



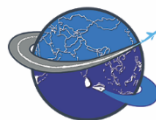
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5th International Conference

Research for Transport and Logistics Industry 2020

21st November 2020

Colombo | Sri Lanka

Organized By



SLSTL
Sri Lanka Society of Transport and Logistics

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**Research for Transport and Logistics Industry
5th International Conference
ABSTRACTS OF PROCEEDINGS**

Organised by
Sri Lanka Society of Transport and Logistics



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Message from the President/ Conference Chair

The Sri Lanka Society for Transport & Logistics (SLSTL: www.slstl.lk) was set up in 2014 to create a professional environment to discuss the issues in Transport and Logistics sector and to recommend sustainable solutions to improve the sector. Furthermore, it aims to promote research and development in collaboration with the industries to develop Sri Lanka as a true logistics hub. On 15th September 2015, the STSTL was admitted to the Eastern Asia Society for Transport Studies (EASTS: www.easts.info) as its 19th domestic member. Domestic societies in all ASEAN countries are members of EASTS which is widely held as the most prestigious research society for transport & logistics in Asia. Thus, Sri Lanka now belongs to one of the most well established and renown transport research societies in Asia.



Research for Transport & Logistics Industry (R4TLI: www.slstl.lk/r4tli-2020) is an initiative that endeavours to promote research and development in the transport & logistics sector in Sri Lanka and the region that would help diagnose its current issues and identify potential improvements based on scientific evidence. This annual research conference intends to build a platform where the needs of the industry can be discussed and scientific processes developed for rectification of issues can be showcases through research presentations. The last year, 2019, SLSTL jointly hosted the EASTS conference in September 2019 in Colombo which attracted more than 500 participants out of which 400 are international delegates. Despite the COVID19 pandemic, we decided hold the fifth conference (R4TLI 2020) online on 21st Nov 2020 to ensure that the series of R4TLI conferences begun in 2016 continue uninterrupted.

On behalf of the conference organising committee, I warmly welcome all participants, presenters, speakers to witness our exciting program - 30 different research presentations along with chief guests from related ministries, two keynote speeches by eminent speakers, Research Award, and an interesting/ timely panel discussion on "Do we have a viable Transport Plan for the Colombo Metropolitan Region?". I thank all those who worked to organise the conference at this scale.

T Sivakumar

B.Sc. (Hons) Eng., M.Eng. (AIT), D.Eng. (YNU), MCILT, AMIE (SL)

President - SLSTL & Conference Chair - R4TLI 2020

Message from the Founding President of SLSTL

The Research for Transport & Logistics Industry (R4TLI) has become a regular annual event that showcases the research efforts of researchers and students in transport & logistics. Even though COVID-19 has posed severe constraints on holding conferences, I am delighted to note that the 5th conference will proceed as an Online Edition.



The importance of research cannot be underlined in a middle-income country amidst rapidly changing parameters both on the demand as well as the supply side of transport & logistics. Traditionally successful models especially those from developed countries are fast becoming unsustainable and technologically irrelevant. It is indigenous research that can pick and choose the specific solutions that would solve local issues which are often complex amalgam of social political and economic parameters.

The scope of the R4TLI which brings experienced researchers as well as fresh undergraduates is a welcome mix. The high standard of review undertaken by the Editorial Committee is seen to have safeguarded the quality of research work presented at previous R4TLI. The launching of the Journal of South Asian Logistics & Transport (JSALT) associated with the conference is also a noteworthy achievement of the Sri Lanka Society of Logistics & Transport (SLSTL).

Amal S Kumarage

B.Sc. Hons Eng. (Moratuwa), Ph.D. (Calgary), FCILT, MIE(SL), CEng

Founding President - SLSTL

Message from the Keynote Speaker

Sri Lanka is strategically located in the Indian Ocean. It is in close proximity to the main East-West shipping corridor and has good liner shipping connectivity to the fast-growing Asian and African markets as well as Europe. Despite the competitive advantage of its geographic location, fully leveraging Sri Lanka's international connectivity to integrate the country's domestic supply chains and provide holistic logistic services has remained a challenge due to issues relating to, but not limited to, inefficiency, inadequate infrastructure, lack of digitization, limited public and private sector coordination, and a lack of supporting regulatory measures.



With this background, the establishment of the Sri Lanka Society for Transport & Logistics (SLSTL) is very much needed. It not only creates a professional environment for research and discussions of the issues in the Transport and Logistics sector, but also its collaboration with the industries and government agencies ensures that the recommendations and solutions proposed are practical and useful. At this global pandemic, safe transport and efficient logistics are more important than ever. I am very honoured to provide the keynote speech for the 5th conference of Research for Transport and Logistics. I look forward to learning more from researchers, academics, industry leaders and government agencies. Together, we will build back better.

Winnie Wang

Senior Transport Specialist - South Asia, World Bank Group

Message from the Keynote Speaker

It's a pleasure to deliver the Keynote address at the 5th International Conference on R4TLI. The topic of my Keynote address will be on transport planning and in particular the exploration of what would be the most appropriate approach for handling the long overdue transport issues with the added constraint of COVID 19 issues and the new normal. The impact that the pandemic has had on lifestyles and travel patterns as well as on the economy needs serious consideration in revising existing transport plans particularly for urban and metropolitan areas. The Keynote address will look at some salient features of previous transport plans for Colombo Metropolitan Region and argue that an incremental development on current transport infrastructure would be the best first steps as opposed to introduction of expensive new transport networks. The Keynote address will also revisit the Colombo Metropolitan Regional Transport Masterplan developed in 2015 as being the most appropriate starting point given that much more ambitious plans have failed to get started or deliver the promised impacts.



Amal S Kumarage

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Head of the Department of Transport and Logistics Management,
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Editorial Preface

Considering the growing spread of the COVID-19 pandemic in Sri Lanka, 5th International Conference of R4TLI-2020 decided to be held as a virtual conference.

Graduating into her fifth successive year, R4TLI has demonstrated her sustainability and her potential in serving ‘to catalyse necessary discourse within the discipline of transport and logistics sector for greater research and development undertakings’, as the Sri Lanka Society for Transport and Logistics (SLSTL) intended in the inaugural 2016 R4TLI Proceedings. We are glad to note that our voice appears to have been heard and well received.

Editorial Committee of the R4TLI-2020 is encouraged that we received a total of 51 initial abstract submissions. After the full paper submissions, in total 22 abstracts were accepted for the conference proceedings (acceptance rate 43.13%) and 8 full papers were accepted for the Journal of the Sri Lanka Society of Transport and Logistics: Journal of South Asian Transport and Logistics (JSALT) (acceptance rate 15.68%). There are 28 abstracts to be delivered as oral presentations. I am even more pleased to tell you that standards have again reached a very high level and we can expect to be exposed to most interesting research and great presentations.

As in preceding years, our task of editing and compiling the Proceedings of the R4TLI Conference has been a rewarding experience, affording new perspectives on the evolving research interests in the field of transport and logistics. Last year, we stated that it was our wish that future research activity will probe deeper into the questions faced by the domestic Transport and Logistics industry and improve its linkages, sharpening Sri Lanka’s competitive edge in the ever-complex and dynamic global and regional business environment. This year’s Proceedings propose innovative solution to the concerns of underserved areas, diverse industrialists, and a cross-section of Sri Lankan society

The Editorial Committee for 2020 is grateful to the eminent panel of academics for reviewing the submissions and providing feedback to each of our contributors – a contribution which is central to maintaining the standards SLSTL has set for itself. Their contribution to industrial research and development in Transport and Logistics is immense and deeply appreciated.

We look forward to continuing our efforts to catalyse necessary discourse within the discipline of transport and logistics sector for greater research and development undertakings.

T Lalithasiri Gunaruwan (Chief Editor)

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**CONFERENCE ON RESEARCH FOR
TRANSPORT AND LOGISTICS INDUSTRY
2020**

5TH INTERNATIONAL CONFERENCE

ORGANISED BY

**SRI LANKA SOCIETY OF TRANSPORT AND LOGISTICS
(SLSTL)**

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*Transport Externalities and
Policy Interventions*

Self-reported Habitual Practices and Perceptions of Young Drivers in Sri Lanka

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It is important to identify the young and inexperienced people's driving practices and perceptions at a very early phase of their driving exposure so that areas of improvement for safer driving can be identified. This study analyses 400 young and inexperienced drivers' self-reported habitual practices and opinions through a questionnaire survey. This questionnaire focuses on supervision of early driving, restrictions by parents, accident and traffic offences involving young drivers, and several other habitual driving practices. Analyses are performed using reliability statistics, inter-item correlation, likelihood ratio tests, and parameter estimates. The highest inter-item correlation value obtained is 0.467 which was for overtaking vehicles in restricted areas and speeding short distances to run a yellow light before it changes to red. Driving after alcohol consumption, mobile phone usage, taking an illegal U-turn at restricted areas, indicating signals when changing lanes and overtaking a slow driver from the left were significantly influenced by the choice of young drivers to not use seat belts. These habitual practices while driving highlight the need for early intervention to improve road safety. In conclusion, there is always one or more habitual driving practices that affects other driving habits of young drivers.

Keywords: *Young Drivers, inexperienced drivers, driving practices, Likert scale, driving habits*

Assessing the Service Quality Gap of Freight Forwarding Sector during an Epidemic Situation in Sri Lanka

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Supply chains are vulnerable to disruption and volatility during epidemics. For example, during the COVID-19 outbreak, it is evident that freight forwarding firms experienced a major decline in business due to market collapse. In such conditions, it was necessary for businesses to maintain optimal service quality to win the limited market. This study examines service quality in the freight forwarding sector under epidemic conditions. Service quality of the freight forwarding sector is attendant on different industries and therefore, provision of services is volatile amid an epidemic. Improvements in existing processes using information technology could enhance existing service quality level during an epidemic condition. Therefore, a key aspect of this study is to identify the gap between expectations of the service quality and perceptions of quality based on technology usage. This study has three objectives which are to (1) identify existing procedures when providing freight forwarding services in Sri Lankan context, (2) identify the global approach to freight forwarding services and (3) determine the service quality gap between expectations and perceptions of the Sri Lankan freight forwarding sector in terms of information technology. For this, SERVQUAL method has been used in differentiating the expectations from perceptions. This method has been proven in literature reviews by considering the global freight forwarding sector. Analysis relates to the service quality in Sri Lanka's freight forwarding businesses and highlights possible areas for improvement to retain in an epidemic conditions and maintaining the required levels of service quality. The service quality gap has been identified by analysing the employee expectations relative to perceptions of services currently provided in the freight forwarding sector: these indicate the technology, people management, communications management and organizational performance-related enhancements that are needed. This paper concludes that shortfalls in service quality during an epidemic requires freight forwarding companies to focus satisfying the customer needs using modern technology to complement traditional procedure.

Keywords: *freight forwarding, service quality, epidemic situation, IT solutions, SERVQUAL method.*

Network Centrality Assessment (NCA): Assessing the Transport Networks' Resilience for Urban Flooding

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Transport systems are vital to the functioning of urban areas. Minimizing disruptions to transport networks due to natural hazards is a key goal in disaster-resilient urban planning. This study presents a framework to assess transport networks' resilience to urban flooding. The proposed framework is developed based on network centrality and graph theory. The study utilizes betweenness and closeness centrality to capture transport network resilience under two movement thresholds: pedestrian movements ($r=1\text{km}$) and vehicular movements ($r=10\text{km}$). The study utilizes Open Source GIS tools to compute centrality values. The case study is carried out in Greater Colombo, Sri Lanka and selects three significant urban flooding events, i.e. 2010 May 17, 2016 May 15 and 2017 May 25. It assesses the transportation network resilience in two respects. First, the topological impacts from each flood event to the transportation network. Second, the accessibility changes in the transportation system. The results reveal three key findings. First, compared with direct impacts on the transportation network ($\leq 7\%$), the relative impact is significantly higher ($>60\%$). This is particularly pronounced in vehicular movements relative to pedestrian movements, because pedestrian movement is hindered by floods where there is a loss of several road segments in a given neighbourhood. For vehicle movement, floods significantly impact the entire transportation system and their pass-by trips. Second, the study revealed redundant depreciation of the transportation accessibility as it shifts the accessibility from downtown (CBD) to suburban areas and creates temporary accessibility hotspots in certain local areas. Third, considering the statistical distribution of network centrality, the study identifies significant declines of transportation accessibility in each flooding event, significantly impacting trips of longer length ($>10\text{km}$) as the loss of shortest path roads segments significantly impact the pass-by movements of the transportation system. The proposed framework can be utilized as a planning tool to assess transport network resilience and devise precautionary measures to mitigate disaster risk.

Keywords: *Urban Flood, Transport Planning, Network Centrality Assessment, Open Source GIS, Transport Network.*

Innovations through ICT and Green Energy in the Logistics Industry in South Asia

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Ports around the world that have been a stagnant industry are currently going through a sudden boom in technological improvements. Investigating how the port industry in South Asia innovates in planning and operations by integrating Information Communication Technology (ICT) is the key purpose of this research. How those developments are brought in while maintaining sustainability and adhering to the concept of a ‘Green Terminal’ is demonstrated. The terminal “X” which is located at the Colombo port is the focal point in this research. In order to test the hypothesis, a systematic review was conducted. With the clear vision of what information to gather, all relevant and recent articles based on this context were reviewed by the authors. Positive and negative impacts of ICT integration in Ports in South Asia were critically evaluated. When transformed to a smart port. The possibility of adopting electronic transport equipment with business application and electronic transaction components using high speed internet emerges. These will address the environmental issues such as noise and air pollution, vibrations and greenhouse gas emissions produced by fossil fuel engines. An analysis of the challenges and possible strategies in implementing ICT background in a terminal such as 5G network for speeding up operations, RFID technology, E-RTG (Electric Rubber Tyred Gantry Crane) for environment sustainability completed this investigation. Methods of developments in “X” and in other ports in South Asia as a whole are provided in the recommendations. Based on information gathered through databases, the research deduces that if these steps are implemented, terminal “X” would experience rapid growth. This can be achieved using long-term planning, sustainable innovation and Internet of Things (IoT). The research finally provides recommendations on countering obstacles in the industry through strategies and infrastructure solutions. ‘Green Terminals’ can reduce the negative impact on environment using green energy for power loading and discharging activities. Based on this the ‘Green Terminal concept’ should be used for further developments in ports of South Asia.

Keywords: *Green Terminal, E-RTG (Electric Rubber Tyred Gantry Crane), 4G/5G Network, RFID (Radio Frequency Identification) Technology, Smart Port, IOT (Internet of Things).*

Evaluation of Land Value Capture for Financing Transportation Infrastructure Development in Sri Lankan Cities

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Transportation-based infrastructure development has become a crucial element in urban milieu. In developing nations, financing transportation infrastructure development has been under pressure due to high cost of compensation, construction and maintenance. However, efforts to improve transportation facilities often focus on ill-suited sources of financing, often involving massive debt, with limited attention to the potential contribution of alternative financial models in financing infrastructure development. This paper seeks to bridge this gap by tracing linkages between financing, transportation and land use systems and how these connections can inform policy development. This will assist governments to achieve positive outcomes for financing transportation infrastructure development in particular projects. This study is built around the theory of land-based value capture in order to explore whether there is any alternative opportunities for infrastructure financing in Sri Lankan cities. By applying this theory, a four-step framework was introduced and validated through the case of Kottawa – Makubura Multi Model Transport Centre Development (MMC) and highway development projects. This framework mainly considered the existing regulatory framework to identify suitable alternative financing opportunities. In addition, it conducted an infrastructure beneficiary analysis to identify beneficiary groups in new developments. As the next stage it analysed the property value impacts through the hedonic pricing method. Findings indicated significant value increments (of around 20%) taking place within a 500m radius of new transportation developments, with lower impacts at distances of 1km and 2km from a given development. It verified that locational factors are the most influential factors in increasing residential property values pursuant to development of new infrastructure. Finally, it was proposed to adopt an active funding policy. The framework was validated by selected practitioners in the field. Accordingly, the conceptual framework developed will accommodate future studies related to land-based value capture.

Keywords: *Land Value Capturing, Transportation Infrastructure Development, Hedonic Pricing Model, Residential Properties*

A Solution for an Unsafe Ferry Crossing at the Kalu Ganga: A Case Study at Galpatha

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People travelling between Galpatha, Bolossagama and its surrounding area face a challenge in crossing the Kalu Ganga using a privately operated ferry. Every year, it has been recorded that a significant number of accidents take place because of this unsafe ferry. It is particularly dangerous to use in the rainy season. This paper proposes a solution to issues faced by people who use this ferry. The issues were captured using a survey done among the users of the ferry and by interviews done with the authorized persons in the area including the Grama Niladaris. Around 50 users were interviewed while 44% of them were travelling for working purposes. The busiest times of the ferry were from 6 am - 9 am and in the evening it was 3 pm - 6 pm. In the dry season, the ferry operate smoothly. In the rainy season ferry ports are flooded and the waves are much stronger. Therefore, during such times the ferry service is unavailable. In an emergency or when the ferry is unavailable, these people have to travel an additional 22.4 km to reach the destination. There are no other ferries operating nearby. Using descriptive analysis, waiting time for the ferry, safety, and difficulties in goods transport were identified as main issues. The best solution was found to be building a bridge over the river at this point. This is one of the narrowest points along the river and is suitable for the construction of a bridge. Results derived from the gravity model showed that if a bridge is built, the volume of travel between the two villages would increase by 411.28%. There is high demand for a bridge than the ferry. If a bridge is built, for a person travelling by motorcycle, the generalized cost will reduce by 98.98% and for a person getting across by foot, the generalized cost will reduce by 92.25%. Financial Feasibility of constructing a bridge has been discussed and estimated using the Oddamavadi Bridge as the sample case. This would save the time and resources of many. It will also provide the best range of choices to users because their mobility and safety will increase.

Keywords: *Unsafe ferry, generalized cost, Gravity model, Utility function, bridge*

An Analysis of Customer Satisfaction with Green Cars

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Transport plays a vital role in human lives, making it more convenient to achieve mobility requirements. However, it is an unavoidable evil due to its significant impact on the environment. The increase of CO₂ and greenhouse gas emissions, high dependency on oil energy, and the impact of an increase in oil prices have directed public concern to green transportation. But the shift to green transportation depends on whether they are satisfied with green modes of transport. Hence this research was designed aiming at analysing customer satisfaction about green cars. The sample comprised respondents who own a car; a majority were hybrid or electric car owners. The factors affecting consumers when purchasing cars have been identified using Exploratory Factor Analysis (EFA) method. The results indicate that the salient features were green technology, performance, and appearance are prominent factors affecting consumers purchasing motor cars. Based on these, consumer satisfaction with green cars is examined. The majority of the green car users are satisfied with features of comfort, efficiency, power, technological features, and the style of green cars. The noteworthy finding is that more than half of all green car users are not satisfied with the prices, and the majority who bears that perception own hybrid cars. Most respondents who do not own a green car ranked high cost of purchase, inconvenience of recharging, and shortage of charging stations among three key factors which prevented them from purchasing a green car. Hence, findings emphasized that consumers can be encouraged to purchase a green car if competitive prices are offered. Further, tax concessions on green cars would attract more consumers since the majority of respondents stated that high prices have prevented them from purchasing a green car. For a greener future, supportive and smart infrastructures should also be implemented. The establishment of smart charging systems is vital.

Keywords: *Green Cars, Customer Satisfaction, Green Transportation, environmental pollution*

Transport Operations

Application of Dynamic Traffic Assignment and Determine Model Parameters for Urban Traffic Conditions in Sri Lanka

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The travel behaviour of people on a road network is not often constant and it changes over the time. Drivers who use a particular road network continuously tend to find more comfortable, congestion free routes with least travel time to reach their destinations. This scenario is complicated in the context of a congested and high-density urban road network where drivers have more freedom to use alternative paths to reach their destinations based on changing traffic patterns within short periods. Further, the presence of navigational tools such as Google Maps help the drivers in making quick decisions in selecting congestion free routes, making route selection more dynamic.

In order to address this dynamic environment, many microsimulation traffic models around the world have developed the dynamic traffic assignment tool which provides the traffic modeller a more realistic modelling environment for urban traffic over the conventional static route assignment. Further, conventional static route assignment may not be able to simulate and give realistic results for urban areas with complex route networks.

However, this facility available in the microsimulation traffic models has not yet been tested under Sri Lankan conditions. Therefore, the objective of this study is to test the dynamic traffic assignment process and find the model parameters that are compatible with Sri Lankan traffic conditions and driver behaviour. For this purpose, PTV Vissim traffic microsimulation software was used.

A 2.5 km stretch of A 000: Kollupitiya-Sri Jayawardenapura road and its vicinity (comprising Rajagiriya junction and flyover) have been considered for the case study. Manual vehicle number plate surveys were carried out at 14 predefined locations covering the entire area to develop origin-destination matrices for different vehicle classes. The average growth factor method was used to develop working matrices from the sample matrices developed through this number plate survey. The origin destination matrices developed for the period between 5.00 pm and 6.00 pm were used as the input for the traffic model. Stochastic (Kirchhoff) traffic assignment method was used to distribute traffic between zones in Vissim. Model convergence, calibration and validation were carried out as per the Vissim manual and Traffic Modelling guidelines developed by Transport for London Institute. The GEH static values of input and output flow values of the modelled network were used as the parameters for model calibration and validation.

The road network developed in Vissim was successfully calibrated to local conditions and a set of model parameters that were compatible with Sri Lankan conditions found. However, there is a need for future research work to find model parameters that are compatible with different road and traffic conditions.

Keywords: *Dynamic Traffic Assignment, Traffic Microsimulation, PTV Vissim, GEH Static, Stochastic Traffic Assignment.*

Factors Improving Bus Transferability as the Choice-Mode of Passengers at Bambalapitiya Railway Station

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Bus transit is one of the main transfer modes which facilitate an efficient integrated transport system by increasing economic and social benefits. Inadequacy and inefficiency of prevailing public bus transport as a mode of transferring at railway stations has led passengers to switch to various other means to reach their destinations. This has led to increased traffic congestion mainly on urban roads at heavy economic cost to society. Improving bus transferability is crucial to enhancing bus-rail integration efficiently and effectively, while providing quality services fulfilling user requirements. In the Sri Lankan context, research identifying determinants of transfer mode choice for improving bus transferability or rail-bus integration is deficient. Hence, determining the factors underlying transfer mode choice is imperative to upgrading the prevailing transfer bus services at railway stations whereas introducing new transfer services. The main objective of this study is to identify the factors influential to the improvement of bus transferability at the Bambalapitiya Railway station. Accordingly, the main motivation of this study is to determine which attributes of the public bus service inclines people to use it as their transfer mode and to identify the user needs to be met by prevailing transfer bus services. The study is based on primary data collected from passengers who do not use public bus transport as their current transfer mode. A structured questionnaire with a five-point Likert scaling was used to ascertain passengers' experience and opinions who had different mode choices. Data analysis is based on the evaluation of passenger satisfaction with service quality. Factor analysis and descriptive statistical analysis were used to identify the factors underlying improved bus transferability. The study mainly considered sixteen attributes of quality: accessibility, waiting time, cleanliness of the bus stop, facilities of the bus stop, loading level, safety of driving, traffic conflict, harassments, curtsey of bus crew, bus route coverage, bus frequency, availability, bus quality, privacy, cleanliness and travel time that affect transfer mode choice. The findings of the descriptive analysis clearly showed a high loading level and increased travel time as crucial factors for not using the existing transfer bus service. As per the results of factor analysis, the six main groups which loaded the sixteen factors are network design, convenience, and safety, quality of buses, background factors, and time consumption. According to the factor extraction, passengers are more concerned about network design which comprises bus route coverage avoiding transfers, availability of service to their destination and frequency of connections aligning with the arrival time of trains. Prioritizing the deployment of additional buses during peak hours, introduction of new bus services with integrated time scheduling and the assurance of

quality, efficient service is imperative to enhancing bus transferability at the railway station. The study gives a reasonable path ahead to transport decision-makers, planners, and managers to configure policies that will ensure more effective bus transferability for existing bus users and attract new passengers through an efficient rail-bus integration.

Keywords: *transferability, quality attributes, bus transit, Factor Analysis, Mode-choice*

Vehicle Kilometres Travelled Estimates using Household Travel Survey

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Vehicle Kilometres Travelled (VKT) is a key factor in transport planning and managing, since data represent existing road transport demand or pattern in a specific area of concern. In Sri Lanka, the expansion and development of the transport sector should be complemented with timely updated data in order to fulfil current needs as well as future growth scenarios as a developing country. VKT is a valuable indicator in identifying these requirements; however, timely VKT data for the country is not available within transport communities so far. Very few researchers have attempted to estimate timely VKT over the past few years, and this too in few areas of Sri Lanka. This study aimed to estimate VKT in Southern, Northern, and Eastern areas of Sri Lanka using a questionnaire based - household travel survey. Three areas were visited and randomly selected respondents were interviewed on their travel information on weekdays, weekends, special seasons, holidays etc. Other than number of kilometres travelled, travel mode and socio demographic information of respondents, all of which are useful in estimating Personal Kilometres Travelled (PKT)—were collected. Estimating PKT of individuals seems important in Sri Lanka since a majority of people do not own personal vehicles for travelling. PKT always refers to an individual while VKT refers to a vehicle. The travel distances of samples were aggregated to the annual level and weighted based on census and population data in the corresponding area of study in order to estimate VKT/PKT per person per year. Estimated VKT and PKT for the three areas were statistically compared based on selected socio demographic factors. The estimated VKT would be useful in the transport sector as well as in environmental agencies' computation of emissions and energy consumption in the country.

Keywords: *Vehicle Kilometres Travelled, Questionnaire based- household survey method, Personal Kilometres Travelled, Transport planning and managing*

Improving the Efficiency of Existing Office Transport Services: A Connectivity-based Case Study

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Employees who work/live in the Colombo district are faced with challenges when commuting. Colombo is a high-density area with heavy traffic congestion during peak hours. This paper examines factors such as cost, comfort, availability, access time, and travel time faced by these commuters. Presently, with increased affordability and availability, there is a perceivable increase in car ownership in both developed and developing nations. In high-density areas such increases in car ownership is unsuitable due to limited road space and impotence for expansion. Even where commuters use their private vehicles, they are not satisfied as presumed with their commute. This is due to the lack of driver discipline on high-density roads and the stress caused by fellow drivers. Therefore, it is unsuitable to promote car ownership/car commutes in high-density areas as it causes several other problems and directs overall satisfaction of road users to decline.

To pre-empt further increase in private vehicles, public transport services must be improved. Another means of addressing this demand would be to introduce ride-sharing services. This study focuses on approaches to optimize existing office transport services and increase their accessibility, thereby alleviating congestion during peak hours. This study recognizes that most commuters are satisfied with the service offered by office transport services compared with public transport and taxi services. Analysing data of 105 survey responses and further research on employees in the Colombo district, it is revealed that office transport services are underutilized as these vehicles are operated below optimal capacity along with several other administrative problems. This study recommends: collective office transport for the government sector using a cloud-based system and ride-sharing services for both public and private organizations through IT-based platforms as means of integrating these services to improve overall performance.

According to our research, a round trip cost 88.9% of public transport users less than 300LKR. Among users of taxis and private vehicles combined, 29.2% spent less than 300LKR while 65.0% spent above. For paid office transport services (Bus and Van) 75% spent below 300LKR and only 15% spent above. In terms of comfort and satisfaction, private transport services and office transport services offer far better satisfaction: the percentages of satisfied, moderate and dissatisfied commuters for public transport were 11.1%, 28.9%, 60.0%; for private vehicle these were 71.9%, 18.8%, 9.4% and for office

transport services (Bus and Van) these were 66.7%, 25.0%, 8.3% respectively. Public transport can be improved by integrating it with ride-sharing to increase overall level of satisfaction. While targeting Taxi/Private vehicle commuters, as ride-sharing services are costly relative to public transport services it is not projected to divert public transport users but increase it through improved connectivity and comfort. Promoting car-pooling can help reduce environmental pollution and total network travel time, accelerating the improvement of commuting opening the door to many opportunities in the long run.

Keywords: *Commute, Ridesharing, Urban transport, Colombo, Staff transport*

Electronic Card System to Reduce Queue Length for Tickets in Kollupitiya Railway Station

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The public transportation sector influences the economy of a country directly and indirectly. Railway transportation is widely used in Sri Lanka, which is used daily by 18% of the total population. This paper is based on a case study of the queue length for tickets at the Kollupitiya railway station. The purpose of this paper is to develop and provide effective solutions to prevent long queues at ticket counters in railway stations in Sri Lanka by providing reliable and affordable service to the customers. The analysis is based on an online survey of 94 commuters which was done over six consecutive days in April 2020, which included four working days and two days of the weekend. All commuters were using the Kollupitiya railway station during evening peak hours and 96% were passengers between the ages of 18 and 30 years. Problems faced by these commuters were identified through a descriptive analysis with results showing that people spend around 9.6 minutes in the queue at the ticket counter. Usage of a season ticket is the only prevailing solution and was used by 44.7% of young passengers, but was not a satisfactory remedy since 45.8% of passengers were not regular users. Generalized cost theory and flow rate theory were used to mathematically derive solutions to determine optimum waiting time at ticket counters. Factors including travel time, travel cost, waiting time, and the number of people in the queue at the time of arrival were considered in the analysis. Time is taken as a proxy for the level of service of rail transportation and the solutions were derived to reduce the waiting time in the queue. Accordingly, three cost-effective solutions were identified to mitigate the formation of long queues. Among them, the implementation of an electronic card system was found to be the most optimal solution as it reduced waiting time as well as the cost of operating ticket counters. Since the rail transportation service acts as a monopoly in Sri Lanka, the whole system should be implemented, operated, and managed totally by the government. A cost-benefit analysis was done using details given in a proposed project by the Ministry of Finance Sri Lanka in 2019 as its reference. The analysis indicated that the government has the ability to recoup the money invested within a payback period of 0.88 years. Hence, there is a need to introduce an efficient and effective ticketing system to ensure the sustainability of the rail transportation in Sri Lanka. If successful, this system can be extended to apply to the bus transport system in Sri Lanka.

Keywords: *Generalized cost, Flow rate, Waiting time, Ticket counter at railway station*

Developing a Suitable Method to Evaluate Mobility Levels in Urban Areas of Sri Lanka

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This paper aims to develop a suitable method to measure urban mobility in Sri Lanka using an appropriate indicator set. The study only focuses on vehicular mobility. The study covers four sub-objectives: review and identification of the limitations of existing evaluation methods, application of already developed evaluation mechanisms to Sri Lankan context in comparison with foreign cities, determining the best criteria to analyse the mobility index for the selected case studies, and urging decision makers to take necessary actions to upgrade the mobility index in Sri Lankan cities. The proposed method includes 13 indicators related to vehicular mobility. Methodology includes creating a definition using cluster analysis, deriving suitable parameters according to content analysis, expert survey and factor analysis in the preceding part. Data analysis is performed using different formulas and spatial analyses, a mobility index is developed using arithmetic mean, and the index is applied to selected case studies from Colombo, Kandy and Galle. The “Urban mobility index” and “Sampling mobility index” are also applied to those cities. Non-judgmental probability sampling method was used for expert analysis with 22 experts participating. Random sampling was used for the public survey. Sample size was 140 from each city. Five experts validated the method. According to the findings Colombo and Galle cities have barely acceptable mobility levels, and in order to improve indicators returning lower values, some targets should be established. Kandy has an unacceptable mobility level. This is not critical but in order to reverse the situation, there should be immediate interventions from society and administrators. Moreover, in the final part of the research, it is expected to urge decision makers to take necessary actions to upgrade the mobility level in Sri Lanka. These indicators will demonstrate areas that should become policy priorities in future. After achieving acceptable mobility, more indicators can be incorporated to the index.

Keywords: *Sampling mobility index, urban mobility index, mobility indicators, vehicular movement, urban centres*

Assessing the Public Transit Service Performance of an Intra-city Bus Route in Malaysia

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Public transport is important for urban mobility and sustainability especially among low and middle-income communities. Its high carrying capacity helps to reduce the number of vehicle-trips, thereby having a positive impact on the environment. Despite the many obvious benefits of public transit, the use of public transit remains low level in many cities in Malaysia because of policies that favour a higher use of private transport. It is generally understandable that the service performance of public transit is one of the key characteristics that can help improve the use of public transit. The purpose of this paper is to assess some of the key service performance indicators of an intra-city bus route in one of the medium-sized cities in Malaysia to understand its effect on the use of public transport. Data on service performance indicators such as “travel time” including journey time, running time, dwell time and “passenger ridership” of an intra-city bus route in Malacca city were collected by administering field surveys. These data were then analysed using both descriptive and inferential statistical methods. The findings show a clear distinction between travel time near city centre and travel time outside the city centre. The higher travel time near the city centre was due to factors like traffic signals and traffic congestion. The findings also show a clear gap between scheduled and observed time of departure at the terminal station and intermediate bus stations. Not surprisingly, the combined aspects of high travel time including delay and dwell time have a knock-on effect on passenger ridership of this selected bus route.

Keywords: *Public transit, Travel time, Dwell time, Passenger ridership, Malacca*

Transport Planning

Use of Deep Learning as an Alternative to Manual Counts in Sri Lanka

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Maintaining a count of vehicles on roads by vehicle category is important for purposes of traffic monitoring, analysis and prediction. To overcome disadvantages in manual traffic counts, this study focuses on computer vision-based deep learning methods of counting vehicles using videos. This study aims to (1) identify the best camera orientation for improved accuracy and to (2) compare the accuracy of classified vehicle counts based on deep learning- with manual counts at site and actual counts in laboratory using video playback methods. It does so to examine the possibility of automating the classified vehicle counts (CVC) which are currently performed manually in Sri Lanka. While manual classified vehicle counts were collected at site, these were also captured on video for the purposes of this study. This was done under different camera orientations (angle projections) using a mobile phone with a 1080p@30fps inbuilt camera. A new deep neural network (DNN) was trained to classify vehicles using a limited dataset, and OpenCV vehicle detection with SSD Mobile Net API was used for deep learning vehicle counting. According to the study, the best camera angle orientation for detecting vehicles is achieved by placing the camera directly opposite to vehicular movement and at a horizontal inclination of 25° ($\beta = 0^\circ$ and $\alpha = 25^\circ$). At this orientation, the highest accuracy of 76.5% was achieved. The study found that both manual and deep learning methods result in error; former due to human error and the latter due to limited training and computation power. However, even with limited data training, deep learning was only 7% less accurate than manual counting. This study observed that the alternative method (deep learning) was a cost-effective solution in terms of human resources, operational difficulties, less pedestrian and vehicle distractions etc. The primary video data collection contains all vehicle types, but this study was limited to only two classes of vehicles: namely cars and motorbikes. Future studies will be done in different locations to generalize initial research.

Keywords: *Vehicle Detection, Camera Orientation, Deep Learning, Video Traffic Counting, Manual Vehicle Counting*

An Investigation of the Effects of New Bypass Roads on Build Form in Small Towns in Sri Lanka

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A bypass road is one of the strategies introduced to reduce traffic congestion in small and medium sized towns in Sri Lanka. However, a limited number of studies have been carried out to examine the impact of bypass roads in towns where the main transport route is replaced by another outside the town. In such a context this study explores the effects of bypass roads on build form of towns and also investigates the changes of land use and building density, along with accessibility. The small towns analysed are Avissawella, Mawenella, Balangoda and Piliyandala in Sri Lanka. The study has utilized network centrality assessment to analyse the changes in accessibility. Finally, the findings of temporal changes are compared and contrasted with theories and the key factors that influence built form changes are identified. The results of the above four case studies indicate three scenarios: i. The bypass road has more accessibility than the existing main road and new land uses and high-density areas emerge along the by-pass road, making this the main centre of the town. ii. Both bypass road and the existing main road show similar levels of accessibility and attraction. iii. Accessibility of the existing main road remains higher than the bypass road and very few new lands uses and build up areas are attracted towards the bypass road - thus the existing main road remains the main centre of the town. According to the results, if the accessibility of the new bypass road is stronger than the existing main road, the commercial activities and buildings move towards the bypass road, However, if the new bypass road has no influence over the accessibility to the town, the commercial activities and buildings of the main town remain as they are. The results confirm that spatial and economic forces are closely interrelated as indicated in the theory of the natural movement economic process. However, the study found out that the above forces are constrained by natural barriers. Accordingly, it is suggested that these findings are useful for transport engineers when making new strategies to implement bypass roads and also to urban planners when they develop local development plans after implementing bypass roads.

Keywords: *Bypass road, Accessibility, Network centrality, Land use changes, Urban transport planning*

Development of the VISSIM Model for Traffic Simulations of the Compound Junction at Peradeniya

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Traffic congestion has become a planning, modelling, and research problem for transportation planners, especially in developing countries where many cities have undergone unplanned development. The continuous growth in research and computer technology along with simulation capabilities has increased the use of traffic models around the world. This paper attempts to develop a VISSIM model for Sri Lanka's heterogeneous traffic conditions based on a case study at Peradeniya compound junction. VISSIM is a microscopic traffic simulation software which was introduced by PTV group which is capable of obtaining individual traffic behaviour. However, a properly calibrated model is needed to secure better results especially in Asian traffic simulations where most of the in-built model parameters are based on European traffic conditions. Peradeniya junction consists of two three-way intersections which are connected by a road link of 150m in length, and it has become one of most congested junctions in Kandy suburban area. Traffic flow reaches nearly 6,000 vehicles per hour in peak hours and is manually operated by the traffic police. Based on a comprehensive literature survey, average standstill distance, additive part of safety distance, multiplicative part of safety distance, waiting time before diffusion, minimum headway, safety distance reduction factor, distance standing (0 kmph) and distance driving (50 kmph) were selected as calibration parameters for VISSIM. Calibration was carried out using measured field travel times and validated using queue lengths collected through a traffic survey. Our model validation results show a mean error of 11.5% which is a well below value than the respective limits found in the literature as a range of 17% - 22%. The calibrated model can be efficiently used as a test bench to compare the operational alternatives at Peradeniya compound junction.

Keywords: *Traffic simulation, VISSIM, Peradeniya junction, model calibration, traffic congestion*

Analysis of Vehicle Ownership Attributes in Western Province, Sri Lanka

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Vehicle ownership affects the ability of available road transport infrastructure to bear transport demand that is distributed across vehicle categories without causing traffic congestion and delay. This paper develops a mathematical model to predict motor vehicle ownership based on household characteristics. The model is tested using household visit surveys in the Western Province of Sri Lanka (CoMTrans study, 2014). The Province has the country's highest population density (1,600/km²) and road density (0.9 km/km²) as well as a motor vehicle ownership of 206 vehicles per 1,000 people. The modelling is aggregated by the vehicle categories of motorcycles, three-wheelers, vans, and cars (including jeep, and pickup). The motor vehicle fleet is made up of 51% motorcycles, 20.2% three-wheelers, 6.7% vans, and 17.7% cars, apart from commercial vehicles. The purchasing cost of motor vehicles in Sri Lanka varies sharply due to different taxes imposed on importation. Binary Logistics Regression is developed in this study for six different scenarios to investigate the effect of five different socioeconomic factors on ownership of different vehicles in a household ranging from the least to the most expensive vehicle category. After removing households with missing values, the resulting estimation sample consisted of 35,850 households. It was found that the decision to own a private vehicle depends on the attributes of household size, average monthly household income, percentage of workers per household, percentage of school and kindergarten children per household, and the percentage of males in a household. Based on this analysis, middle- and low-income households demonstrate a preference for motorcycle and three-wheeler ownership, while high income households show a greater likelihood of car ownership. Furthermore, results confirmed that income had a positive effect on motor vehicle ownership and the type of vehicle they own; more so than any other socioeconomic variable. Households with more members prefer to own a van than a car. The number of members in a household is also seen to have a positive impact on both the type as well as number of vehicles. It is also found that the ownership of vehicles in a household increases when the percentage of males in a household increases: upon comparison of coefficients, this was observed to be strongest in the case of the ownership of motorcycle and three-wheeler and for vans. It was also found that owning a van is influenced by the number of school and kindergarten students in a household. Results show that the percentage of workers in a household has less influence on car ownership compared to motorcycle ownership: households tend to have more than one motorcycle when there have more workers. Finally, the analysis of household motor

vehicle ownership could be refined using further variables such as the demand for public transportation, the number of drivers in a household and their ages, perception of the quality transportation services, and land use attributes.

Keywords: *Vehicle Ownership, Household Characteristics, Regression Analysis, Western Province, Household Visit Survey*

Trips-in-Motion Time Matrix to Identify Time Windows as an Input for Time-of-Day Modelling

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Time-of-Day (ToD) modelling is an additional step to the conventional four-step Travel Demand Models (TDMs). ToD models are developed to obtain more detailed outputs over the temporal dimension, specially focusing the metropolitan level where need more demand management solutions. With this additional step, daily (24-hour) travel demand is distributed into a discrete number of time-windows. Simulation of the peak period is one of the major concerns in ToD modelling. Traditionally, the trip allocation into time-windows is based on departure-time, arrival-time or temporal mid-point of individual trip timing. Even though the past studies have applied either one of above trip timings, the major drawback of this was not considering the total trip duration. The trips-in-motion concept is applied to estimate the actual trips/vehicles traversed within a particular time window, where the concept follows a more logical approach of capturing the entire trip duration compared to the three time stamps above. The objective of this paper is to identify the most precise starting-time stamps that maximize the trips that fall within a given time-window and minimizes the trip-tailing associated with it. A time-matrix was introduced to apply the trips-in-motion concept to meet these objectives and all trips were allocated to the time matrix based on departure and arrival time stamps of each trip. Time-matrix represented the entire day (24-hour) and the time window represented a few cells of the matrix. Then, all door-to-door trips were evaluated according to four criteria which reflect the objectives of the study. Finally, the precise starting-time stamps for time windows were selected that comply with all four criteria. The 2013 database of Colombo Metropolitan Region Transport Masterplan (ComTrans) was analysed using Bentley Cube Voyager transport demand modelling software. First, we distinguished morning, mid-day and evening peak periods. Then, the most precise starting timestamps of two-hour time windows were selected for each peak, as 6:30 A.M., 01:30 P.M. and 05:00 P.M. respectively. Further, it was estimated that 52% of door-to-door trips are traversed only these time windows. The above results are similar those of the ComTrans peak-periods, which reported 7 - 8 A.M., 1 - 3 P.M. and 5 - 7 P.M. as peak periods in which 55% of daily trips took place. The study was further extended to motorized transfers of trips, which account for only 78% of door-to-door trips. The results were the same as for door-to-door trips. The proposed method paves a rational approach to derive time windows to represent peak characteristics and are consistent with previously defined values. Therefore, this study has developed a systematic approach to identify time-windows as an input for ToD based modelling. The above results were limited

to two-hour time windows and also the passenger modes were neglected, but there are provisions to test such scenarios. It is recommended to study further the shift in peak periods with the change in time of demand which would be the behavioural change most expected to occur post COVID-19.

Keywords: *Time of day, Travel Demand Model, Time-Window, Trips-in-motion, Time-Matrix*

*Logistics and
Supply Chain Management*

Estimating the Catchment Area of a Supermarket in Sri Lanka

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Unplanned developments are a serious issue contributing to traffic congestion in most countries. Therefore, a "Traffic Impact Assessment (TIA)" for with a proposed development should be undertaken before granting approval to proceed. Locally, the Urban Development Authority (UDA) in Sri Lanka considers a 500m radius from the site boundaries as the traffic impact study area in which TIAs are conducted. Many scholars argue that the geographical extent of a traffic impact area is not fixed: it may differ and should therefore be flexible. The vehicles attracted by new retail developments negatively impact on transport, contributing to traffic congestion relative to other developments. Retail stores along the road network generate additional traffic and change the spatial travel pattern of the street network. Therefore, it is better to understand spatial configurations and classify the retail spatial patterns of retail stores. This paper derives the spatial patterns of retail activity in Colombo, Sri Lanka by calculating the level of street integration and street connectivity using the space syntax technique in depth map software. This paper categorizes spatial patterns of retail activity to delineate the true catchment area of a supermarket through the GIS overlay tool and Network-Based Kernel Density Estimation (NKDE). The findings of this research illustrate that the true catchment area is not fixed and will differ based on the diverse operational requirements of each new retail development. This helps to create a better understanding of spatial patterns of the urban retail stores in Colombo area. It supports strategies for sustainable planning and development.

Keywords: *Catchment Area, Delineate, Retail Agglomerations, Supermarket, Traffic Impact Area*

A Simulation Model for Evaluating Warehouse Layout Design Parameters based on Process Strategy

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Products flowing through the supply chain to warehouses is a necessary evil: although there is no value addition to the product, warehousing is inevitable due to market volatility and uncertainty. Therefore, customized value propositions have been introduced to the warehouse which has led to changes in its role. In such conditions, performance of the warehouse is critical for customer value creation, be it in terms of cost, speed or accuracy. Therefore, the need to improve the warehouse operation is significant. This paper is an attempt to use Arena simulation package to describe a simulation model of a warehouse operation process for receiving and issuing goods. The aim of this study is to find warehouse design decisions that optimize the performance of an operation considering different process options, in relation to given input parameters. Six different strategies are simulated to evaluate feasibility in relation to overall cost and service levels. The simulation is done for a set of input parameters considering changes in design variables. Results show the total cost, resource and time required for each option in a predictable manner. Moreover, it provides a tool to understand system behaviours by carrying out “what-if” assessments and to identify which factors can be changed to optimize operations. Therefore the purposes of this study are to 1) identify the input, decision and response parameters of the warehouse process, 2) derive values for each based on time and activity based study, 3) develop a simulation model to support systematic decision making through “what-if” analysis, 4) conclude on the optimal processes based on input parameters, and 5) provide recommendations and future study opportunities to expand the paper.

Keywords: *Arena simulation, warehouse design, warehouse layout design, warehouse processes, warehouse simulation*

Sri Lankan Vegetable Supply Chain Mapping and Comparison with International Best Practices

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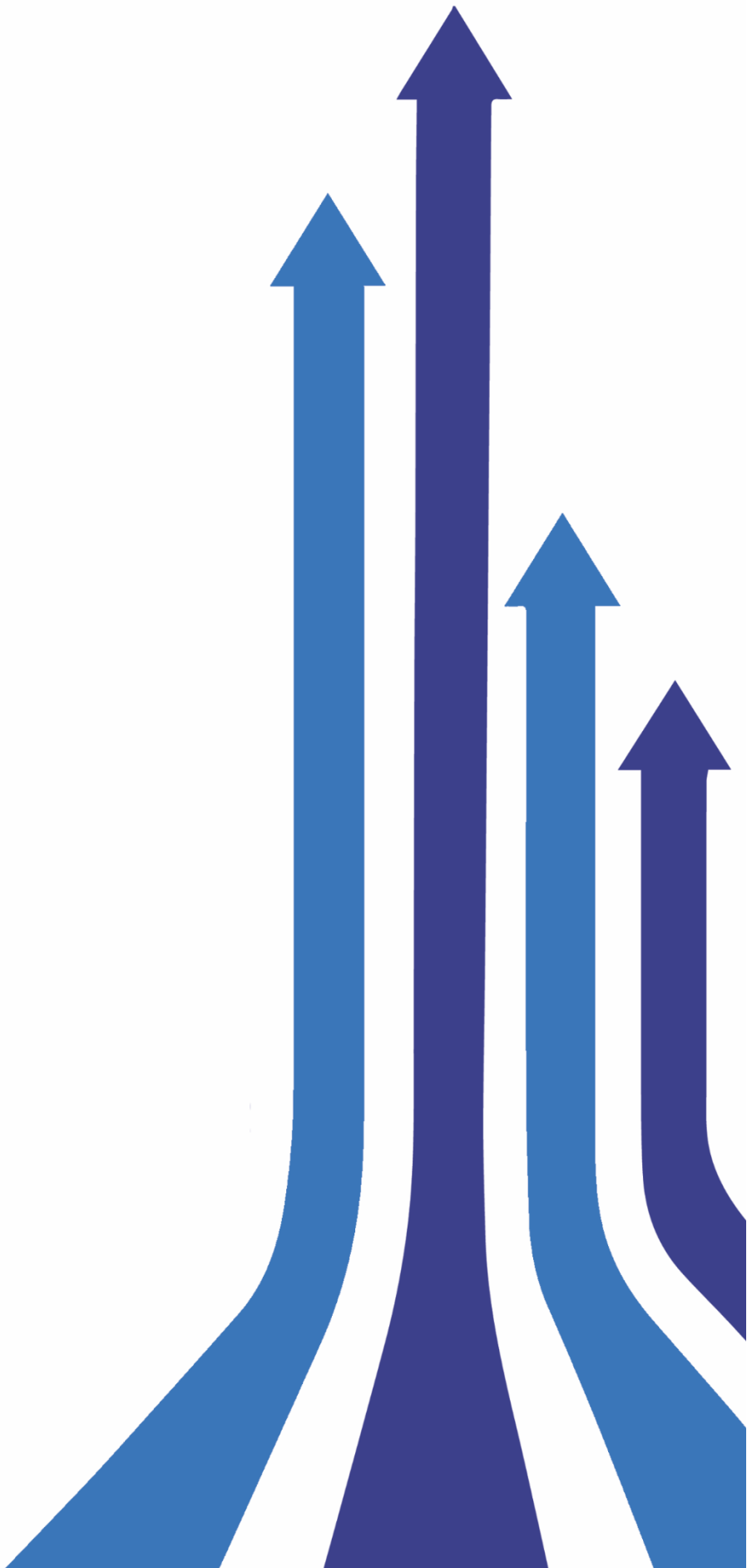
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The Sri Lankan vegetable supply chain is based on a hub and spoke system. Fourteen economic centres perform as hubs for the major traditional vegetable supply chains. There are however many other minor supply chains connecting vegetable producers to consumers. In this research, the different supply chains are mapped, including for economic centres, receiving and delivering chains, supermarket vegetable supply chains, large consumers' and low-volume consumer supply chains. Based on information collected using field visits and discussions with stakeholders, a composite map is developed by combining individual maps.

Best practices in vegetable supply chain management from around the world have been reviewed for comparison with Sri Lanka and to identify how supply chain issues could be resolved, especially by using information technology including artificial intelligence, internet of things, data analytics and blockchain systems. It is found that more efficient and reliable supply chains can be designed using information technology, minimizing system implementation cost and maintenance cost, optimizing required supply chain conditions and conducting benefits analysis to provide more efficient vegetable supply chain solutions for the Sri Lankan context.

Since Sri Lanka has a gradually increasing digital literacy rate, conditions for implementing digital solutions are improving. However, Sri Lanka's internet accessibility is currently below the world average. Therefore, more infrastructure & facilities development is required to facilitate digital solutions that serve entire vegetable supply chains. This can be achieved using different technologies available at present that can help create a more robust and inclusive vegetable supply chain solution for Sri Lanka.

Keywords: *Sri Lankan Vegetable Supply Chain, Best Practices, Mapping, Digital Literacy, Information Technology*



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