USE OF HIGH FREQUENCY DATA IN TRANSPORT AND LAND USE INTEGRATED MODEL

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Degree of Doctor of Philosophy

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CERTIFICATION

I, Thivya Precilla Amalan, declare that this thesis submitted in fulfilment of the requirements for the conferral of the degree Doctor of Philosophy, from the University of Moratuwa, is wholly my work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

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The above candidate has carried out research for the PhD thesis under our supervision.

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LIST OF PUBLICATIONS

1. Amalan, T. P., Du, B., Kumarage, A. S., Wickramasuriya, R., & Perez, P. (2023). High frequency data in Land use and transport integrated model: A review of sources and application. Asian Transport Studies, 9, 100092. doi: *https://doi.org/10.1016/j.eastsj.2022.100092*

2. Amalan, T. P., Du, B., Kumarage, A. S (2023). A Fuzzy Logic based Trip Generation Approach using High-Frequency Data. Travel Behaviour and Society, Under Review

3. Amalan, T. P., &, Wickramasuriya, R., (2024). Developing Trip Generation and Attraction Model using High Frequency Data. JSALT, Under Review

ABSTRACT

Efficient urban planning is crucial for creating liveable and sustainable cities. This involves designing urban areas that maximize economic, social, and environmental viability while minimizing negative impacts. Land use and transport development play a significant role in shaping transport patterns and infrastructure needs. However, applying Land Use and Transport Integrated (LUTI) models in developing countries can be challenging due to limited resources and data availability. This dissertation aims to explore freely, or low-cost high-frequency (HF) data related to land use and transport and develop an integrated model using available data in Sri Lanka as an example for developing countries.

The complexity of the urbanisation process, particularly in developing countries, demands sophisticated decision support tools such as the Land Use and Transport Integrated (LUTI) models to assist in the balanced and sustainable development of transport and land use. However, the high cost and time-consuming nature of LUTI models have limited their application in developing countries due to limited resources and funding.

The advent of information and communication technology (ICT) has revolutionised data collection and analysis, providing more extensive and high frequency (HF) data, such as real-time traffic data collected from sensors and mobile devices. This data can be used for various purposes, including traffic management, urban planning, public health and safety, and research and innovation. The availability of high-frequency data presents both opportunities and challenges for urban planning and development. However, based on the literature review, application of HF data in developing countries are very limited due to the data availability such as high resolution satellite data, technological constraints, lack of understanding of potential benefits of HF data, data sensitivity and privacy concerns and resource constraints including financial and human capacity. For these cases, researchers and planners can use HF proxy data as a substitute for HF data.

The study aims to extend the use of LUTI models by incorporating HF proxy data in Western Province, Sri Lanka, and demonstrates the approach's effectiveness. It utilizes electricity consumption data, GPS point data of customers, and satellite imagery to develop the model. The resulting trip generation model achieves high accuracy in predicting travel demand of 79% in 2013. Additionally, the study uses

satellite imagery and supervised classification to obtain land use area information. Separate trip attraction models for general and industrial areas are developed, achieving accuracy of 70% and 79.5% for general and industrial purpose related trip in predicting attracted trips, respectively. A gravity model is then employed to obtain the final trip distribution, highlighting the value of incorporating household electricity consumption data and satellite imagery in travel demand modelling. The research involves assessing the impact of land use and transport on each other based on the developed model. Different scenarios are tested, revealing insights into various transportation metrics such as work trips, passenger kilometres, average trip length, passenger hours, average speed, and costs. The comparison underscores the benefits of land use improvements and a developed transport network in optimising travel patterns, increasing passenger kilometres, and enhancing system efficiency. This emphasizes the importance of careful analysis in transportation and land use decision-making.

Finally, the research also focuses on developing a disaggregated trip generation model using HF proxy data and assessing its accuracy. By utilizing a fuzzy model based on electricity consumption data and satellite imagery, the study overcomes the limitations of traditional models that rely on costly and challenging data acquisition. The developed disaggregated model achieves high accuracy of 88.7% calculating trip rates compared to the aggregated model.

Overall, this dissertation showcases the potential of leveraging HF data for efficient urban planning in developing countries. It highlights the importance of incorporating household electricity consumption data and satellite imagery in travel demand modelling, and the benefits of land use improvements and a developed transport network in optimising travel patterns and enhancing system efficiency. The research findings contribute to the field of urban planning and provide valuable insights for planners and decision-makers in developing sustainable and liveable cities.

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LIST OF NAMES OR ABBREVIATIONS

LUTI	: Land use and Transport Integrated Model
ICT	: Information and Communication Technology
RS	: Remote Sensing
CDR	: Call Details Record
GPS	: Global Positioning System
GDP	: Gross Domestic Product
USD	: United States Dollars
DSD	: Divisional Secretariat Division
GND	: Grama Niladari Division
NRT-LUTI	: Near Real Time- Land use and Transport Integrated Model
HVS	: Home Visit Survey
CoMTrans	: Urban Transport System Development Project for Colombo Metropolitan Region and Suburbs
UDA	: Urban Development Authority
MLR	: Multiple Linear Regression
OD	: Origin- Destination matrix
UOM	: University of Moratuwa
JICA	: Japan International Cooperation Agency
CVC	: Classified Vehicle Count
LUS	: Land use Survey
FSM	: Four step model
ABM	: Activity Based Model
USGS	: United States Geological Survey
VGI	: Volunteered Geographic Information
RFID	: Radio Frequency Identification Technology
CMC	: Colombo Municipal Council
LVI	: Land Assessment Index
CBD	: Commercial Business District
CEB	: Ceylon Electricity Board
LECO	: Lanka Electricity Company (Private) Limited
SH	: Single Household
AJH	: Adjoining Households

EPZ	: Export Processing Zone
IE	: Industrial Estates
HBW	: Home based Work
HBNW	: Home based Non Work
NHB	: Non Home based
DOT	: Department of Transport
LKR	: Sri Lankan Rupees
kWh	: Kilowatt hour
TAZ	: Traffic Analysis Zone
UE	: User Equilibrium
SO	: System Optimum Assignment
RDA	: Road Development Authority
SLS	: Screen Line Survey
VCR	: Velocity Capacity Ratio
ERP	: Electronic Road Pricing
RMSE	: Root Mean Square Error
VOT	: Value of Time
KPI	: Key Performance Indicator