Table 5: Main Zone and Related Schools.

Zone	Schools
North Zone	St. Anthony's Boys' College, St. Anthony's Girls' College, Vidyartha Primary School, Vidyartha College, Badi Ud Din Mahmud Girls' College, Trinity College, Hemamali Girls' College, Wariyapola Sri Sumangala College, Wariyapola Sri Sumangala College, St. Sylvester's College, St. Sylvester's Primary School
East Zone	Gothami Balika Maha Vidyalaya, Hillwood Girls' College, Mahamaya Girls' College, Mahamaya Primary School, D. S. Senanayaka Vidyalaya, Dharmaraja College
West Zone	Good Shepherd's Convent, Sri Pushpadana Girls' College, Vihara Mahadevi Girls' College, Girls' High School, Swarnamali Girls' College , Darmawickrama Girls' College, Sithadevi Girls' College, Kingswood College, Mahanama Maha Vidyalaya, Sarasavi Uyana Maha Vidyalaya

2.4 Bus Route Generation

The Bus route generation method constructs the school route. The algorithm can select either the route first – cluster second approach or cluster first – route second approach. Route first - cluster second route approach uses Travelling Salesmen Problem (TSP) algorithm. TSP creates a long route and it considers all the stops; also it is partitioning into smaller routes after considering constraints. Cluster first – route second approach, first categorizes the students. According to route scheduling criteria that cluster can be considered as a route satisfying constraint that exists. After creating the route, the improved heuristic can be applied to the route. A heuristic approach is widely adapted for VRP.

This study selected a cluster first - route second approach. One bus stop is considered as one cluster. VRP is the selected analysis tool in ArcGIS and it has 13 classes. Bus stops are used in order and starting and ending locations are considered as "Terminals". There are three locations, Katugasthota, Thannekumbura and Peradeniya. The route has a relationship with terminals. In this study, it is used to introduce the starting and ending point of the service. Route zone class is used to create all bus stops and terminals.

All these classes have a facility to define the criteria selected. It is assumed that each bus takes two minutes to pick up or drop students at the school. It is called service time and the entire travel time is calculated including the service time. As a result, the quickest path was obtained considering travel time. Historical traffic data with 30-minute intervals increase the accuracy of the quickest route.

Fig. 8 summarizes the entire methodology of this study. Additionally, network analyzing data set can be used to create a video to show traffic condition on roads within 24 hour using the time slide tool in Arc GIS and it can export as avi file format.

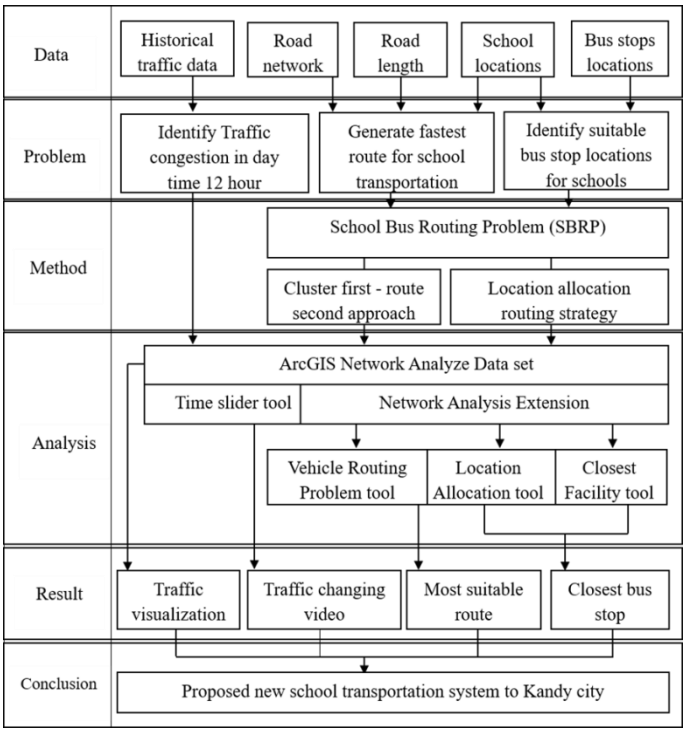

Fig. 8: The Complete Analysis Process of the Study.

3 Results and Discussion

3.1 Traffic Visualization

Traffic visualization on roads is one of the specific objectives of this study. According to the data, traffic congestion is shown from 5.30 a.m. to 6.00 p.m. Night-time traffic is shown as free-flow speed. According to historical traffic data traffic, variation is visualized every ½ hour as four levels using four different colours. The red colour shows the heavy traffic areas and is named "stop and go". The orange colour shows slow-moving areas and that level is introduced as "slow". Normal speed is present in yellow colour and named "moderate speed". The maximum travel speed of the road is shown as green and named "free flow".

Higher attention is paid to traffic congestion during school time on roads. According to traffic data, 6.00 a.m. to 8.00 a.m. and 12.00 p.m. to 2.30 p.m. are identified as school times. This time has been decided considering the route schedule timetable of the study and school buses move around the entire city during that time period.

3.2 Morning Traffic Condition at School Time

Table 6 describes the present existing traffic conditions of the school time in the morning and it is graphically presented in Fig. 9. According to the findings, there are heavy traffic congestions during the school time near the

schools as well as near the main entrances. The reason for heavy traffic congestion at 7.30 a.m. to 8.00 a.m. near the main entrances is the office crowd trying to pass these places.

3.3 Afternoon Traffic Condition at School Time

The existing traffic conditions of the school time in the afternoon are described in Table 7. It was observed that there was a systematic pattern for the traffic congestion, but there are also heavy traffic near the main entrances of both the north and west zones, which is reduced after 2.00 p.m. (Fig.10).

3.4 Selected Bus Stops for Schools to Drop-off Students

As explained in the methodology, all schools are divided into north, east and west zones. In the present system, all buses stop in front of the school to drop off students. Also, there are road crossings available near the schools for the students who are coming by vehicles from the opposite direction. These two reasons are the main causes for heavy traffic near the schools. The distance from the bus halt to each school according to the new system is defined in Table 8, while Fig. 11 show the all selected bus stop locations and the newly proposed bus stops.

Table 6: Morning School Traffic Congestion.

Zone	Traffic Level					
	North		East		West	
Place	Main Entrance	Near Schools	Main Entrance	Near Schools	Main Entrance	Near Schools
6.00 - 6.30	Heavy	Moderate	Heavy	Heavy	Heavy	Heavy
6.30 - 7.00	Heavy	Heavy	Moderate	Heavy	Heavy	Heavy
7.00 - 7.30	Heavy	Heavy	Moderate	Heavy	Heavy	Heavy
7.30 - 8.00	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy/ slow

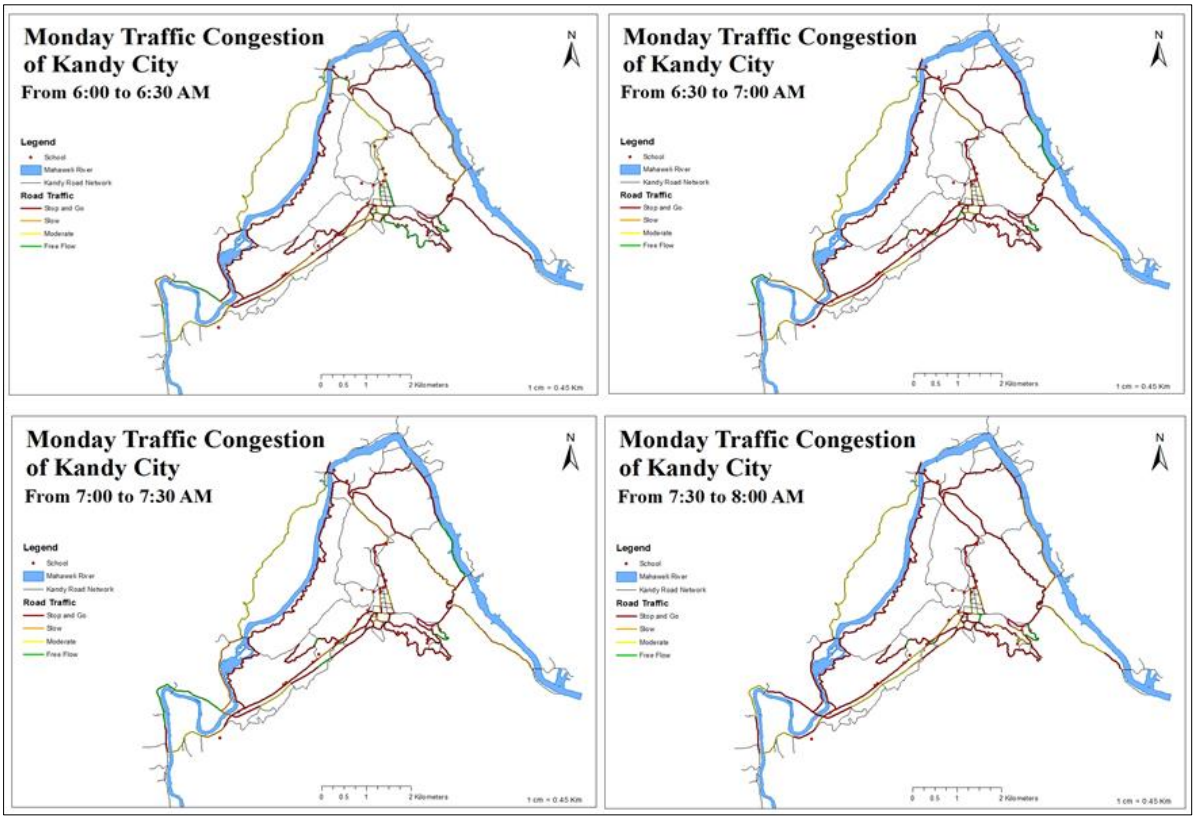

Fig. 9: Monday morning traffic congestion, left to right and top to bottom; 6.00 am – 6.30 am, 6.30 am – 7.00 am, 7.00 am to 7.30 am, and 7.30 am to 8.00 am.

Table 7: Afternoon School Traffic Congestion.

Zone	Traffic Level					
	North		East		West	
Place	Main Entrance	Near Schools	Main Entrance	Near Schools	Main Entrance	Near Schools
12.00 - 12.30	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy
12.30 - 1.00	Heavy	Heavy/ Moderate	Slow	Heavy	Heavy	Heavy
1.00 - 1.30	Heavy	Moderate	Heavy	Heavy / Free flow	Heavy	Heavy
1.30 - 2.00	Heavy	Heavy	Moderate	Heavy	Heavy	Heavy
2.00 - 2.30	Heavy	Heavy/ Moderate	Moderate	Slow	Free flow	Free flow

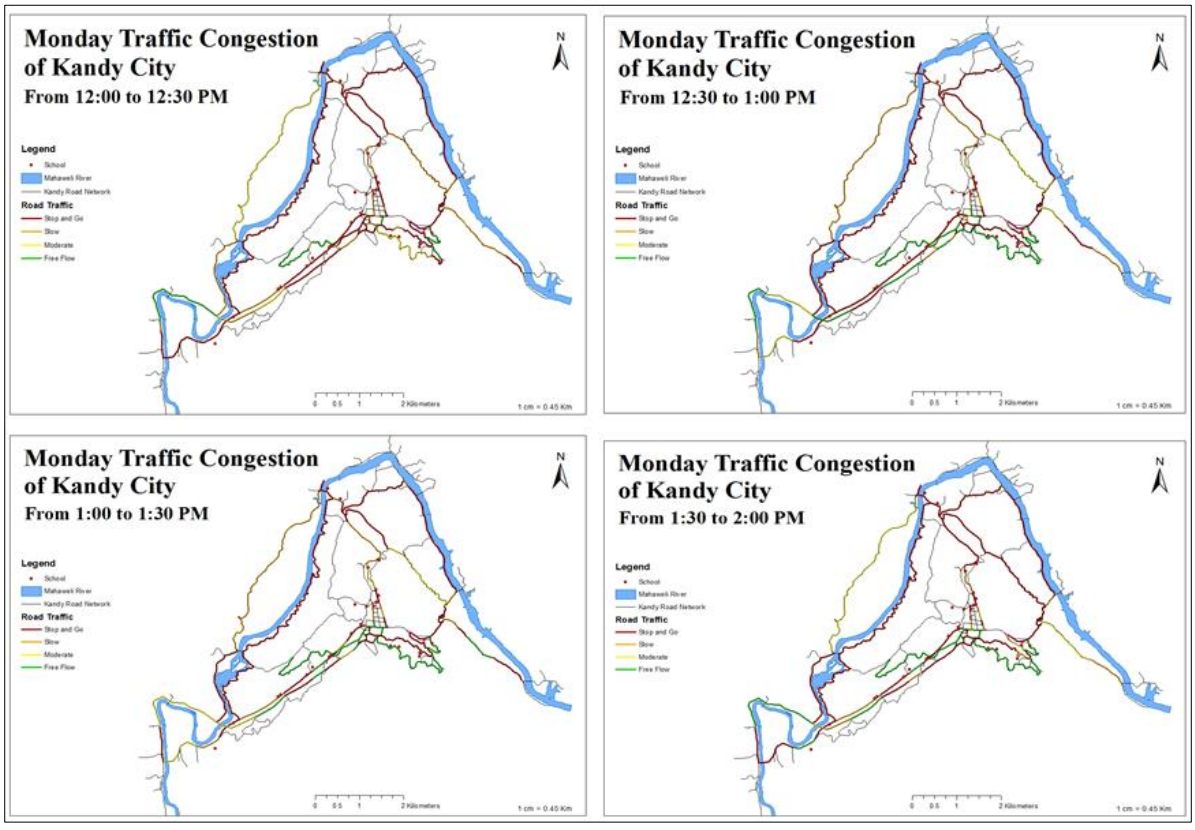

Fig. 10: Monday afternoon traffic congestion, left to right and top to bottom; 12 noon – 12.30 pm, 12.30 pm – 1.00 pm, 1.00 pm to 1.30 pm, and 1.30 pm to 2.00 pm.

Table 8: Selected Bus Stops

No	Zone	Bus Stop	School	Distance (m)
1	East Zone	Hillwood bus stop	Gothami Balika Maha Vidyalaya	414
2		Hillwood bus stop	Hillwood Girls' College	624
3		Lakeside bus stop	Mahamaya Girls' College	21
4		Mahamaya Girls' College (Primary) bus stop	Mahamaya Primary School	12

5		Buwelikada bus stop	D. S. Senanayaka Vidyalaya	44
6		Buwelikada bus stop	Darmaraja College	237
1	North Zone	Badi Ud Din bus stop	Badi Ud Din Mahmud Girls' College	19
2		Badi Ud Din bus stop	Trinity College	4
3		Vidyarthaya bus stop	Viddyartha College	7
4		Mahaiyawa bus stop	Viddyartha Primary School	134
5		Anthony's College bus stop	St. Anthony's Boys' College	95
6		Anthony's Convent bus stop	St. Anthony's Girls' College	167
7		Proposed bus stop 1	St. Sylvester's College	540
8		Proposed bus stop 1	Hemamali Balika Maha Vidyalaya	97
9		Proposed bus stop 2	St. Sylvester Primary School	25
10		Proposed bus stop 2	Wariyapola Sri Sumangala College	248
1	West Zone	Sarasawi Uyana bus stop	Sarasavi Uyana Maha Vidyalaya	11
2		Getambe ground bus stop	Mahanama Maha Vidyalaya	119
3		Regal bus stop	Darmavikrama Balika Maha Vidyalaya	128
4		Regal bus stop	Swarnamali Girls' College	85
5		High school bus stop	Girls' High school	3
6		High school bus stop	Vihara Mahadevi Girls' College	47
7		Police station bus stop	Sri Pushpadana Girls' College	9
8		Good Shepherd's bus stop	Good Shepherd's Convent	63
9		Propose bus stop 3	Kingswood College	75
10		Propose bus stop 3	Seethadevi Girls' College	63

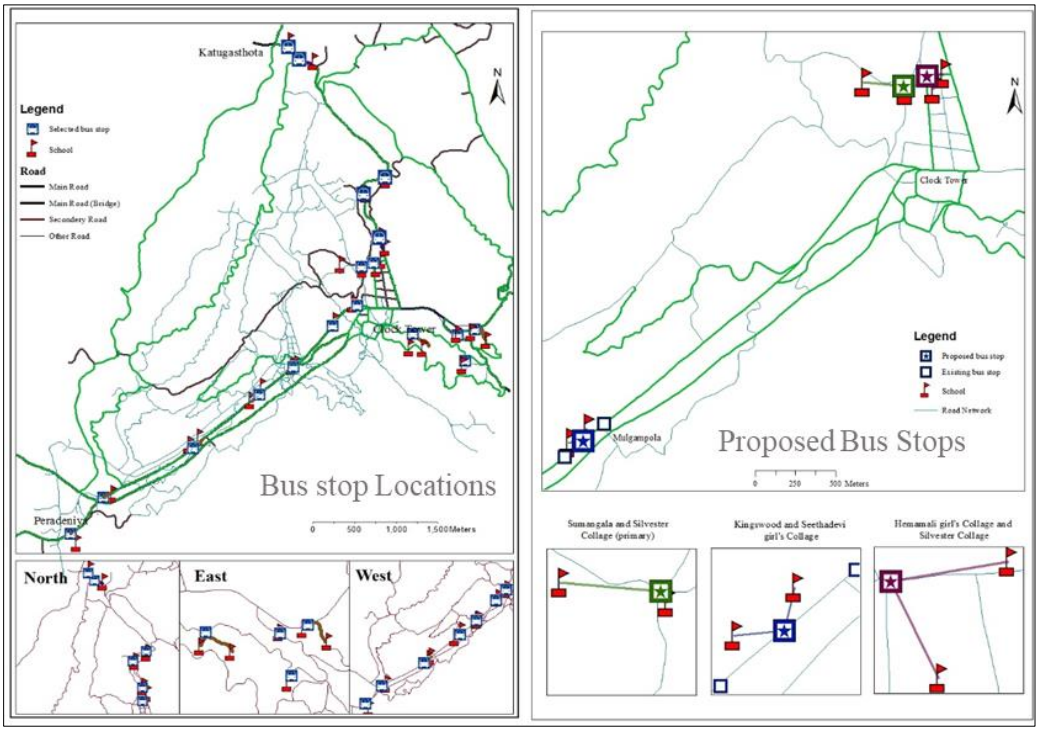

Fig. 11: All selected bus stops within the study area (left) and newly proposed bus stops (right).

3.5 Route Schedule Plan

The new schedule with the fastest bus route can be considered as a model. To reduce the number of school vehicles entering the city and to reduce the traffic congestion on the road during school time are the main aims of this model. Only three main entrance roads, such as SBM, A9 and A26 are considered.

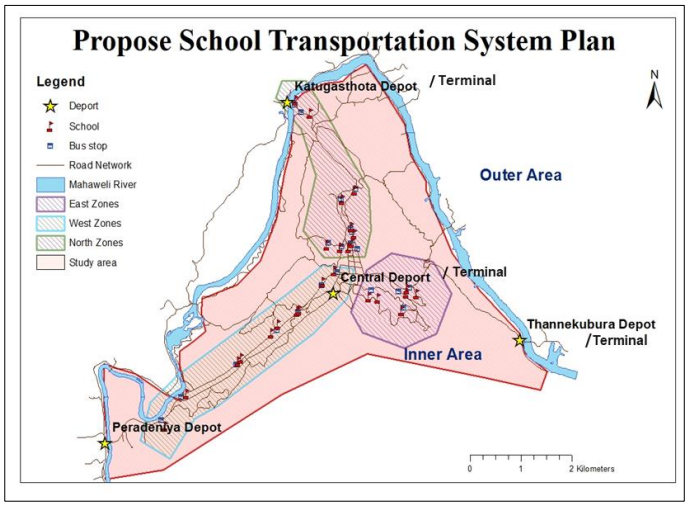

Fig. 12: Proposed School Transportation System Plan.

According to this model (Fig. 12), students are clustered into two categories; (I) students coming to schools from the study area (II) students coming to schools from outside of the study area. Routes are planned for both categories separately. Parking spaces and starting locations of the journey had to be identified. Considering the current traffic and space, it is recommended to locate a place outside the city. Most of the vehicles enter the city using three main entrances, and therefore these main entrances can be used to control the vehicles entering the city. These locations are Katugasthota, Thannekumbura and Peradeniya. The new students' transport system or the model can also be controlled from these three locations. These control stations can be introduced as terminals or destinations. In addition, one terminal must need to be set up at the center of the city because some of the morning services end up in the city and afternoon services need to start from the city. Students cannot go to this terminal. It is used only for the parking purpose.

The proposed new system can be managed by the government or any other authorized transportation organization. When the government manages this system, they can use Ceylon Transportation Board (CTB) buses to transport students and bus depot as parking places or buses can be used for passenger transportation outside school time. The system governed by other organizations can select parking places for vehicles until school time.

According to the new plan, all buses are starting from these three terminals in the morning and separate buses are assigned to take students from the outer and inner study area. The students who live outside the study area should come to the assigned terminal and needs to select a provided bus from the system management. They have the freedom to use any vehicle type to travel from their homes to the assigned terminal.

The last bus departure time from each zone in the morning and the first bus departure time from the afternoon are only mentioned in this system. In the morning, empty bus departs from the terminal to pick up students from the study area. Buses that bring students from outside the study area do not pick up students from the inner area and it stops only at the school bus stops to drop the students. Inner buses stop at all the bus stops to pick up students and school bus stops to drop off students. The system schedules to drop off all the students around 7.15 a.m. which gives them 15 minutes to walk to the school. In the afternoon, the first bus should reach the first school at 1.35 p.m. and 5 minutes are allocated for the students to get into the bus.

The buses stop around 2 minutes at each school after the first school and stop up to 3 minutes if two schools share the same bus stop. Inner study area buses are allowed to stop 1 minute at every bus stop which is within the study area. The buses which are carrying the outer students stop only at school bus stops and they are not allowed to stop at other bus stops within the study area.

Special attention is given during the process of route scheduling for the outer buses. Since the large buses are used to carry students coming from the outside of the city, they cannot travel by bypass roads because those are narrower than the main roads. This becomes an issue at the time of deciding the fastest route because if the route fell through the narrow road, the bus must be redirected and a new route must be selected. However, minibuses can be used to transport the inner students. Therefore they can use the bypass roads, and yet, the time difference between the main road and the bypass road is less than 5 minutes.

3.5.1 Generated routes for school vehicles

Generated fastest bus routes in the morning and afternoon for three terminals are shown in Fig. 13 to Fig. 15. Every route has a scheduled time frame. The bus starting terminal, destination terminal, total time and distance of the journey, bus arriving sequence of schools, and accumulated distances are included in that frame (Appendix 01 – 03) and most important details gathered in to one table in (Table 9).

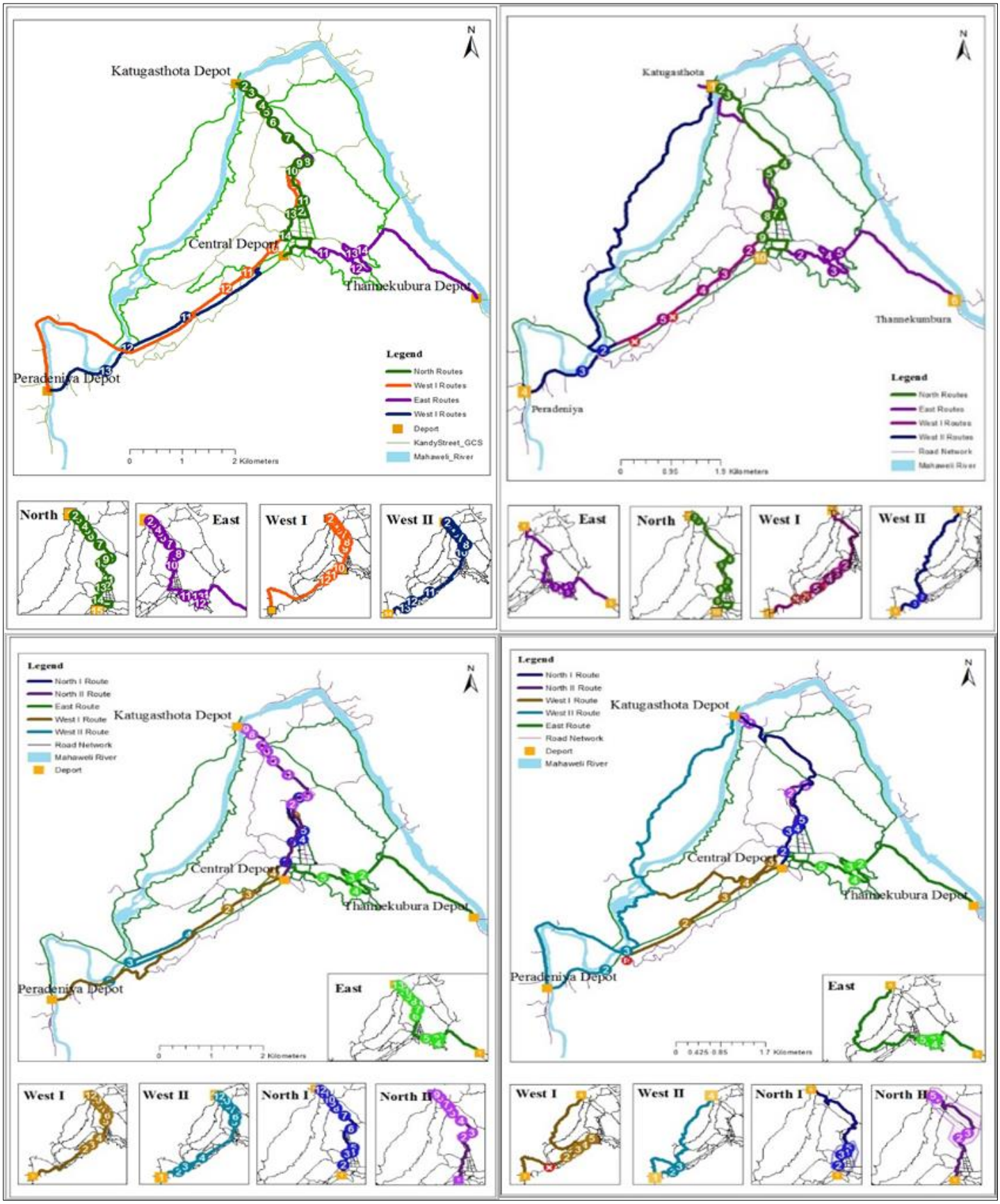

Fig. 13: Generated routes for Katugasthota terminal, left to right and top to bottom; morning inner service, morning outer service, afternoon inner service, and afternoon outer service.

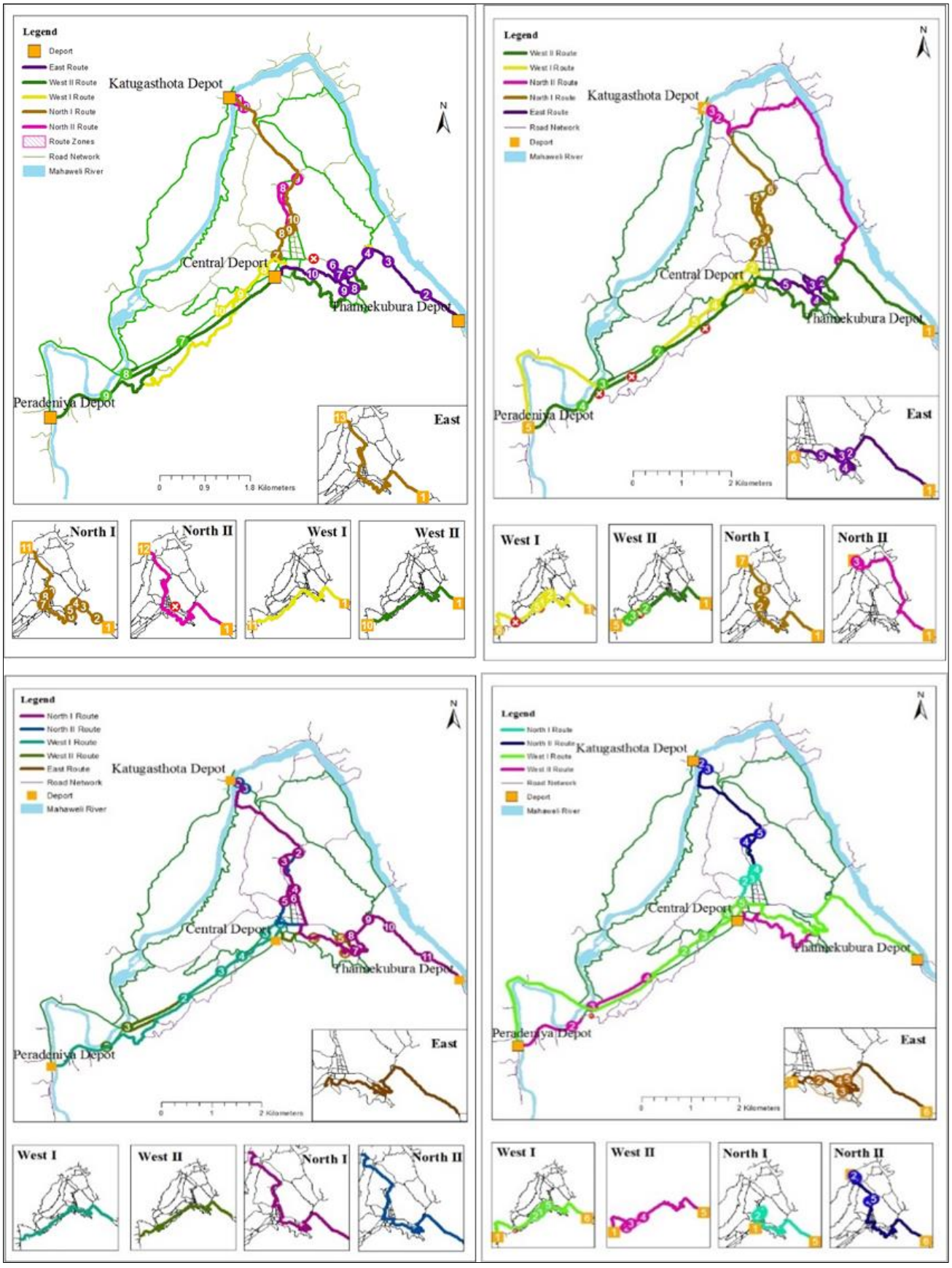

Fig. 14: Generated routes for Thannekumbura terminal, left to right and top to bottom; morning inner service, morning outer service, afternoon inner service, and afternoon outer service.

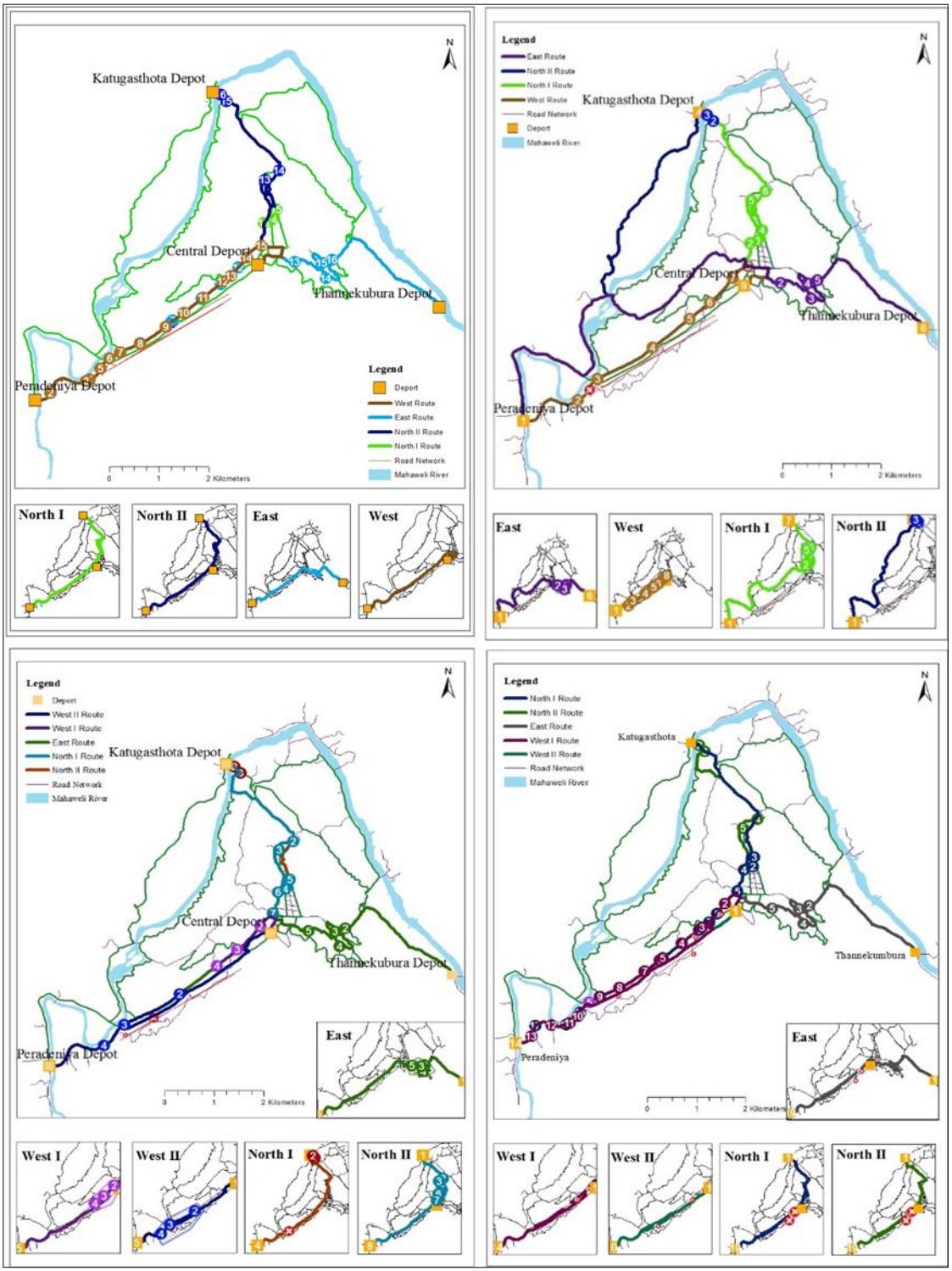

Fig. 15: Generated routes for Peradeniya terminal, left to right and top to bottom; morning inner service, morning outer service, afternoon inner service, and afternoon outer service.

According to the new schedule, the total time and distance of each route is less than 1 hour and 16 km respectively. The maximum time is 59 minutes. It is from Thannekumbura terminal to west II inner zone route during the morning service. West II outer zone to Thannekumbura terminal during the afternoon route is 16.1 km, which is the maximum distance.

Table 9: Schedule time and distance of routes

Zone	Service	Morning Services						Afternoon Services					
		Katugasthota		Thannekumbura		Peradeniya		Katugasthota		Thannekumbura		Peradeniya	
		Time (Minutes)	Distance (km)	Time (Minutes)	Distance (km)	Time (Minutes)	Distance (km)	Time (Minutes)	Distance (km)	Time (Minutes)	Distance (km)	Time (Minutes)	Distance (km)
North I	Inner	21	5.4	49	8.4	38	7	31	4.7	34	8.9	47	9.7
	Outer	23	5.3	52	10.9	35	13.1	24	5	28	8.2	32	9.2
North II	Inner	-	-	56	13.1	51	11.6	23	3.2	30	10.9	43	13.2
	Outer	-	-	45	9.1	29	10.8	19	3.8	39	12.5	26	10.8
East	Inner	47	9.5	52	5.6	51	7.12	42	10.5	21	6.1	44	11.7
	Outer	36	8.7	48	5.5	38	12.8	35	12.2	24	6.1	30	9.3
West I	Inner	35	7.4	49	8.7	36	5.8	34	6.7	33	9.8	36	10.5
	Outer	30	7.1	46	8.8	34	5.14	23	11.5	30	9.1	22	7.2
West II	Inner	56	10.9	59	14.4	-	-	40	10.8	32	12.7	30	9
	Outer	30	9.2	58	12.2	-	-	23	12.7	48	16.1	23	6.8

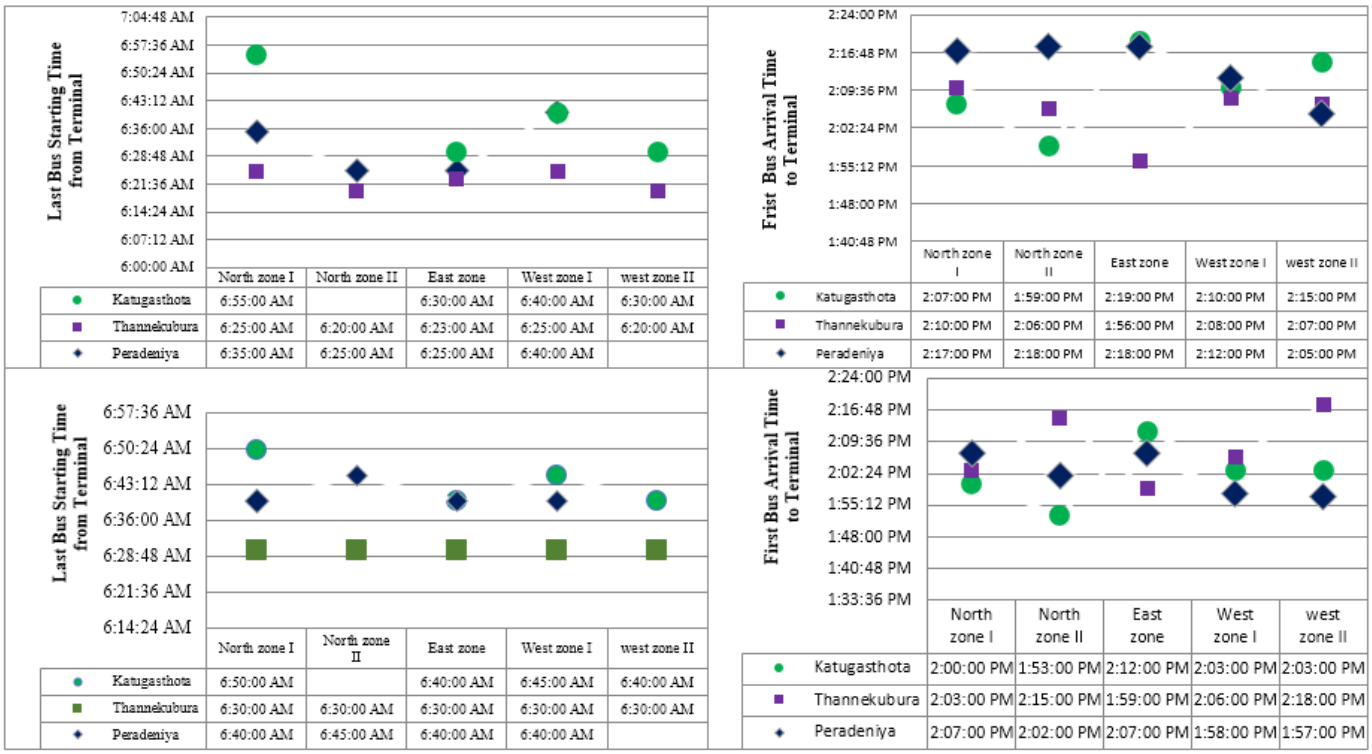

Fig. 16: Summary of scheduled bus routes, left to right and top to bottom; morning inner service, afternoon inner service, morning outer service and afternoon outer service.

3.6 Summarization of Bus Route Scheduling

Morning and afternoon school transportation route scheduling is covered under three major and two minor zones. Fig. 16 provides the summary of the last bus departure time of the morning service and the first bus arrival time to the terminals in the afternoon service.

4 Conclusions and Recommendations

4.1 Conclusions

This study proposes a method to reduce the traffic congestion due to school services, which will consequently reduce the time wasted on the road, cutting down the fuel cost and vehicle wastage, and most of all reduce environmental pollution. Assigning each student to a particular bus which must be routed in an efficient manner could be the solution to the school traffic congestion. Visualizing the present traffic congestion level on the road, assigning a suitable bus stop for each school and generating the fastest route for the school buses will be an added advantage.

This study successfully applied the SRBP in GIS to organize school buses in Kandy City. The maps developed in ArcGIS using historical traffic data for every 30-minute interval can be used to visualize 12-hour daytime traffic. This helps to calculate traffic costs during the route schedule. According to historical traffic data, the "school time" in Kandy City is considered as 1 hour 15 minutes after 6.25 a.m. in the morning and 1 hour after 1.25 p.m. in the afternoon.

The proposed system reduces the time wasted during the drop or pick up of students from individual vehicles. According to the proposed school transportation system, 56 fastest routes are identified in order to cover all schools. With the existing traffic congestion, all routes end in less than one hour and 16 km. This is only one trip to each direction

Hence the new system can reduce the large number of vehicles entering the city. It increases travel speed and as a result, the traveling time of all students will be less.

4.2 Recommendations

Though a new school transportation concept was introduced here, the infrastructure and number of buses required, safety measures and capital needed to invest are not mentioned in this study. At the time of implementation, the above factors must be considered. Furthermore, there is room to extend this concept to rural areas, which means the students can be picked up at their doorsteps.

This system itself can be linked through a web GIS, which can allow the parents, teachers, and transport system management to obtain details of the system such as the route of buses, bus stop locations, arrival and departure time and the traffic congestion of the city in the school time. School buses are not the only reason that increases traffic congestion during school time. In relation to this concept, traffic congestion can be reduced even further if the schools can introduce overhead bridges instead of road crossings.

4.2.1 Quality of the Service and the Security of the Students

Since a different system has been introduced than the existing student transportation system, the quality of the service and student protection must be maintained throughout the journey. Those are the key factors to the success of this new system. This system can be implemented either by the government or the private sector but they should follow rules and regulations which are introduced by the responsible institutions in the transportation sector. Rules and regulations can be introduced considering the following factors:

- The maximum number of the student must be limited to the number of seats
- All buses should have seat belts
- A student friendly environment should be maintained inside the bus
- Throwing out things from the bus and putting out body parts through the windows must be stopped Every bus must have an assistant
- No student stays on the bus after passing the last school
- If a student gets sick, it should be informed to the parent

When considering the protection of the student, there should be special attention when students get into the bus at the terminal and when they reached the destination. Outsiders are not allowed to enter the terminal area during school time. To maintain these discipline and security measures, some officials should be assigned and they should be given this responsibility with the assistance of the police officers. The school traffic team and police officers who are assigned duties near the school are responsible for escorting students safely from the bus to the school premises.

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Author Contributions

Conceptualization, methodology, analysis, writing - original draft preparation, A.B.G.T.L. review and editing, N.H and expert consultations S.I.M.S. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Appendix 1: Generated Routes for Katugasthota Terminal (Fig. 14)

Zone	Route Details					Latest Bus			
	Sequence	Name	Arrive Time (AM)	Accumulated Distance (km)	Service Time (Minutes)	Departure Time from Depot	Arrive Time to Depot	Total Time (Minutes)	Total Distance (km)
Morning Inner Service									
Katugasthota to North Zone	1	Anthony's college	6:55	175 m	2	6:55:00 AM	7:20:00 AM	25	6.8
	2	Anthiny's convent	6:57	355 m	2				
	3	Bus stop 1	6:58	771 m	<1				
	4	Bus stop 2	6:59	982 m	<1				
	5	Bus stop 3	7:00	1.2	<1				
	6	Bus stop 4	7:01	1.7	<1				
	7	Viddyartha college (primary)	7:03	2.7	1				
	8	Bus stop 5	7:05	2.9	1				
	9	Viddyartha college	7:06	3.2	2				
	10	Badi UD Din girl's college	7:08	3.9	2				
	11	Trinity college							
	12	Hemamali girl's college	7:11	4.6	2				
	13	Silvester college							
	14	Silvester college (primary)	7:14	4.9	2				
	15	Sri Sumangala maha viddyalaya							
	16	Pushpadana girl's college	7:16	5.4	1				
Katugasthota to East Zone	1	Anthony's college bus stop	6:32	175 m	<1	6:30:00 AM	7:24:00 AM	1 hr	12.4
	2	Anthiny's convent bus stop	6:38	355 m	<1				
	3	Bus stop 1	6:42	771 m	<1				
	4	Bus stop 2	6:44	982 m	<1				
	5	Bus stop 3	6:45	1.2	<1				
	6	Bus stop 4	6:47	1.7	<1				
	8	Bus stop 5	6:48	2.3	1				
	9	Hillwood girl's college	7:02	6.9	2				
	10	Gothami balika maha vidyalaya							
	11	Mahamaya girl's college	7:07	7.9	2				
	12	Mahamaya girl's college (primary)	7:12	8.7	2				
	13	D.S Senanayaka maha vidayalaya	7:17	9.5	2				
	14	Darmaraja college							

Katugasthota to West Zone I	1	Anthony's college bus stop	6:42	175 m	<1	6:40:00 AM	7:30:00 AM	50	13.3
	2	Anthiny's convent bus stop	6:47	355 m	<1				
	3	Bus stop 1	6:50	771 m	<1				
	4	Bus stop 2	6:52	982 m	<1				
	5	Bus stop 3	6:53	1.2	<1				
	6	Bus stop 4	6:55	1.7	<1				
	7	Bus stop 5	6:57	2.5	1				
	8	Vidyarthaya bus stop	7:00	3.8					
	9	Good shephered convent	7:08	6.2	2				
	10	Viharamahadevi girl's college	7:12	6.9	2				
	11	Girl's High school							
	12	Swarnamali girl's college	7:15	7.4	2				
	13	Darmavickrama girl's college							
Katugasthota to West Zone II	1	Anthony's college bus stop	6:32	175 m	<1	6:30:00 AM	7:31:00 AM	1 hr 1 min	12.3
	2	Anthiny's convent bus stop	6:38	355 m	<1				
	3	Bus stop 1	6:41	771 m	<1				
	4	Bus stop 2	6:43	982 m	<1				
	5	Bus stop 3	6:44	1.2	<1				
	6	Bus stop 4	6:46	1.7	<1				
	7	Bus stop 5	6:49	2.5	1				
	9	Seethadevi girl's college	7:04	9	2				
	10	Kingswood boy's college							
	11	Mahanama college	7:16	10.3	2				
	12	Sarasavi Uyanna maha vidyalaya	7:26	10.9	2				
Morning Outer Service									
Katugasthota to North Zone	1	Anthony's college	6:50	174.6	2	6:50:00 AM	7:19:00 AM	29	6.1
	2	Anthiny's convent	6:53	355.1	2				
	3	Viddyartha college (primary)	6:58	2672	2				
	4	Viddyartha college	7:01	3.1	2				
	5	Badi UD Din girl's college	7:04	3.9	2				
	6	Trinity college			2				
	7	Hemamali girl's college	7:07	4.5	3				
	8	Silvester college							
	9	Silvester college (primary)	7:10	4.8	3				
	10	Sri Sumangala maha viddyalaya							
	11	Pushpadana girl's college	7:13	5.3	2				
Katugasthota to East Zone	1	Hillwood girl's college	7:01	6.2	3	6:40:00 AM	7:28:00 AM	48	11.8
	2	Gothami balika maha vidyalaya							
	3	Mahamaya girl's college	7:06	7.2	2				

	4	Mahamaya girl's college (primary)	7:10	8	2				
	5	D.S Senanayaka maha vidayalaya	7:16	8.7	3				
	6	Darmaraja college							
Katugasthota to West Zone I	1	Good shephered convent	7:01	5	2	6:45:00 AM	7:39:00 AM	54	10.4
	2	Viharamahadevi girl's college	7:05	5.6	3				
	3	Girl's High school							
	4	Swarnamali girl's college	7:08	6.2	2				
	5	Darmavickrama girl's college							
	6	Seethadevi girl's college	7:15	7.1	3				
	7	Kingswood boy's college							
Katugasthota to West Zone II	1	Mahanama college	7:01	8.6	2	6:40:00 AM	7:17:00 AM	37	10.9
	2	Sarasavi Uyanna maha vidyalaya	7:10	9.2	2				
Afternoon Inner Service									
North Zone I to Katugasthota Depot	1	Pushpadana girl's college	1:36	601	1	1:35:00 PM	2:07:00 PM	32	5.3
	2	Silvester college (primary)	1:38	1.1	2				
	3	Sri Sumangala maha vidyalaya							
	4	Silvester college	1:41	1.5	2				
	5	Hemamali girl's college							
	6	Trinity college	1:44	1.8	2				
	7	Badi UD Din girl's college							
	8	Bus stop 5	1:48	2.8	<1				
	9	Bus stop 4	1:54	3.6	<1				
	10	Bus stop 3	1:58	4.1	<1				
	11	Bus stop 2	2:01	4.3	<1				
	12	Bus stop 1	2:03	4.5	<1				
	13	Anthiny's convent bus top	2:05	5	<1				
	14	Anthony's college bus stop	2:06	5.1	<1				
North Zone II to Katugasthota Depot	1	Viddyartha college	1:36	2.2	1	1:32:00 PM	1:59:00 PM	27	5.4
	2	Viddyartha college (primary)	1:38	2.9	1				
	9	Bus stop 4	1:45	3.7	<1				
	10	Bus stop 3	1:49	4.1	<1				
	11	Bus stop 2	1:52	4.4	<1				
	12	Bus stop 1	1:54	4.6	<1				
	3	Anthiny's convent	1:56	5	1				
	4	Anthony's college	1:57	5.2	1				
East Zone to Katugasthota Depot	1	Darmaraja college	1:37	3	2	1:25:00 PM	2:19:00 PM	54	10.8
	2	D.S Senanayaka maha vidayalaya							
	3	Mahamaya girl's college (primary)	1:41	3.7	1				

	4	Mahamaya girl's college	1:45	4.6	1				
	5	Gothami balika maha vidyalaya	1:51	5.5	2				
	6	Hillwood girl's college							
	7	Mahaiyawa bus stop	1:58	7.7	<1				
	8	Bus stop 5	2:00	8	<1				
East Zone to Katugasthota Depot	9	Bus stop 4	2:06	9.1	<1				
	10	Bus stop 3	2:10	9.6	<1				
	11	Bus stop 2	2:13	9.8	<1				
	12	Bus stop 1	2:15	10	<1				
	13	Anthiny's convent bus top	2:17	10.4	<1				
	14	Anthony's college bus stop	2:18	10.6	<1				
West Zone I to Katugasthota Depot	1	Darmavickrama girl's college	1:36	4.8	2	1:28:00 PM	2:10:00 PM	42	11.5
	2	Swarnamali girl's college							
	3	Girl's High school	1:39	5.3	2				
	4	Viharamahadevi girl's college							
	5	Good shephered convent	1:34	6.8	1				
	6	Mahaiyawa bus stop	1:48	8.5	<1				
	7	Bus stop 5	1:50	9	<1				
	8	Bus stop 4	1:57	9.8	<1				
	9	Bus stop 3	1:01	10.3	<1				
	10	Bus stop 2	2:03	10.5	<1				
	11	Bus stop 1	2:05	10.7	<1				
	12	Anthiny's convent bus top	2:08	11.2	<1				
	13	Anthony's college bus stop	2:08	11.3	<1				
West Zone II to Katugasthota Depot	1	Sarasavi Uyanna maha vidyalaya	1:35	1.41	1	1:30:00 PM	2:15:00 PM	45	12.2
	2	Mahanama college	1:41	3.8	1				
	3	Seethadevi girl's college	1:45	5.1	2				
	4	Kingswood boy's college							
	5	Mahaiyawa bus stop	1:54	9.1	<1				
	6	Bus stop 5	1:56	9.7	<1				
	7	Bus stop 4	2:02	10.5	<1				
	8	Bus stop 3	2:06	11	<1				
	9	Bus stop 2	2:09	11.2	<1				
	10	Bus stop 1	2:11	11.4	<1				
	11	Anthiny's convent bus top	2:14	11.8	<1				
	12	Anthony's college bus stop	2:14	12	<1				

Afternoon Outer Service									
North Zone I to Katugasthota Depot	1	Pushpadana girl's college	1:36	589 m	2	1:35:00 PM	2:00:00 PM	25	5.6
	2	Silvester college (primary)	1:39	1.1	3				
	3	Sri Sumangala maha vidyalaya							
	4	Silvester college	1:42	1.4	3				
	5	Hemamali girl's college							
	6	Trinity college	1:47	1.8	3				
	7	Badi UD Din girl's college							
North Zone II to Katugasthota Depot	1	Viddyartha college	1:34	2.2	3	1:30:00 PM	1:53:00 PM	23	6
	2	Viddyartha college (primary)	1:38	2.9	2				
	3	Anthiny's convent	1:47	5.6	2				
	4	Anthony's college	1:50	5.8	2				
East Zone to Katugasthota Depot	1	Darmaraja college	1:37	3	3	1:25:00 PM	2:12:00 PM	47	15.2
	2	D.S Senanayaka maha vidayalaya							
	3	Mahamaya girl's college (primary)	1:42	3.7	2				
	4	Mahamaya girl's college	1:47	3.7	2				
	5	Gothami balika maha vidyalaya	1:53	5.5	3				
	6	Hillwood girl's college							
West Zone I to Katugasthota Depot	1	Kingswood boy's college	1:35	5.1	3	1:25:00 PM	2:03:00 PM	38	16.6
	2	Seethadevi girl's college							
	3	Darmavickrama girl's college	1:39	6.1	3				
	4	Swarnamali girl's college							
	5	Girl's High school	1:43	6.6	3				
	6	Viharamahadevi girl's college							
	7	Good shephered convent	1:49	8.1	2				
West Zone II to Katugasthota Depot	1	Sarasavi Uyanna maha vidyalaya	1:35	1.4	3	1:30:00 PM	2:03:00 PM	33	14.1
	2	Mahanama college	1:48	6.2	2				

Appendix 2: Generated Routes for Thannekumbura Terminal (Fig. 15)

Zone	Route Details					Latest Bus			
	Sequence	Name	Arrive Time (AM)	Accumulated Distance (km)	Service Time (Minutes)	Depart Time from Depot	Arrive Time to Depot	Total Time (Minutes)	Total Distance (km)
Morning Inner Service									
Thannekumbura to North Zone I	1	Thannekumbura junction	6:28	861 m	<1	6:25:00 AM	7:29:00 AM	1 hr 4 min	11.6
	2	Thalwattha bus stop	6:36	1.9	<1				
	3	Lewella junction	6:43	2.5	<1				
	4	Darmaraja junction	6:50	3.1	<1				
	5	Children's park bus stop	6:59	4.1	<1				
	6	Pushpadana girl's college	7:06	7.2	1				
	7	Silvester college (primary)	7:07	7.7	2				
	8	Sri Sumangala maha vidyalaya							
	9	Silvester college	7:10	8	2				
	10	Hemamali girl's college							
	11	Trinity college	7:14	8.4	2				
	12	Badi UD Din girl's college							
Thannekumbura to North Zone II	1	Thannekumbura junction	6:23	861 m	<1	6:20:00 AM	7:21:00 AM	1 hr 1min	13.2
	2	Thalwattha bus stop	6:29	1.9	<1				
	3	Lewella junction	6:34	2.4	<1				
	4	Darmaraja junction	6:48	3.1	<1				
	5	Children's park bus stop	6:52	4.2	<1				
	6	Viddyartha college	7:02	8.9	1				
	7	Viddyartha college (primary)	7:06	10.8	1				
	8	Anthiny's convent	7:15	12.9	1				
	9	Anthony's college	7:16	13.1	1				
Thannekumbura to East Zone	1	Thannekum bura junction	6:26	861 m	<1	6:23:00 AM	7:20:00 AM	57	6.5
	2	Thalwattha bus stop	6:34	1.9	<1				
	3	Lewella junction	6:41	2.5	<1				
	4	Darmaraja college	6:54	3.1	2				
	5	D.S Senanayaka maha vidayalaya							
	6	Mahamaya girl's college (primary)	7:01	3.8	1				
	7	Mahamaya girl's college	7:10	4.7	1				
	8	Gothami balika maha vidyalaya	7:15	5.6	2				
	9	Hillwood girl's college							

Thannekumbura to West Zone I	1	Thannekum bura junction	6:28	861 m	<1	6:25:00 AM	7:27:00 AM	1 hr 2 min	15
	2	Thalwattha bus stop	6:36	1.9	<1				
	3	Lewella junction	6:42	2.5	<1				
	4	Darmaraja junction	6:56	3.1	<1				
	5	Children's park bus stop	7:00	4.2	<1				
	6	Good shephered convent	7:08	7.5	1				
	7	Viharamahadevi girl's college	7:11	8.2	2				
	8	Girl's High school							
	9	Swarnamali girl's college	7:14	8.7	2				
	10	Darmavickrama girl's college							
Thannekumbura to West Zone II	1	Thannekumbura junction	6:23	861 m	<1	6:20:00 AM	7:23:00 AM	1 hr 3 min	15.7
	2	Thalwattha bus stop	6:29	1.9	<1				
	3	Lewella junction	6:35	2.5	<1				
	4	Darmaraja junction	6:48	3.1	<1				
	5	Children's park bus stop	6:52	4.2	<1				
	6	Seethadevi girl's college	7:04	9.6	2				
	7	Kingswood boy's college							
	8	Mahanama college	0:00	11.9	1				
	9	Sarasavi Uyanna maha vidyalaya	7:19	14.4	1				
Morning Outer Service									
Thannekumbura to North Zone I	1	Silvester college (primary)	7:06	7.6	2	6:30:00 AM	7:44:00 AM	1 hr 14 min	13.3
	2	Sri Sumangala maha viddyalaya							
	3	Silvester college	7:08	7.9	2				
	4	Hemamali girl's college							
	5	Trinity college	7:12	8.2	2				
	6	Badi UD Din girl's college							
	7	Viddyartha college	7:16	9	2				
	8	Viddyartha college (primary)	7:22	10.9	2				
Thannekumbura to North Zone II	9	Anthiny's convent	7:12	8.9	2	6:30:00 AM	7:20:00 AM	50 min	9.2
	10	Anthony's college	7:15	9.1					
Thannekumbura to East Zone	1	Darmaraja college	6:56	3	2	6:30:00 AM	7:22:00 AM	52	6.4
	2	D.S Senanayaka maha vidayalaya							
	3	Mahamaya girl's college (primary)	7:02	3.7	2				
	4	Mahamaya girl's college	7:11	4.6	2				
	5	Gothami balika maha vidyalaya	7:18	5.5	2				
	6	Hillwood girl's college							

Thannekumbura to West Zone I	1	Pushpadana girl's college	7:05	7.1	2	6:30:00 AM	7:36:00 AM	1 hr 6 min	14.6
	2	Good shephered convent	7:09	7.5	2				
	3	Viharamahadevi girl's college	7:13	8.2	2				
	4	Girl's High school							
	5	Swarnamali girl's college	7:16	8.8	2				
	6	Darmavickrama girl's college							
Thannekumbura to West Zone II	1	Seethadevi girl's college	7:11	9.8	2	6:30:00 AM	7:36:00 AM	1 hr 6 min	14.1
	2	Kingswood boy's college							
	3	Mahanama college	7:19	12.2	2				
	4	Sarasavi Uyanna maha vidyalaya	7:28	12.2	2				
Afternoon Inner Service									
North Zone I to Thannekumbura Depot	1	Viddyartha college	1:36	2.8	1	1:28:00 PM	2:10:00 PM	42	11.7
	2	Viddyartha college (primary)	1:39	3.3	1				
	3	Trinity college	1:42	4.0	2				
	4	Badi UD Din girl's college							
	5	Silvester college (primary)	1:45	4.6	2				
	6	Sri Sumangala maha viddyalaya							
	7	Silvester college	1:48	4.9	2				
	8	Hemamali girl's college							
	9	Children's park bus stop	1:55	7.6	<1				
	10	Buwelikada bus stop	1:57	8.7	<1				
	11	Lewella junction bus stop	2:01	9.3	<1				
	12	Thalwattha bus stop	2:04	9.8	<1				
	13	Thannekumbura junction	2:07	10.9	<1				
North Zone II to Thannekumbura Depot	1	Anthiny's convent	1:36	175 m	1	1:35:00 PM	2:06:00 PM	31	11.1
	2	Anthony's college	1:39	355 m	1				
	3	Children's park bus stop	1:52	6.9	<1				
	4	Buwelikada bus stop	1:54	8	<1				
	5	Lewella junction bus stop	1:58	8.6	<1				
	6	Thalwattha bus stop	2:00	9.2	<1				
	7	Thannekumbura junction	2:03	10.2	<1				
East Zone to Thannekumbura Depot	1	Hillwood girl's college	1:35	1.3	2	1:33:00 PM	1:56:00 PM	23	7.4
	2	Gothami balika maha vidyalaya							
	3	Mahamaya girl's college	1:38	2.3	1				
	4	Children's park bus stop	1:40	2.7	<1				
	5	Mahamaya girl's collage (primary)	1:41	3.1	1				
	6	D.S Senanayaka maha vidayalaya	1:44	4.4	2				
	7	Darmaraja college							

	8	Lewella junction bus stop	1:50	5	<1				
	9	Thalwattha bus stop	1:52	5.5	<1				
	10	Thannekumbura junction	1:54	6.6	<1				
West Zone I to Thannekumbura Depot	1	Seethadevi girl's college	1:35	4.1	2	1:28:00 PM	2:08:00 PM	40	13.9
	2	Kingswood boy's college							
	3	Darmavickrama girl's college	1:38	5	2				
	4	Swarnamali girl's college							
	5	Girl's High school	1:41	5.6	2				
	6	Viharamahadevi girl's college							
	7	Good shephered convent	1:46	7.1	1				
	8	Pushpadana girl's college	1:49	7.5	1				
	9	Children's park bus stop	1:53	9.8	<1				
	10	Buwelikada bus stop	1:55	10.9	<1				
	11	Lewella junction bus stop	2:00	11.5	<1				
	12	Thalwattha bus stop	2:02	12	<1				
	14	Thannekumbura junction	2:05	13.1	<1				
West Zone II to Thannekumbura Depot	1	Sarasavi Uyanna maha vidyalaya	1:35	1.4	1	1:30:00 PM	2:07:00 PM	37	14.1
	2	Mahanama college	1:41	3.8	1				
	3	Children's park bus stop	1:53	9.9	<1				
	4	Buwelikada bus stop	1:55	11	<1				
	5	Lewella junction bus stop	1:59	11.6	<1				
	6	Thalwattha bus stop	2:02	12.2	<1				
	7	Thannekumbura junction	2:05	13.2	<1				
Afternoon Outer Service									
North Zone I to Thannekumbura Depot	1	Silvester college (primary)	1:35	1.1	5	1:33:00 PM	2:03:00 PM	30	9.3
	2	Sri Sumangala maha viddyalaya							
	3	Silvester college	1:40	1.4	3				
	4	Hemamali girl's college							
	5	Trinity college	1:45	1.8	3				
	6	Badi UD Din girl's college							
North Zone II to Thannekumbura Depot	1	Anthiny's convent	1:36	175 m	2	1:35:00 PM	2:15:00 PM	40	12.7
	2	Anthony's college	1:43	355 m	2				
	3	Viddyartha college	1:51	3.1	2				
	4	Viddyartha college (primary)	1:54	3.5	2				
East zone to Thannekumbura Depot	1	Hillwood girl's college	1:35	1.3	5	1:33:00 PM	1:59:00 PM	26	7.4
	2	Gothami balika maha vidyalaya							
	3	Mahamaya girl's college	1:41	2.3	2				
	4	Mahamaya girl's college (primary)	1:45	3.1	2				

	5	D.S Senanayaka maha vidayalaya	1:40	4.4	3				
	6	Darmaraja college							
West Zone I to Thannekumbura Depot	1	Darmavickrama girl's college	1:36	5.8	3	1:25:00 PM	2:06:00 PM	41	14.9
	2	Swarnamali girl's college							
	3	Girl's High school	1:40	6.4	3				
	4	Viharamahadevi girl's college							
	5	Good shephered convent	1:46	8.1	2				
	6	Pushpadana girl's college	1:50	8.6	2				
West Zone II to Thannekumbura Depot	1	Sarasavi Uyanna maha vidyalaya	1:35	1.4	2	1:30:00 PM	2:18:00 PM	48	17.5
	2	Mahanama collage	1:51	6.7	2				
	3	Seethadevi girl's college	1:56	8	3				
	4	Kingswood boy's college							

Appendix 3: Generated Routes for Peradeniya Terminal (Fig. 16)

Zone	Route Details					Latest Bus			
	Sequence	Name	Arrive Time (AM)	Accumulated Distance (km)	Service Time (Minutes)	Depart Time from Depot	Arrive Time to Depot	Total Time (Minutes)	Total Distance (Meter)
Morning Inner Service									
Peradeniya to North Zone I	1	Galaha junction bus stop	6:36	375 m	<1	6:35:00 AM	7:43:00 AM	1 hr 8 min	12.3
	2	Peradeniya hospital bus stop	6:38	1.3	<1				
	3	Dangolla bus stop	6:41	1.7	<1				
	4	Art Lanka bus stop	6:47	2.2	<1				
	5	bus stop 1	6:49	2.7	<1				
	6	Danasiri bus stop	6:54	3.5	<1				
	7	Suwasewana bus stop	6:57	3.8	<1				
	8	Darmavickrama girl's college	7:00	4.2	<1				
	9	Swarnamali girl's college							
	10	Girl's High school	7:02	4.7	<1				
	11	Viharamahadevi girl's college							
	12	Dodanwala junction bus stop	7:03	5	<1				
	13	Good shephered convent	7:04	5.2	<1				
	14	Silvester collage (primary)	7:07	6.3	2				
	15	Sri Sumangala maha viddyalaya							
	16	Silvester collage	7:09	6.6	2				
	17	Hemamali girl's college							
	18	Trinity college	7:13	7.0	2				
	19	Badi UD Din girl's college							
Peradeniya to North Zone II	1	Galaha junction bus stop	6:25	375 m	<1	6:25:00 AM	7:21:00 AM	56	11.8
	2	Peradeniya hospital bus stop	6:28	1.3	<1				
	3	Dangolla bus stop	6:30	1.7	<1				
	4	Art Lanka bus stop	6:35	2.2	<1				
	5	bus stop 1	6:38	2.7	<1				
	6	Danasiri bus stop	6:43	3.5	<1				
	7	Suwasewana bus stop	6:45	3.8	<1				
	8	Darmavickrama girl's college	6:49	4.2	<1				
	9	Swarnamali girl's college							
	10	Girl's High school	6:53	4.7	<1				
	11	Viharamahadevi girl's college							
	12	Dodanwala junction bus stop	6:55	5	<1				
	13	Good shephered convent	6:56	5.2	<1				
	14	Viddyartha college	7:02	7.4	1				

	15	Viddyartha college (primary)	7:06	9.3	1				
	16	Anthiny's convent	7:15	11.5	1				
	17	Anthony's college	7:16	11.6	1				
Peradeniya to East Zone	1	Galaha junction bus stop	6:26	375 m	<1	6:25:00 AM	7:28:00 AM	1 hr 3 min	12.3
	2	Peradeniya hospital bus stop	6:28	1.3	<1				
	3	Dangolla bus stop	6:30	1.7	<1				
	4	Art Lanka bus stop	6:35	2.2	<1				
	5	bus stop 1	6:38	2.7	<1				
	6	Danasiri bus stop	6:43	3.5	<1				
	7	Suwasewana bus stop	6:45	3.8	<1				
	8	Darmavickrama girl's college	6:49	4.2	<1				
	9	Swarnamali girl's college							
	10	Girl's High school	6:53	4.7	<1				
	11	Viharamahadevi girl's college							
	12	Dodanwala junction bus stop	6:55	5	<1				
	13	Good shephered convent	6:56	5.2	<1				
	14	Hillwood girl's college	7:02	6.8	2				
	15	Gothami balika maha vidyalaya							
	16	Mahamaya girl's college	7:11	8.6	1				
	17	Mahamaya girl's college (primary)	7:11	8.6	1				
	18	D.S Senanayaka maha vidayalaya	7:16	7:12	2				
	19	Darmaraja college							
Peradeniya to West Zone I	1	Glaha junction bus stop	6:41	375 m	<1	6:40:00 AM	7:21:00 AM	41	7.1
	2	Peradeniya hospital bus stop	6:44	1.3	<1				
	3	Sarasavi Uyanna maha vidyalaya	6:45	1.4	<1				
	4	Dangolla bus stop	6:48	1.7	<1				
	5	Mahanama college	6:53	2	1				
	6	Art Lanka bus stop	6:55	2.2	<1				
	7	bus stop 1	6:58	2.7	<1				
	8	Kingswood boy's college	7:01	3.3	2				
	9	Seethadevi girl's college							
	10	Suwasewana bus stop	7:04	3.8	<1				
	11	Darmavickrama girl's college	7:06	7:12	2				
	12	Swarnamali girl's college							
	13	Girl's High school	7:10	4.8	2				
	14	Viharamahadevi girl's college							
	15	Dodanwala junction bus stop	7:12	5	<1				
	16	Good shephered convent	7:14	5.5	1				

	17	Pushpadana girl's college	7:16	5.8	1				
Morning Outer Service									
Peradeniya to North Zone I	1	Silvester college (primary)	6:59	9.6	2	6:40:00 AM	7:31:00 AM	51	15.6
	2	Sri Sumangala maha viddyalaya							
	3	Silvester college	7:01	9.9	2				
	4	Hemamali girl's college							
	5	Trinity college	7:05	10.3	2				
	6	Badi UD Din girl's college							
	7	Viddyartha collage	7:10	11	2				
	8	Viddyartha college (primary)	7:15	13.1	2				
Peradeniya to North Zone II	1	Anthiny's convent	7:12	10.6	2	6:45:00 AM	7:20:00 AM	35	11
	2	Anthony's college	7:14	10.8					
Peradeniya to East Zone	1	Hillwood girl's college	7:02	10.3	2	6:40:00 AM	7:30:00 AM	50	15.8
	2	Gothami balika maha vidyalaya	7:07	11.2	2				
	3	Mahamaya girl's college							
	4	Mahamaya girl's college (primary)	7:12	12.1	2				
	5	D.S Senanayaka maha vidayalaya	7:18	12.8	2				
	6	Darmaraja college							
Peradeniya to West Zone	1	Sarasavi Uyanna maha vidyalaya	6:43	1.4	2	6:40:00 AM	7:20:00 AM	40	7.1
	2	Mahanama college	6:51	2	2				
	3	Kingswood boy's college	7:00	3.3	2				
	4	Seethadevi girl's college							
	5	Darmavickrama girl's college	7:04	4:03	2				
	6	Swarnamali girl's college							
	7	Girl's High school	7:08	4.8	2				
	8	Viharamahadevi girl's college							
	9	Good shephered convent	7:11	5.5	2				
	10	Pushpadana girl's college	7:14	5.14	2				
Afternoon Inner Service									
North Zone I to Peradeniya Depot	1	Hemamali girl's college	1:34	3.8	2	1:20:00 PM	2:17:00 PM	57	13.5
	2	Silvester college							
	3	Badi UD Din girl's college	1:37	4.1	2				
	4	Trinity college							
	5	Silvester college (primary)	1:40	4.6	2				
	6	Sri Sumangala maha viddyalaya							
	7	Pushpadana girl's college	1:42	5.2	2				

	8	Good shephered convent	1:44	5.8	<1				
	9	Dodanwala junction	1:45	6	<1				
	10	Viharamahadevi girl's college	1:46	6.3	<1				
	11	Girl's High school							
	12	Regal bus stop	1:47	6.8	<1				
	13	Suwasewana bus stop	1:57	7.3	<1				
	14	Danasiri bus top	1:59	7.3	<1				
	15	Kingswood boy's college	2:01	16:48	<1				
	16	Vision bus stop	2:02	8.3	<1				
	17	Art Lanka bus stop	2:07	8.8	<1				
	18	Dangolla junction bus stop	2:12	11.9	<1				
	19	Peradeniya hospital junction	2:13	12.2	<1				
	20	Galaha junction bus stop	2:16	13.2	<1				
North Zone II to Peradeniya Depot	1	Anthony's college	1:35	175 m	1	1:34:00 PM	2:18:00 PM	44	13.4
	2	Anthiny's convent	1:38	355 m	1				
	3	Viddyartha college (primary)	1:44	2.8	1				
	4	Viddyartha college	1:47	3.3	1				
	5	Good shephered convent	1:51	5.7	<1				
	6	Dodanwala junction	1:52	5.9	<1				
	7	Viharamahadevi girl's college	1:53	6.2	<1				
	8	Girl's High school							
	9	Regal bus stop	1:54	6.7	<1				
	10	Suwasewana bus stop	2:00	7.1	<1				
	11	Danasiri bus top	2:01	7.2	<1				
	12	Kingswood boy's college	2:02	7.6	<1				
	13	Vision bus stop	2:03	8.2	<1				
	14	Art Lanka bus stop	2:08	8.7	<1				
	15	Dangolla junction bus stop	2:14	11.7	<1				
	16	Peradeniya hospital junction	2:15	12.1	<1				
	17	Galaha junction bus stop	2:17	13.1	<1				
East Zone to Peradeniya Depot	1	Darmaraja college	1:34	3	2	1:20:00 PM	2:18:00 PM	58	14.7
	2	D.S Senanayaka maha vidayalaya							
	3	Mahamaya girl's college (primary)	1:38	3.7	1				
	4	Mahamaya girl's college	1:42	4.6	1				
	5	Gothami balika maha vidyalaya	1:46	5.5	2				
	6	Hillwood girl's college							
	7	Good shephered convent	1:52	7	<1				
	8	Dodanwala junction	1:53	7.2	<1				
	9	Viharamahadevi girl's college	1:54	7.5	<1				

	10	Girl's High school							
	11	Regal bus stop	1:55	7.9	<1				
	12	Suwasewana bus stop	2:00	8.4	<1				
	13	Danasiri bus top	2:01	8.5	<1				
	14	Kingswood boy's college	2:02	8:09	<1				
	15	Vision bus stop	2:04	9.5	<1				
	16	Art Lanka bus stop	2:09	10	<1				
	17	Dangolla junction bus stop	2:14	13	<1				
	18	Peradeniya hospital junction	2:15	13.4	<1				
	19	Galaha junction bus stop	2:17	14.3	<1				
West Zone I to Peradeniya Depot	1	Good shephered convent	1:36	872 m	1	1:35:00 PM	2:12:00 PM	37	11.3
	2	Viharamahadevi girl's college	1:38	1.6	2				
	3	Girl's High school							
	4	Regal bus stop	1:41	2.1	2				
	5	Suwasewana bus stop	1:48	5	<1				
	6	Danasiri bus top	1:50	5.1	<1				
	7	Kingswood boy's college	1:55	55	<1				
	8	Vision bus stop	1:58	6.1	<1				
	9	Art Lanka bus stop	2:03	6.5	<1				
	10	Dangolla junction bus stop	2:08	9.7	<1				
	11	Sarasavi uyanna maha vidyalaya	2:09	9.9	<1				
	12	Peradeniya hospital junction	2:10	10.3	<1				
	13	Galaha junction bus stop	2:11	10.9	<1				
West Zone II to Peradeniya Depot	1	Seethadevi girl's college	1:35	2.3	2	1:30:00 PM	2:05:00 PM	35	11.3
	2	Kingswood boy's college							
	3	Vision bus stop	1:39	2.9	<1				
	4	Art Lanka bus stop	1:45	3.4	<1				
	5	Mahanama college bus stop	1:51	6.3	<1				
	6	Dangolla junction bus stop	2:00	9.7	<1				
	7	Sarasavi uyanna maha vidyalaya	2:01	9.9	<1				
	8	Peradeniya hospital junction	2:02	10.3	<1				
	9	Galaha junction bus stop	2:04	10.9	<1				
Afternoon Outer Service									
North Zone I to Peradeniya Depot	1	Viddyartha college (primary)	1:35	2.8	2	1:25:00 PM	2:07:00 PM	42	12
	2	Viddyartha college	1:38	3.3	2				
	3	Hemamali girl's college	1:42	4.6	3				
	4	Silvester college							
	5	Badi UD Din girl's college	1:47	5	3				
	6	Trinity college							

	7	Silvester collage (primary)	1:51	5.5	3				
	8	Sri Sumangala maha viddyalaya							
	9	Pushpadana girl's college	1:55	6	2				
North Zone II to Peradeniya Depot	1	Anthony's college	1:36	175 m	3	1:35:00 PM	2:02:00 PM	27 min	11
	2	Anthiny's convent	1:41	355 m	2				
East Zone to Peradeniya Depot	1	Darmaraja college	1:37	3	3	1:25:00 PM	2:07:00 PM	42	12.3
	2	D.S Senanayaka maha vidayalaya							
	3	Mahamaya girl's college (primary)	1:42	3.7	2				
	4	Mahamaya girl's college	1:47	4.6	2				
	5	Gothami balika maha vidyalaya	1:53	4.6	3				
	6	Hillwood girl's college							
West Zone I to Peradeniya Depot	1	Good shephered convent	1:36	872 m	2	1:35:00 PM	1:58:00 PM	23	8.1
	2	Viharamahadevi girl's college	1:39	1.6	3				
	3	Girl's High school							
	4	Swarnamali girl's college	1:43	2.1	3				
	5	Darmavickrama girl's college							
West Zone II to Peradeniya Depot	1	Seethadevi girl's college	1:34	2.7	3	1:30:00 PM	1:57:00 PM	27	9.5
	2	Kingswood boy's college							
	3	Mahanama college	1:42	4.5	2				
	4	Sarasavi uyanna maha vidyalaya	1:52	8.2	2				