Development of a Monitoring and Evaluation Framework for sustainability assessment of Microtransit systems

by

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Declaration

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Abstract

Background: Mobility has always been essential to nearly every aspect of human existence. Due to the intrinsic aim of transport systems to improve our lives, it is unsurprising that transport development is rarely considered without also considering 'sustainability'. Evidence however suggests that current modes of transport are unsustainable. An abundance of research has been conducted on identifying and addressing current real-world problems faced due to our current and traditional modes of transport. Although the sustainability of transport systems is seen as a significant challenge, it is essential to ensure that future generations have the same opportunities we do today without compromising on environmental, social and economic development.

Need: Due to technological advancements in Information and Communications Technology (ICT), the internet, and the sharing economy, alternative 'smart mobility' modes of transport like microtransit systems are emerging. Such solutions are regarded to have great potential to address several real-world problems and adverse effects of current modes of transport. Microtransit can be described as private vans/buses/small vehicles offering rides or freight transport along fixed or constantly changing routes operating as a more technology-enabled shuttle in a demand-responsive manner by utilising ICTs and the internet of things (IoT). It is however still in the developmental stage. Once microtransit systems have been fully deployed and integrated into current transport systems, decision-makers, policy-makers, and other stakeholders will require a carefully designed monitoring and evaluation (M&E) framework towards assessing the system, which comes down to conducting sustainability evaluation and analysis of the transport system towards improving its sustainability performance. The framework could act as a management tool for decision support towards building realistic and profitable value propositions economically, socially and environmentally and will also enable the validation of decisions through continuous M&E. It could also assist microtransit and possibly also similar "smart mobility" businesses especially in penetrating public-sector verticals and securing funding since hard data is essential in proving real business cases.

Method and Results: This research aims at developing such an M&E framework for microtransit systems concerning the degree towards which it contributes to sustainable development based on a systematic literature review. Following the development of a conceptual framework consisting of 12 areas of sustainability and 50 indicators, the framework is applied as a management tool to a microtransit company, *Mellowcabs*, as case study. Interview and survey results based on the framework allowed for determination of a sustainability index (SI) and the execution of importance-satisfaction analysis (ISA). From the analysis, top five over- and underperforming indicators were identified and an overall sustainability index of 7.78 was obtained which is considered a 'satisfactory' score. The generalisability of the framework to the wider context of ITS / "shared mobility" was also tested through a second case study application to *GoMetro*, a sustainability index of 8.62 obtained, and the validation thereof completed through final case study interviews.

Conclusion: The original contribution of this study is a novel M&E framework designed specifically for microtransit systems' sustainability assessment. The reproducable systematic approach developed and followed in this study allows for future development of similar needed frameworks, and also allows for easy adjustments like addition, modification, or removal of any elements as deemed necessary in future. While the validation process delivered positive responses and confirmed the

efficiency, effectiveness, applicability, and validity of the tool, complete implementation of the tool on a microtransit system (once it has been fully deployed) could give rise to new issues that should be addressed in future. In the short term, results would assist in decision-making especially in the production-process. Its usefulness should also become apparent in the long-term as its overall goals are achieved through continuous monitoring and conducting regular evaluations.

Opsomming

Agtergrond: Mobiliteit is noodsaaklik vir byna elke aspek van die menslike bestaan. As gevolg van die inherente doel van vervoerstelsels om ons lewens te verbeter, is dit geen verrassing dat vervoerontwikkeling selde oorweeg word sonder om ook 'volhoubaarheid' in ag te neem nie. Bewyse dui egter daarop dat huidige vervoerwyses onvolhoubaar is. 'n Groot hoeveelheid navorsing is reeds gedoen om huidige regte-wêreld faktore te ondersoek wat te make mag hê met huidige en tradisionele vervoermiddele. Alhoewel die volhoubaarheid van vervoerstelsels as 'n beduidende uitdaging gesien word, is dit noodsaaklik om te verseker dat toekomstige generasies dieselfde geleenthede as wat ons tans geniet, sonder om omgewings-, sosiale en ekonomiese ontwikkeling in die gedrang te bring.

Behoefte: As gevolg van tegnologiese vooruitgang in inligting- en kommunikasietegnologie (IKT), die internet en die deel-ekonomie word alternatiewe maniere om 'slim mobiliteit' soos mikrotransitostelsels ontwikkel. Sulke oplossings beskik oor die potensiaal om verskeie probleme in die wêreld aan te spreek soos nadelige gevolge van die huidige vervoersisteme. *Microtransit* kan beskryf word as privaat klein-bus voertuie wat ritte of vragvervoer aanbied op vaste of veranderlike roetes wat op 'n vraggerigte manier, 'n meer tegnologiese pendelbasis gebruik word deur gebruik te maak van IKT's en die internet van die dinge (IvD). Dit is egter nog in die ontwikkelingsfase. Sodra mikrotransitostelsels ten volle ontplooi en geïntegreer is in die huidige vervoerstelsels, sal besluitnemers, beleidmakers en ander belanghebbendes 'n sorgvuldig ontwerpte raamwerk vir monitering en evaluering (M&E) benodig vir die beoordeling van die stelsel, wat neerkom op die uitvoering van volhoubaarheidsevaluering en ontleding van die vervoerstelsel om volhoubaarheidsprestasie te verbeter. Die raamwerk kan dien as 'n instrument vir besluitnemingsondersteuning vir die opbou van realistiese en winsgewende ekonomies-, sosiaal- en omgewings-waardeproposisies en sal ook die bekragtiging van besluite deur middel van deurlopende M&E moontlik maak. Dit kan ook mikrotransit en moontlik ook soortgelyke "slim mobiliteit"-ondernemings help, veral met die penetrasie van vertikale in die openbare sektor en die verkryging van geld, aangesien harde data noodsaaklik is vir die bewys van besigheidsake.

Metode en resultate: Hierdie navorsingstesis is gemik daarop om, op grond van 'n sistematiese literatuuroorsig, 'n M&E-raamwerk vir mikrotransitosisteme te ontwikkel rakende die mate waartoe dit bydra tot volhoubare ontwikkeling. Na die ontwikkeling van 'n konseptuele raamwerk bestaande uit 12 volhoubaarheidsareas en 50 indikatore, word die raamwerk as 'n gevallestudie as 'n bestuursinstrument op 'n mikrotransitonderneming, *Mellowcabs*, toegepas. Resultate van onderhoude en opnames gebaseer op die raamwerk dra by tot die bepaling van 'n volhoubaarheidsindeks (SI) en die uitvoering van 'n belangrikheidsbevrediging-analise (ISA). Uit die analise is die top vyf oor-en-onderpresterende indikatore geïdentifiseer en is 'n algehele volhoubaarheidsindeks van 7.78 verkry, wat as 'n 'bevredigende' telling beskou word. Die veralgemeenbaarheid van die raamwerk vir die wyer konteks van Intelligente Transitosisteme (ITS) / Gedeeldemobiliteit is ook getoets deur 'n tweede gevallestudie te voltooi, deur *GoMetro*, en 'n volhoubaarheidsindeks van 8.62 is behaal. Die validering van die raamwerk is voltooi deur middel van finale gevallestudieonderhoude.

Gevolgtrekking: Die oorspronklike bydrae van hierdie studie is 'n nuwe M&E-raamwerk wat spesifiek ontwerp is vir die volhoubaarheidsbeoordeling van mikrotranitosisteme. Die herhaalbare sistematiese benadering wat in hierdie studie ontwikkel en gebruik is, maak voorsiening vir toekomstige ontwikkeling van soortgelyke benodigde raamwerke, en is ontwerp om maklik aanpasbaar te wees ten opsigte van byvoeging, wysiging of verwydering van enige elemente wat in die toekoms mag benodig word. Terwyl die valideringsproses positiewe reaksies gelewer het en die doeltreffendheid, toepaslikheid en geldigheid van die instrument bevestig het, kan die volledige implementering van die instrument op 'n mikrotransitostelsel (sodra dit ten volle ontplooi is) aanleiding gee tot nuwe probleme wat aandag moet vereis in die toekoms. Op die kort termyn sal resultate help met die besluitneming, veral in die produksieproses. Die bruikbaarheid daarvan moet ook op die langtermyn ondersoek word, aangesien die algemene doelwitte daarvan bereik word deur deurlopende monitering en gereelde evaluerings.

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List of Acronyms and Abbreviations

ADB	Asian Development Bank
AHP	Analytic Hierarchy Process
AoS	Area of Sustainability
AQI	Air Quality Index
AQHI	Air Quality Health Index
CAI	Comprehensive Air-quality Index
CAQI	Common Air Quality Index
CFA	Conceptual Framework Analysis
CNS	Courier Network Services
CV	Coefficient of Variance
ECMT	European Conference of Ministers of Transport
EV	Electric Vehicle
GTM	Grounded Theory Methodology
ICT	Information and Communication Technology
IE	Industrial Engineering
IMECA	Índice Metropolitano de la Calidad del Aire
IoT	Internet of Things
ITS	Intelligent Transportation System
JCSEE	Joint Committee on Standards for Educational Evaluation
KPI	Key Performance Indicator
M&E	Monitoring and Evaluation
NDP	National Development Plan
NMT	Non-motorised Transport
OECD	Organization for Economic Co-operative Development
P2P	Peer-to-peer
PVS	Personal Vehicle Sharing
RBM	Results-based Management
SACOG	Sacramento Area Council of Governments
SLR	Systematic Literature Review
SOE	State-Owned Enterprise
TNC	Transportation Network Companies
UNDP	United Nations Development Programme

Chapter 1 **Introduction**

This chapter sets the context of the study as it provides the reader with background information and the rationale of the research with a clear introduction to the research problem. From the identified problem, the research aim, objectives, and outcomes are established. This is followed by a discussion on the research scope, assumptions, and limitations providing a clear outline and establishing the focus of the study. Lastly, ethical implications of the research are considered and discussed. A report content breakdown is also included at the end of this chapter.

Chapter key outcomes	Provide context to the study through background information
	Explain the rationale of the research
	Describe the research problem statement
	Describe research aim, objectives, and outcomes
	Establish research scope, assumptions, and limitations
	Consideration of ethical implications of the research
	Report content breakdown

1.1 Background to and Rationale of the research

Humankind has always had the need for mobility. When we consider mobility today, we are prone to think about transport and transport systems: the movement of humans and goods from one location to another. Transport is considered indispensable for human existence, development and civilisation (Bailey, Mokhtarian and Little, 2008). It enables people to have physical access to their jobs, health services, education, and other essential social necessities and amenities. It is considered one of the primary drivers of economic growth through trade by connecting people to resources and markets (Hall, 2002). Modern companies, industries and general activities are all dependent on transport and transport infrastructure for global and urban economic survival (Rodrigue, Comtois and Slack, 2016). Developing a variety of and adequate transport systems is vital for social and economic development. However, only considering these aspects would lead us to define transport for suiting the 'developed nation model', which would mean it was designed to encourage activities focusing on seeking freedom of mobility and wealth creation – typical for industrialised nations – without consideration of environmental protection (Hall, 2002). Since transport also triggers negative impacts regarding human health and the environment, it requires decisions-makers and policy-makers to also consider possible negative impacts in addition to the social and economic benefits it might bring.

Transport is thus linked to nearly all aspects of human life: our natural environment, economic prosperity, and social welfare which all are dependent on clean, effective, efficient, and equitable transport systems (Hall, 2002). Due to the inherent aim of transport systems to improve our lives, it is unsurprising that transport development is rarely considered without also considering 'sustainability' (in this thesis used interchangeably with 'sustainable development'), which reflects the fundamental human desire to protect and improve our planet (Litman, 2016). It was only after the publication of *Our Common Future* (commonly referred to as the Brundtland Report) by the World Commission on Environment and Development (Brundtland, 1987), that the concept of sustainable development

began to gather momentum. They define sustainable development: *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987, p. 15). This report forms the foundation for most discussions on sustainable development today (Zuidgeest, Witbreuk and Maarseveen, 2000; Hall, 2002; Zegras, 2006; Olofsson *et al.*, 2011; Haghshenas and Vaziri, 2012; Litman, 2016). The concept of sustainability is however a vast and complex issue often having conflicting goals and eliciting much debate. Its meaning changes according to the context to which it is applied (Olofsson *et al.*, 2011), and it encompasses several different disciplines including the natural and social sciences, medicine, and engineering, and requires various decisions (Poor and Lindquits, 2007). Sustainable development is therefore closely related to the values and the value systems of those who attempt to define it (Koglin, 2009).

The concept of sustainability was first applied to the transport sector in developed countries during the early nineties. Two reports in particular played a vital role during these early stages of the sustainable transport debate (Hall, 2002): 1) *Urban Travel and Sustainable Development* by the Organization for Economic Co-operative Development (OECD) Group on Urban Affairs and the European Conference of Ministers of Transport (ECMT) (Breheny, 1995), and 2) *Sustainable Transport: Priorities for Policy Reform* by the World Bank (World Bank, 1996). Since then the debate has persisted, and is still an ongoing process today. Similar to the difficulty in defining sustainable development, defining sustainable transport is not an easy task due to the strong influence of human factors and the non-material side of life including perception, morals, and behaviour (Olofsson *et al.*, 2011).

A continued discussion on sustainable transport and its definition is found later in this research. Still, every development aspect of a country today considers sustainability as an integral part (Munira and Santoso, 2017). Most societies have committed themselves explicitly or implicitly to the principles of sustainable development in recent years (Zuidgeest, Witbreuk and Maarseveen, 2000; Klinger, Kenworthy and Lanzendorf, 2013). The South African Department of Transport realises its responsibility regarding conducting research, formulating legislation and policies, regulating, and implementing monitoring systems in this regard towards achieving its strategic goals. The Government has defined their broad objectives of its transport policy as follows:

- *"To support the goals of the prevailing, overarching plan for national development to meet the basic accessibility needs of the residents of South Africa, grow the economy, develop and protect human resources and involve stakeholders in key transport-related decision making;*
- *To enable customers requiring transport for people or goods to access the transport system in ways that best satisfy their chosen criteria;*
- *To improve the safety, security, reliability, quality, and speed of transporting goods and people;*
- *To improve South Africa's competitiveness and that of its transport infrastructure and operations through greater effectiveness and efficiency to better meet the needs of different customer groups, both locally and globally;*

- *To invest in infrastructure or transport systems in ways that satisfy social, economic or strategic investment criteria; and*
- *To achieve the above objectives in a manner that is economically and environmentally sustainable, and minimises negative side effects."* (Department of Transport, 2017, p.2)

Despite these objectives and past attempts at changing transport systems to become sustainable, we still observe many real-world problems today regarding current transport systems worldwide. Most of the major negative effects of transport systems identified by Rosén in 2001 are still problems we face today: pollution, loss of community, car dependence and widespread ownership, social exclusion, land consumption, adverse economic, environmental and social impacts of traffic congestion, and non-renewable natural resource depletion (Rosen, 2001).

Urban transport systems are considered the engine for economic activities and the backbone for general mobility (Hall, 2002). Various modes of transport exist towards different purposes of physical and economic development and general mobility. Some typical urban facilities include: railways, waterways, airways and roads: the biggest player being road systems (Gwilliam, 2013). Urban areas tend to develop at nodal points in transport networks with good road networks (Wyatt, 1997). Naturally then, most sustainable transport research efforts and discussions revolve around road transport, particularly in urban areas (Hall, 2002). This is also clear in the major negative effects of current transport systems worldwide as identified by Rosén (Rosen, 2001).

As if addressing complex and at times abstract sustainability problems of which much debate and conflicting ideas exist is not difficult enough, in recent times many urban areas have experienced large increases in transport demands and road traffic as urbanisation continues (Gwilliam, 2013). This has led to capacity deterioration and inefficient road network performance. Simply adding additional road space to address these issues is ineffective since it also induces travel growth, and is not always possible in already built-up and dense environments like cities (Chowdhury and Sadek, 2003). A more relevant and acceptable strategy for addressing capacity and efficiency problems is through traffic management applications like the recently introduced Intelligent Transportation Systems (ITS) (Nelson and Mulley, 2013; Gschwender, Munizaga and Simonetti, 2016). A simple definition would be: innovative and advanced application of information and communication technology (ICT) to various modes of transport, particularly to road transport infrastructure, vehicles, users, and its interfaces with other modes of transport (European Union, 2010). The directive of the European Union states that ITS:

> *"…will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, safety and security of road transport, including the transport of dangerous goods, public security and passenger and freight mobility, whilst at the same time ensuring the functioning of the internal market as well as increased levels of competitiveness and employment."*
> (European Union, 2010)

Another recent strategy also utilising ICTs is the emergence of 'shared mobility' described as "the shared use of a vehicle, bicycle, or other low speed mode that enables users to have short-term access

to transportation modes on an 'as-needed' basis" (Shaheen *et al.*, 2015). Shared mobility is considered an umbrella term that includes various forms of vehicle sharing, on-demand ride services as well as alternative transit services including shuttles and private transit services e.g. microtransit (Shaheen *et al.*, 2015). According to Shaheen *et al.* (2015), microtransit has only recently emerged as a more technology-enabled alternative transit service incorporating flexible routing and/or flexible scheduling (Shaheen *et al.*, 2015). A key characteristic is connecting supply and demand through the use of ICTs, specifically in a demand-responsive manner often with a focus on "first-and-last-mile" transit (Bos, 2015). Utilising the internet and ICTs in an era of IoT towards intelligent transport systems (ITS), combined with the concept of shared mobility within an era of sharing economies, applied to the urban transport sector towards addressing current real-world problems, is what microtransit is all about.

Modes of transport are thus continuously evolving and growing to adapt to changes and find innovative and optimal ways of addressing current transport problems and the negative effects caused by them. It is essential that continuous research must be conducted on both current and alternative modes of transport as it contributes to an enormous variety of areas. However, since microtransit is a contemporary concept, little in-depth research has been conducted in this area and a gap is identified in the body of knowledge. Although microtransit presents an innovative new (or re-emerging) mode of transport with great potential, it would however require a tool that decision-makers, policy-makers, and stakeholders can use to monitor and evaluate the system concerning its sustainability performance once it has been fully deployed and integrated with current traditional transport networks and infrastructure.

A vital aspect for any organisation, state-owned enterprise (SOE), or institution that aims at progressively improving the performance of any particular activity or service is monitoring and evaluation (M&E) (Channa, 2013). M&E is however a wide field with many approaches, paradigms, and types of evaluation. A general but brief description could be: M&E is a method used to increase performance and succeed in reaching goals and achieving results by assessing the performance of activities and projects of organisations and state-owned enterprises (SOEs). The major goal of M&E is to improve the management of outcomes and outputs by establishing links between past, present and future procedures and decisions (UNDP, 2009). The National Development Plan (NDP) of South Africa also clearly states that planning and implementation should be informed by evidence-based monitoring and evaluation (National Planning Commission, 2011). The UK Department of Transport has also indicated the importance of M&E for them regarding decision-making, stating that effective application of M&E can reduce the risk of making poor decisions, inefficiency, inability to demonstrate accountability and unnecessary regulatory activities (Channa, 2013).

It is against this background that the importance and need are identified for appropriate monitoring and evaluation of microtransit systems towards sustainable development, especially once it has been fully deployed. Clearly, addressing sustainability is a complex and at times abstract subject around which much debate and conflicting ideas exist (Hall, 2002). Despite the challenges of implementing a measurement approach for transport sustainability evaluation and it being considered "more than daunting" (Zegras, 2006), it is necessary to ensure future generations have the same benefits from transport as we do today. An M&E framework for microtransit systems concerning sustainable

development would ensure that social well-being and economic growth is promoted while still considering the environmental and health impacts it might have.

Apart from the importance of this research as pointed out in a theoretical sense, the need therefore is also indicated by the start-up microtransit company *Mellowcabs*, used in this research for the case study application.

1.2 Research problem statement, aim, objectives, and outcomes

> *"Sustainability is the next great game in transportation. The game becomes serious when you keep score."* (Greenroads International., 2018)

1.2.1 Research problem statement

It is widely recognised that urban transport systems in its current form are unsustainable and in dire need of improvement (Dobranskyte-Niskota *et al.*, 2009; Olofsson *et al.*, 2011; Haghshenas and Vaziri, 2012; Litman, 2016). Despite plentiful research conducted on current transport systems' sustainability, we increasingly observe the emergence of new 'smart mobility' modes of transport through technological advancements in ICT including ITS (Nelson and Mulley, 2013; Gschwender, Munizaga and Simonetti, 2016), shared mobility (Cohen and Kietzmann, 2014; Shaheen *et al.*, 2015), and microtransit systems (Bos, 2015; Jaffe, 2015; MaRS Discovery District, 2016). These initiatives challenge traditional ideas and support the claims that global economic sustainability cannot be accomplished sufficiently with incremental improvements in our current systems (Lovins and Cohen, 2011; Stead and Stead, 2013). These alternative modes of transport ('smart mobility'), particularly microtransit systems, present great potential in addressing current real-world problems regarding the transport sector (Shaheen *et al.*, 2015).

While there seems to be an abundance of research concerning the sustainability assessment of current modes of transport and general city mobility through monitoring and evaluation (M&E), little research exists regarding sustainability evaluation of the contemporary 'smart mobility' transport alternatives. Although some research has been conducted on the sustainability potential of shared transport and ITS, a dearth of research exists regarding microtransit systems especially with regard to evaluating the system's sustainability performance.

As an emerging new field with great potential, microtransit is still in the developmental stage. For it to effectively address and solve current real-world transport-related problems, stakeholders and decision-makers would require a carefully designed Monitoring and Evaluation (M&E) framework once the service has been fully deployed and integrated with current transport systems. This framework would focus on improving transport sustainability through continuous M&E. The framework could act as a management tool for decision support towards building realistic and profitable value propositions economically, socially and environmentally and will also enable the validation of decisions through continuous M&E. This framework could assist microtransit businesses especially in penetrating public-sector verticals and securing funding since hard data is essential in proving real business cases.

1.2.2 Research aim, objectives, and outcomes

Due to microtransit being a contemporary concept of which little in-depth research has been conducted, and the need for transport systems to contribute towards sustainable development, a gap was identified in literature. This research aims to fill this gap by developing an appropriate M&E framework for microtransit systems concerning its sustainability. This was done through conducting two qualitative literature studies on microtransit and M&E followed by a systematic literature review towards conceptual framework development by means of indicator identification. The framework was validated through expert interviews and surveys and applied to a case study as a management tool by quantitatively estimating sustainability performance of transport activities. The generalisability of the framework was then evaluated in the broader context of ITS through a second case study application.

The following research objectives have been created to aid in solving the research problem by achieving the aim of this research:

I. Obtain a comprehensive understanding of microtransit through conducting a conceptual literature study.
II. Conduct a second conceptual literature study to explore and fully understand the process of Monitoring and Evaluation (M&E) through extensive literature analysis and recognize how to apply the obtained knowledge towards building a conceptual framework.
III. To identify key approaches and concepts for a microtransit M&E framework by means of a systematic comparative literature review.
IV. Develop the microtransit M&E conceptual framework.
V. Validate the microtransit M&E conceptual framework through expert interviews.
VI. Application of the validated framework to a case study as a management (M&E) tool for evaluating its effectiveness and applicability in the context of an existing microtransit company.
VII. Test the generalisability of the finalised framework in the broader context of ITS by application to a second case study

The outcome of the research is to have developed an effective and generic M&E framework for microtransit systems with the possibility of utilising it on similar small scale urban transport systems. This framework will assist with decision support towards building a realistic, profitable, and overall sustainable company and validate their decisions through continuous M&E. The M&E framework will also to some extent be useful for other types of transport companies and possibly also distribution companies.

In the specific case of *Mellowcabs* the M&E framework could assist them in effectively proving their business case by quantifying data into practical information that can be used as compelling evidence to secure funding. It could also provide guidance on how initiatives should be rolled out and how they can be continuously monitored and evaluated effectively.

1.3 Research scope, assumptions, and limitations

Two conceptual literature studies, on microtransit and M&E, comprising the scope of this research are conducted towards establishing a basis for framework development by means of conducting the systematic literature review. While only the key concepts ‘microtransit’ and ‘M&E’ were considered initially, drawing links between the two focal concepts led to sustainable transport becoming a third

focal point, even though not initially identified. The scope of this study is limited to developing a conceptual framework for monitoring and evaluating microtransit systems' sustainability.

For each of the two focal concepts, some limitations were identified in the form of including and excluding terms as search criteria during the scoping and planning stage of the systematic comparative literature review in Chapter 5

1.3.1 Limitations

The development of a conceptual framework for M&E of microtransit systems concerning sustainable development is the primary aim of this research. While the framework could be used as a management tool, the application thereof by means of a case study in this research is limited due to the following reasons:

- The management tool can only be applied towards satisfaction measurement, and not performance measurement since required data for several variables are not available at this stage as microtransit systems have not yet been fully deployed.
- The tool is applied through limited satisfaction measurement interviews as only three respondents from the first case study company, *Mellowcabs*, and three respondents from the second case study company, *GoMetro*, had adequate knowledge and were available.
- The number of case study applications at this stage is limited by the contemporary nature of ITS and microtransit systems and the existence of such companies. No iterative process was undergone for improving the tool based on multiple practical case study applications to similar companies – the tool could only be applied once to a single microtransit company, *Mellowcabs*, as case study since it is the only company within realistic geographical proximity to the researcher to his knowledge, and once to an ITS company, *GoMetro*, that was identified as ideal towards determining the generalisability of the framework.

Other limitations of this research include:

- Due to time constraints, after multiple attempts, and the difficulty when attempting to arrange interviews with Western Cape government officials from the Ministry of Transport and Public Works, no government officials could be included in the final set of experts interviewed.
- Experts in the field of microtransit are significantly rare since very few microtransit companies exist locally, which then complicates the validation of the framework.
- The developed framework is conceptual and would require further additional research and validation through experts prior to achieving a generic model for application to any particular microtransit system.
- The developed framework is not suitable for application to traditional transport systems since it was developed specifically for microtransit systems. Generalisability of the framework to other ITS contexts will however be considered.

1.3.2 Delimitations

The delimitations within the control of the researcher identified for this research are as follows:

- This research focuses on monitoring and evaluation of microtransit systems.
- Initially, the literature research focused on only two concepts: Microtransit systems, and Monitoring and Evaluation. This naturally led to the consideration of transport sustainability as well. These three concepts outline the scope of literature consulted for this study.

- Microtransit systems are considered within urban areas.
- Only peer-reviewed literature was used for framework development through indicator identification.
- While literature from diverse geographical contexts around the globe was considered for framework development, framework application is only considered in a South African context.
- Only individuals who could be considered experts in fields relevant to microtransit systems or sustainable development were interviewed. This is essential since indicator importance cannot be weighted by individuals who do not have adequate knowledge of either of the two concepts.
- With the development of a conceptual M&E framework for microtransit systems, this research will focus on appropriate concept identification towards a comprehensive sustainability 'skeleton' for such systems.
- The developed conceptual framework will serve as a 'foundational skeleton' for organisations to which variables could easily be added, removed and/or modified.

1.4 Ethical implications of the research

The need for conducting interviews and surveys was identified in this research. Participation of respondents thus requires an ethical clearance process to be completed. In doing this, the researcher ensures that all ethical aspects regarding scientific research are adhered to in accordance with SU requirements. Even though the needed information is considered not sensitive, all information will be handled anonymously and confidentially. Following successful completion of the ethical clearance process (Project number: ING-2018-1646), institutional permission was also requested and granted for allowing interviews to be conducted with SU academics.

The following stipulations regarding participation by respondents are followed to ensure an ethical approach:

- The research is expected not to have any (negative) impact on those who are studied. No risk of causing harm or any negative experiences or discomforts are anticipated.
- Before any interview or survey commences, informed consent will be obtained from the participants by completing consent forms.
- All interviews and surveys are entirely voluntary and participation can be withdrawn at any time during the interview with no negative consequences.
- Participants may choose not to answer certain questions. If information is refused (not answered), research will commence without it and be based on the relevant information that can well be disclosed.
- If the participant decides to withdraw completely from the interview and the research study, all data will be eliminated and will not be used for the research.

The following stipulations regarding confidentiality ensured that all research was executed ethically:

- All information obtained from the participants will represent the company rather than the individuals – the participants will thus remain anonymous.
- The information obtained from the interviews and surveys will be considered as opinion rather than fact. No personal questions or personal details will be asked. If any information is obtained that might be considered sensitive, it will not be disclosed.

- Voice recordings of the interviews instead of video recordings will ensure the interviewee's privacy. Voice recordings will be made with the investigator's phone which is password protected.
- All hard copy consent forms with personal information (e.g. signature) will be scanned and kept on the investigator's laptop which is password protected and kept in a secure location, and always locked or shut down when left unattended.
- All digital and hard copies of the consent forms will be destroyed within five years or after completion of the Master's thesis and the completion of journal article publication(s) within the five-year period.

1.5 Report content breakdown

The layout of this research document and a content overview of each chapter are provided in Table 1-1. It serves as a summary of main themes considered in each chapter as well as a general overview of the approach followed in completing this research: From acquiring the necessary background knowledge, deriving research methods, and comprehensive literature studies, towards literature analyses and comparative reviews for framework development, validation, and application.

Table 1-1 Report content breakdown

Chapter	*Heading*	*Brief description*
Chapter 1:	*Introduction*	Through providing background information and the rationale of the research, the context is set. The research problem statement is described followed by the research aim, objectives, and outcomes. By describing the research limitations and assumptions, the scope of the study is also outlined. After consideration of the ethical implications of the study, the chapter concludes with this report content breakdown.
Chapter 2:	*Research Methodologies and Design*	Elucidation is provided on research approaches and the grounded theory methodology (GTM) towards delineating the research strategy. Methodologies are developed for conducting two conceptual literature studies and a systematic literature review towards the development of a conceptual microtransit M&E framework.
Chapter 3:	*A Conceptual Review of Microtransit Systems*	This chapter conducts the first qualitative literature study. Contextualisation through defining sustainable development, transport sustainability and shared mobility within the sharing economy paves the way towards defining microtransit systems. The concept is discussed in detail along with some of its strengths and weaknesses towards a framework for microtransit system evaluation.
Chapter 4:	*A Conceptual Review of Monitoring and Evaluation*	The second qualitative conceptual literature study is conducted regarding monitoring and evaluation (M&E). A brief historical overview is provided followed by an introduction to intervention logic towards defining the concept of evaluation. The various evaluation types, purposes, and leading evaluation theories (main paradigms) are then discussed. After defining 'monitoring', the concept of M&E is defined and discussed towards the development of an evaluation framework for microtransit.

Chapter	*Heading*	*Brief description*
Chapter 5:	*Conducting the Systematic Comparative Literature Review*	From the systematic literature review (SLR) method defined in chapter 2, this chapter conducts the systematic comparative part thereof through review stages 2.1-2.4. Defined research questions, keywords, and inclusion and exclusion terms assist in identifying a set of relevant studies. High-level reading enables identification of main components and recurring themes. The chapter concludes with descriptive statistical analysis of the identified studies.
Chapter 6:	*Developing the Microtransit M&E Conceptual Framework*	By completing the second part of the SLR in this chapter, a comprehensive understanding of the final set of relevant articles is obtained through extensive reading. Data extraction, categorisation, and the analysis thereof enabled concept identification, deconstruction, categorisation, and integration into the initial subjective conceptual microtransit M&E framework.
Chapter 7:	*Validation of the Microtransit M&E Conceptual Framework*	The SLR concludes with the validation of the initial subjective conceptual framework into an enhanced conceptual framework. The methodology for validation is developed first, followed by a discussion on and analysis of the semi-structured and indicator-weighting interviews and their techniques. The chapter concludes with the enhanced and weighted conceptual framework.
Chapter 8:	*Case Study Application: Mellowcabs*	The enhanced and weighted conceptual framework is applied to a case study to illustrate its usefulness as a management tool. The *Mellowcabs* initiative is introduced and used towards this purpose. Performance and satisfaction measurement is considered towards the determination of a sustainability index (SI). Importance-satisfaction analysis (ISA) is then conducted. The chapter concludes with feedback from case study interviews and finalise the microtransit M&E conceptual framework.
Chapter 9	*Case Study Application: GoMetro*	The finalised conceptual framework is applied in a different context than it was originally developed for. Case study application to the *GoMetro* company considers a context of “smart mobility”/ITS that is wider than microtransit, and tests the generalisability of the framework in this broader context. Sustainability index (SI) values are again determined and importance-satisfaction analysis (ISA) conducted followed by a case study interview to provide feedback. The results are then analysed, discussed, and compared to the first case study with critical reflection.
Chapter 10:	*Conclusions and Recommendations*	In the final chapter of this research study, a concise summary of the research is provided, conclusions are drawn about the findings regarding the research objectives, and recommendations of future research are suggested.

Chapter 2 **Research Methodologies and Design**

In Chapter 2, the aim is to develop and explain the research methodologies and design needed for conducting two conceptual literature studies as well as a systematic literature review comprising of a comparative literature review and a conceptual framework development process.

The chapter starts with elucidation on research approaches towards defining types of research strategies. The Grounded Theory Methodology (GTM) is chosen for this study as the research strategy for conducting the aforementioned two literature studies and systematic literature review. The complete conceptual framework development process is created based on different research approaches from various authors. Finally, the succinct research plan for this document is explained followed by a summary of the study's research methodologies and design in a 'Document Structure' table.

Chapter key outcomes	Discussion on the research approaches employed
	Introduction to and explanation of the Grounded Theory Methodology (GTM)
	Delineation of the overall research strategy
	Elucidation of the two conceptual literature studies' methodology
	Development and break-down of a comprehensive systematic literature review methodology
	Elucidation of the systematic comparative literature review methodology
	Elucidation of the conceptual framework development methodology
	Development of a succinct research plan
	Summary of this document's research strategy and design

2.1 Research Approaches

When conducting research, we typically find the research approach to be either quantitative or qualitative. When both of these approaches are used, it is referred to as mixed methods (Diriwächter and Valsiner, 2006). In logic however, the two common approaches to reasoning are either inductive or deductive (Trochim, 2006). Using inductive and deductive reasoning in conjunction forms the basis of the grounded theory methodology (Datt and Chetty, 2016). This section clarifies what is meant by quantitative versus qualitative research, and inductive versus deductive research towards defining the research strategy in Section 2.2.

2.1.1 Quantitative vs Qualitative research

We typically define the difference between quantitative and qualitative research according to the form of the data, where quantitative research is in numerical form and qualitative research is not. There are however fundamental differences regarding their definitions and their conceptual and methodological approaches.

Punch (1998) defines qualitative research as "empirical research where the data are not in the form of numbers" (Punch, 1998). According to Denzin and Lincoln (1994), "Qualitative research is multimethod in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin *et al.*, 1994). This type of research approach is thus exploratory, seeking to understand the underlying motivation and explain "how" and "why" a phenomenon operates the way it does (Corbin and Strauss, 1990). The researcher acts as the instrument for data collection and interpretation as the ultimate aim is to understand the social reality of individuals and groups as close to how they experience it. People are thus studied within their natural environment (Soiferman, 2010). A variety of data collection methods are employed to understand how people perceive and act within their social realities: unstructured/semi-structured individual/group interviews, multi-case studies, open-ended questionnaires, document analysis, participation observation and ethnography (Denzin *et al.*, 1994). The limited number of respondents are chosen carefully according to their level of expertise on the field that is investigated. Qualitative research often forms the foundation for quantitative research since insights are gained into the problem and patterns recognised before conducting the quantitative research.

Quantitative research can be defined as "systematic empirical investigation of observable phenomena via statistical, mathematical or computational techniques" (Given, 2008). Punch (1998) provides a simple definition: "Quantitative research gathers data in a numerical form which can be put into categories, or in rank order, or measured in units of measurement. This type of data can be used to construct graphs and tables of raw data" (Punch, 1998; Soiferman, 2010). The objective thus is to explain phenomena by collecting numerical data that can be analysed by developing and employing mathematically based methods, models, theories or hypotheses - in particular statistical methods (Aliaga and Gunderson, 2000; Bhawna and Gobind, 2015). Either descriptive or inferential statistics are used to understand the relationship among variables where descriptive statistics summarise the data and inferential statistics identify differences in the data that are significant (Soiferman, 2010). Data that are not in numerical format, such as opinions, behaviours or feelings, thus have to be quantified. For data to be measurable and accurate, the method of data collection has to be structured e.g. various forms of surveys, face-to-face interviews etc. Facts are formulated from statistical analysis

of the generated measurable data to uncover patterns in research. Researchers using quantitative analysis draw their conclusions from logic, evidence, and argument (Trochim, 2006). Protocols are often employed to control and/or anticipate as many threats to validity as possible (Soiferman, 2010). The key differences between quantitative and qualitative research are summarised in Table 2-1. While quantitative research may be refered to as objective, the argument can be made that nothing can be purely objective. Objectivism integrates both subjectivity as well as objectivity since objective knowledge would always require some form of active, sophisticated subjective reasoning (perception / synthetic reasoning / analytical reasoning / logical deduction etc). These subjective processes can thus enhance objective comprehension. Differentiating between quantitiative and qualitative research can thus be more accurately described by referring to quantitative research as *more* objective and qualitative research as *more* subjective.

Table 2-1 Key differences between Quantitative and Qualitative research (Adapted from (Celano, 2014)**)**

	Qualitative research	*Quantitative research*
Type of knowledge	More subjective	More objective
Aim	Exploratory and observational	Generalisable and testing
Characteristics	Flexible	Fixed and controlled
	Contextual portrayal	Independent and dependent variables
	Dynamic, continuous view of change	Pre- and post-measurement of change
Sampling	Mostly purposeful	Mostly random
Data collection	Semi-structured or unstructured	Structured
Nature of data	Narratives, quotations, descriptions	Numbers, statistics
	Value uniqueness, particularity	Replication
Analysis	Thematic	Statistical

Cresswell and Plano Clark (2011) believe that no study is however purely quantitative or qualitative, but rather always mixed-method to some degree. They assume both approaches address the same elements in the research process and only differ in how each step is implemented. These differences are not opposites, they say, but rather differences on a continuum (Creswell and Plano Clark, 2011).

In this study the mixed method approach, a combination of both quantitative and qualitative research, is adopted due to the research complexity. Work conducted with a qualitative approach includes the conceptual literature studies, fieldwork consisting of initial semi-structured interviews, indicator-weighting interviews, and the development of the conceptual framework and application thereof on a case study. Research work with a quantitative approach includes most of the systematic comparative literature review, analysis of the indicator-weighting interviews, and sustainability index (SI) calculation and importance-satisfaction analysis (ISA) of the case study.

2.1.2 Inductive vs Deductive research

The primary difference between inductive and deductive research approaches is that a deductive approach aims at testing theory with an emphasis on causality whereas an inductive approach is oriented towards generating a new theory from data by exploring new phenomena or earlier researched phenomena from a new perspective (Gabriel, 2013). It is generally found that inductive

approaches are associated with qualitative research and deductive approaches with quantitative research, although not as a rule (O'Reilly, 2009; Soiferman, 2010; Gabriel, 2013).

Trochim (2006) defines the deductive approach as working from 'the more general' to 'the more specific' (Trochim, 2006). O'Reilly (2009) describes the process: "In deductive research a hypothesis is derived from existing theory and the empirical world is then explored, and data are collected, in order to test the hypothesis" (O'Reilly, 2009). Deductive reasoning is considered as the standard for scientific research by many (Crossman, 2017). This approach is considered a "top-down" approach (Trochim, 2006; Soiferman, 2010) as illustrated in Figure 2-1.

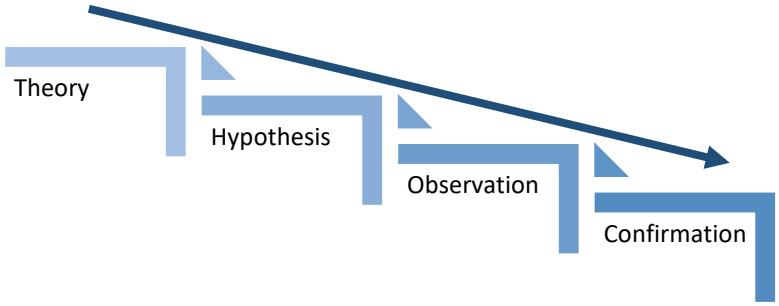


Figure 2-1 Deductive reasoning approach ("Top-down") (Adapted from (Trochim, 2006)**)**

Trochim (2006) observed that the inductive approach is the reverse of deductive as it starts with specific observations and then works towards broader generalisations and theories. O'Reilly (2009) states: "An inductive approach is where the researcher begins with as few preconceptions as possible, allowing theory to emerge from the data" (Znaniecki, 1934; O'Reilly, 2009). Crossman (2017) explains that after gathering and analysing data, a theory is constructed to explain the findings (Crossman, 2017). This approach is generally considered a "bottom-up" approach (Trochim, 2006; Soiferman, 2010) and is illustrated in Figure 2-2.

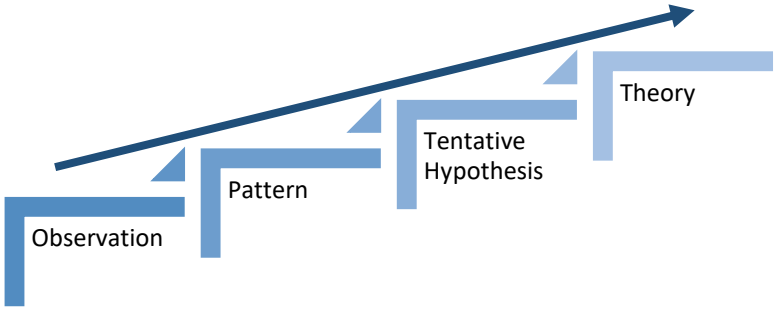


Figure 2-2 Inductive reasoning approach ("Bottom-up") (Adapted from (Trochim, 2006)**)**

While inductive research is also used in scientific research, critics suggest that this approach might not be logically valid since a general principle cannot accurately be assumed as correct from only a limited number of cases. (Crossman, 2017) Inductive research is more open-ended and exploratory during early stages while deductive research is narrower and used for testing and confirmation of hypotheses. Social research does however in most cases involve both inductive and deductive reasoning (Crossman, 2017).

2.2 Research Strategy

Saunders *et al* (2016) define the research strategy as the "general plan of how the researcher will go about answering the research questions" (Saunders, Lewis and Thornhill, 2016). Considering that research strategies can be either inductive or deductive, or both, Datt (2016) proposes seven research strategies to choose from based on the research approach employed as illustrated in Figure 2-3 (Datt and Chetty, 2016). Although these seven strategies are by no means and exhaustive list, it provides a broad range of strategies to consider (Saunders, Lewis and Thornhill, 2016).

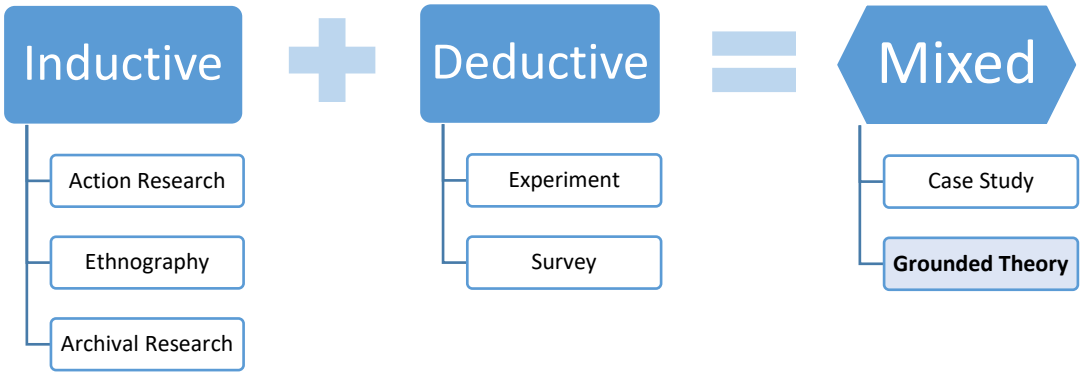


Figure 2-3 Research strategy types (Adapted from (Datt, 2016))

For this research, it was decided to employ the Grounded Theory Methodology (GTM) as research strategy for reasons explained in the following section. A definition and discussion on this strategy are also provided.

2.2.1 Grounded Theory Methodology (GTM)

GTM was first introduced by sociologists Glaser and Strauss in 1967 arguing that researchers needed a method that allowed for theory to be created from data (Glaser and Strauss, 1967). These theories would be specific to the context and 'grounded' in the data from which they had emerged. This created an opportunity for the development of new and contextualised theories from data or elaborating on existing ideas by exploring supplementary data (Glaser and Strauss, 1967; Corbin and Strauss, 1990; Strauss and Corbin, 1994; Jabareen, 2009; Glaser, 2013).

GTM has systematic but flexible guidelines for the progressive identification and integration of 'categories of meaning' from systematically gathered data points (Strauss and Corbin, 1994; Charmaz, 2006; Glaser, 2013). The data, coded in a consistent manner (Corbin and Strauss, 1990), is then analysed towards constructing new theories (Charmaz, 2006). Glaser (2013) describes the category identification and integration process as the 'method' and its end-product, e.g. a conceptual explanatory framework, as the 'theory' which can be used to understand the phenomenon under investigation (Glaser, 2013). As the collected data is reviewed by the researcher by extracting codes, recurring themes and concepts become apparent. Continuing with reviewing data enables categorisation of these concepts which can become the basis for a novel theory (Allan, 2003). This process is illustrated in Figure 2-4. The creation of knowledge is thus promoted through research expert interpretations instead of merely rearranging existing theories and ideas, differentiating GTM from other qualitative research methods (Strauss and Corbin, 1994).

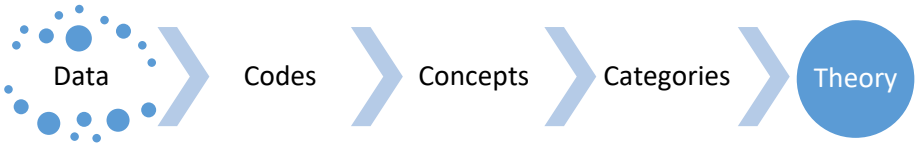


Figure 2-4 Overview of GTM process

The GTM strategy consists of both inductive and deductive reasoning (Glaser and Strauss, 1967). The formulation of hypotheses based on conceptual ideas and the ultimate derivation of a theory from initial data as illustrated in Figure 2-4 requires inductive reasoning (Glaser and Strauss, 1967). GTM became more prescriptive however, when Strauss and Corbin (1990) introduced step-by-step guides to the method (Corbin and Strauss, 1990). For instance, a specific coding paradigm was included that necessitates the researcher to identify patterns in the data, adding a deductive element to GTM (Glaser, 2013). Glaser and Strauss (1967) also stated that a central feature of GTM is its method of comparative analysis. The verification of hypotheses by comparing conceptualised data on different levels of abstraction also requires deductive thinking (Glaser and Strauss, 1967).

For studies using the GTM strategy, a set of questions or a collection of qualitative data is required to begin with (Allan, 2003; Saunders, Lewis and Thornhill, 2016). For this reason, two conceptual literature studies of a qualitative nature were conducted for this research to provide context on the research objectives towards theory development as illustrated in Figure 2-5.

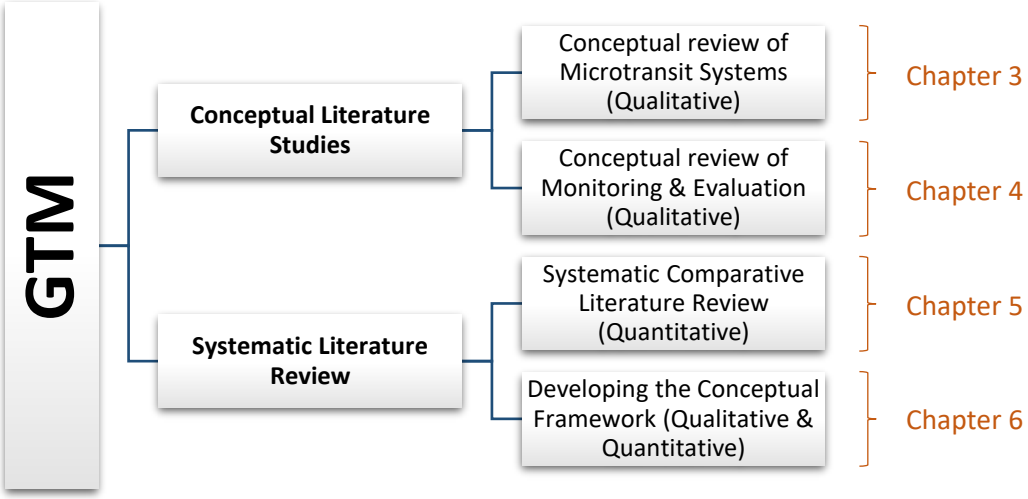


Figure 2-5 Foundation for research design methodologies

Also, with its foundation in GTM, a systematic literature review will be conducted consisting of 1) A systematic comparative literature review and 2) The development of the conceptual framework also illustrated in Figure 2-5. The GTM is recognised by several researchers as the foundation for the development of conceptual frameworks (Jabareen, 2009; Astalin, 2013). Jabareen's (2009) well-known 8-phase Conceptual Framework Analysis (CFA) method, consisting mostly of inductive reasoning (Hussein *et al.*, 2014), is commonly used towards this purpose (Jabareen, 2009). The GTM chosen as research strategy will therefore provide a foundation for the development of the research design methodologies developed in Section 2.3

2.3 Research Design

In this section, the methodologies for conducting the two conceptual literature studies, the systematic comparative literature review, and the method for developing the conceptual framework are developed.

2.3.1 Conceptual Literature Studies' Methodology

As mentioned before, the conceptual literature study for this research comprises two separate literature studies for 1) Microtransit and 2) Monitoring and Evaluation. Although this was not conducted in a detailed step-by-step and systematic manner, the broad process that was followed in exploring, understanding and reporting the topics towards a comprehensive theoretical background is illustrated in Figure 2-6.

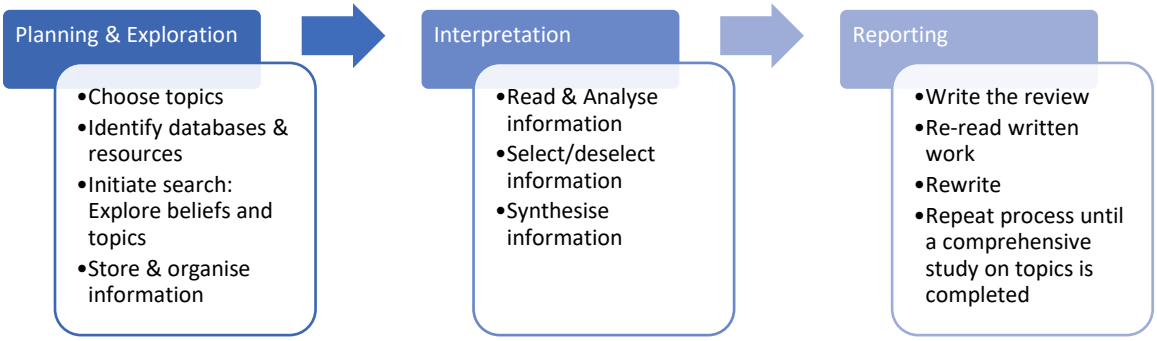


Figure 2-6 Conceptual literature studies' methodology

With its systematic approach towards collecting articles the systematic literature review confirmed that a shortage on information about microtransit systems exists. Grey literature thus had to be used to a large extent in Chapter 3. Interviews were also held with personnel from a microtransit company to develop a better understanding of the initiative towards completing the literature study.

2.3.2 Systematic Literature Review Methodology

The research towards building a conceptual framework will be conducted in a systematic manner. This process, in identifying relevant articles to the proposed research problem and analysing the information towards framework development, is now discussed. A systematic review of the literature is essential in ensuring all relevant existing literature at the time is considered.

Characteristics of systematic literature reviews include: objectivity, replicability, and transparency (Siddaway, 2014). There are various stages in conducting a systematic literature review. Various authors have proposed different methods of conducting these reviews and divide them into different phases/stages (Khan *et al.*, 2003; Potter, 2004; Kitchenham and Charters, 2007; Jabareen, 2009; Siddaway, 2014). Some authors and their respective methodological frameworks (stages of undertaking a systematic literature review) are included and discussed briefly in Table 2-2.

Table 2-2 Different systematic literature review methodologies proposed by various authors

Author	*Proposed Systematic Literature Review process*	*Comments*
Khan, Kunz, Kleijnen, & Antes (2013)	**Step 1:** *Framing questions for a review* **Step 2:** *Identify relevant work* **Step 3:** *Assessing the quality of studies* **Step 4:** *Summarising the evidence* **Step 5:** *Interpreting the findings*	Not a lot of information on the proposed steps is included. Steps are discussed briefly. No specifics or framework provided.
Kitchenham & Charters (2007)	**Stage 1:** *Planning the review* a. Identification of the need for a review b. Commissioning a review c. Specifying the research question(s) d. Developing a review protocol e. Evaluating the review protocol **Stage 2:** *Conducting the review* a. Identification of research b. Selection of primary studies c. Study quality assessment d. Data extraction and monitoring e. Data synthesis **Stage 3:** *Reporting the review* a. Specifying dissemination mechanisms b. Formatting the main report c. Evaluating the report	Kitchenham & Charters (2007) divide the process of systematic literature review into three distinct stages. Each stage has steps that are discussed extensively. This reference provides a good framework that can be followed step by step.
Siddaway (2014)	**Stage 1:** *Scoping* a. Formulate one or more research question(s) b. Clarify whether the planned systematic review has already been done **Stage 2:** *Planning* a. Break research question(s) down into individual concepts to create search term b. Formulate preliminary inclusion and exclusion criteria - and then review these in the initial stages of the literature searching and sifting process c. Create clear record keeping systems and keep meticulous records by working systematically **Stage 3:** *Identification (searching)* a. Use your search terms to search at least two different (relevant) electronic databases b. Carefully inspect the search results c. Conduct additional searches to ensure you have located all potentially relevant published and unpublished work **Stage 4:** *Screening* a. Export references to a citation manager to collate the search results b. Read the Title and/or Abstract of identified work **Stage 5:** *Eligibility* a. Sift the full-text version of potentially eligible articles and extract relevant information to be included	Siddaway (2014) provides useful information but does not include a clear framework. This reference is useful in ensuring that all concepts are understood since extensive explanations are given. Besides the key stages in conducting a systematic review, the author has also included other useful information: i. *Deciding when to do a quantitative or a qualitative research synthesis* ii. *How to present (write up) a systematic review*

Author	*Proposed Systematic Literature Review process*	*Comments*
Potter (2004)	**Step 1:** *Selecting a review topic* **Step 2:** *Searching the literature* **Step 3:** *Gathering, reading and analysing the literature* **Step 4:** *Writing the review* **Step 5:** *References*	A brief overview of the literature review process is provided step by step. No specifics or framework is included.
Jabareen (2009)	**Phase 1:** *Mapping the selected data sources* **Phase 2:** *Extensive reading and categorizing of the selected data* **Phase 3:** *Identifying and naming concepts* **Phase 4:** *Deconstructing and categorizing the concepts* **Phase 5:** *Integrating concepts* **Phase 6:** *Synthesis and resynthesis* **Phase 7:** *Validating the conceptual framework* **Phase 8:** *Rethinking the conceptual framework*	Jabareen (2009) propose 8 phases and briefly explains each phase. The main phases lack in providing sub steps that can be followed step by step. The brief explanations are however clear and informative.

These literature review methodologies presented by various authors were broken down and combined into a single systematic literature review method as illustrated in Table 2-3. This suggested framework contains all the required steps in performing a proper systematic literature review regarding the proposed research problem.

Table 2-3 Proposed methodological framework for conducting the systematic literature review

Stage	*Steps*	*Additional Comments and Objectives*	*Chapter*
Stage 1: Scoping and Planning	a. Identify need for review b. Formulate/Frame/Specify research questions c. Break research questions down into key search terms (Define search terms) (Data categories) d. Prelim identification of inclusion and exclusion terms	• Indicate whether the review has been conducted previously • Confirm that a gap exists in the body of knowledge regarding the proposed topic.	1
Stage 2: Identification (Searching)	a. Choose data sources b. Identification/Data collection from chosen data sources c. Data selection criteria and data selection	• Develop a system to keep record of obtained data in a systematic manner. • Ensure that all potential relevant published and unpublished work is located. • Assess quality of obtained data (published vs unpublished) • Mapping	5
Stage 3: Extensive	a. High level reading & preliminary categorisation	• Extensive reading of identified studies and understanding of relevant terms	5 & 6

Stage	*Steps*	*Additional Comments and Objectives*	*Chapter*
reading and categorisation of data	b. Extensive reading & data extraction c. Categorisation of data	• Categorisation and organisation of data from studies	
Stage 4: Results, Analysis and Interpretation	a. Data summaries (Results) b. High level interpretation of findings c. Comprehensive interpretation & analysis	Summarising and interpretation of findings: • Number of publications per document type • Literature publications timeline (number of publications per year) • Geographic analysis • Relevance of publications • Recurring themes & frequency of appearance • Citation count per publication	5 & 6
Stage 5: Conceptual Framework Development	a. Identifying and naming concepts b. Deconstructing and categorisation of concepts c. Integrating concepts d. Synthesis and resynthesis	• The categorised data is analysed and broken down into concepts • The summarised data and concepts are synthesised in the form of a conceptual framework to tell us more about the "real" world (Jabareen, 2009) • The approach for developing the conceptual framework is through qualitative analysis	6

Throughout the process of performing the systematic literature review it is important to note that the researcher must continuously take notes, document work and give explanations as new discoveries are made and concepts are understood. It is essential to make use of external inputs and feedback to ensure that objectivity is maintained. This will guarantee that critical analysis is done and improve consistency (Pautasso, 2013).

As mentioned earlier and referring to Figure 2-5, the systematic literature review will consist of:

I. A systematic comparative literature review; and
II. The development of a conceptual framework

This was kept in mind when designing the systematic literature review in Table 2-3. Besides for reasons explained earlier in this chapter, the method was designed to be able to complete a high-level interpretation and analysis of the identified studies via the comparative review, before continuing with extensive reading and a comprehensive analysis towards the development of the conceptual framework from the studies identified in the comparative review.
The five stages from the systematic literature review thus form the methodologies of I. and II. above as follows:

I. Systematic Comparative Literature Review Methodology

The systematic comparative literature review methodology is defined through stages 1-4 of the systematic literature review and illustrated in Figure 2-7.

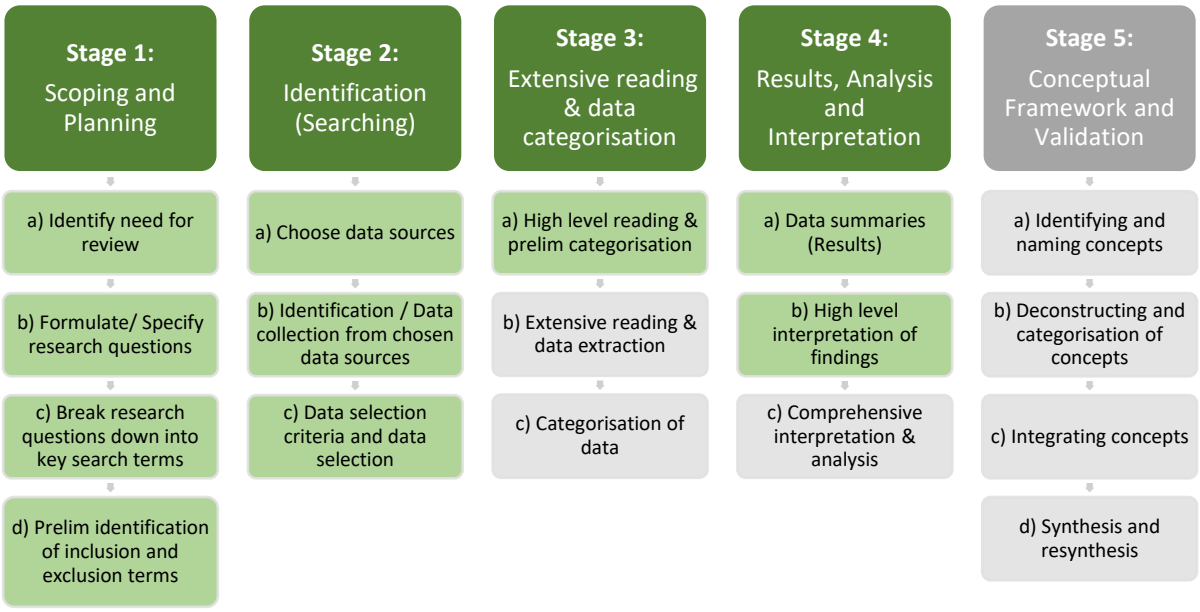


Figure 2-7 Systematic comparative literature review methodology

II. (Systematic) Conceptual Framework Development Methodology

The conceptual framework development methodology is defined through stages 3-5 of the systematic literature review and is illustrated in Figure 2-8. These steps were largely adapted from Jabareen's (2009) CFA method. Jabareen (2009) perceives the validation of the framework as part of the CFA method for framework development (Jabareen, 2009). Since the validation must be done prudently and is not considered as part of the systematic conceptual framework development methodology, it will be considered in another chapter. This is done since validation is a crucial part that must be considered comprehensively and executed accurately.

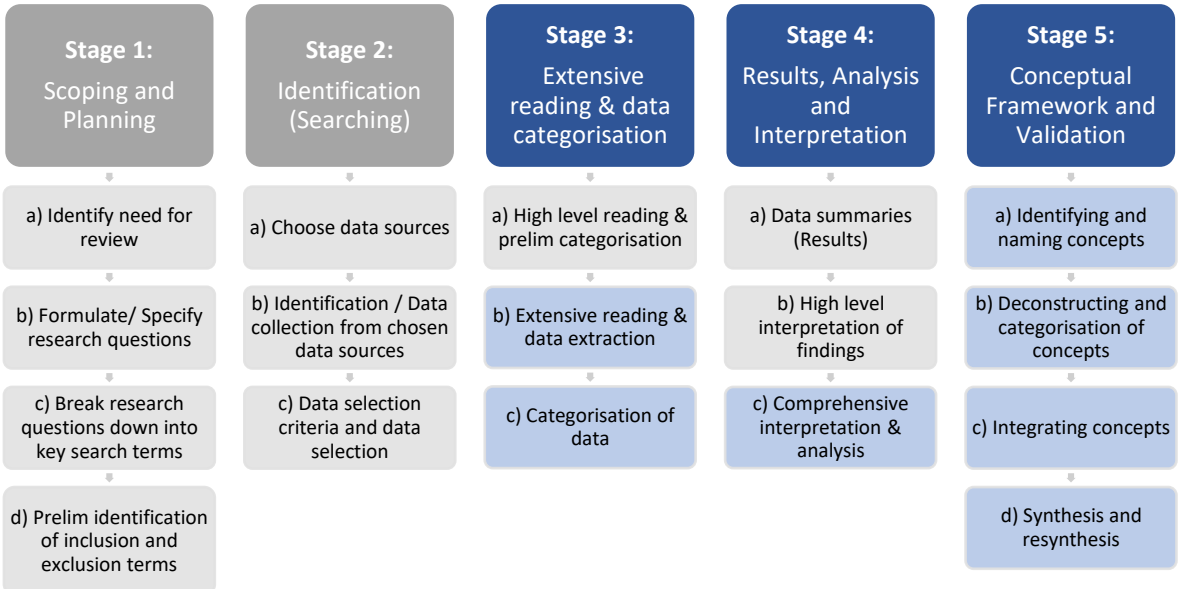


Figure 2-8 Conceptual framework development methodology

2.4 Research Plan

The research plan provides an overview of the process that is followed from start to finish of this research study. This summary provides an organised and easily understandable step-by-step guide broken down into six parts.

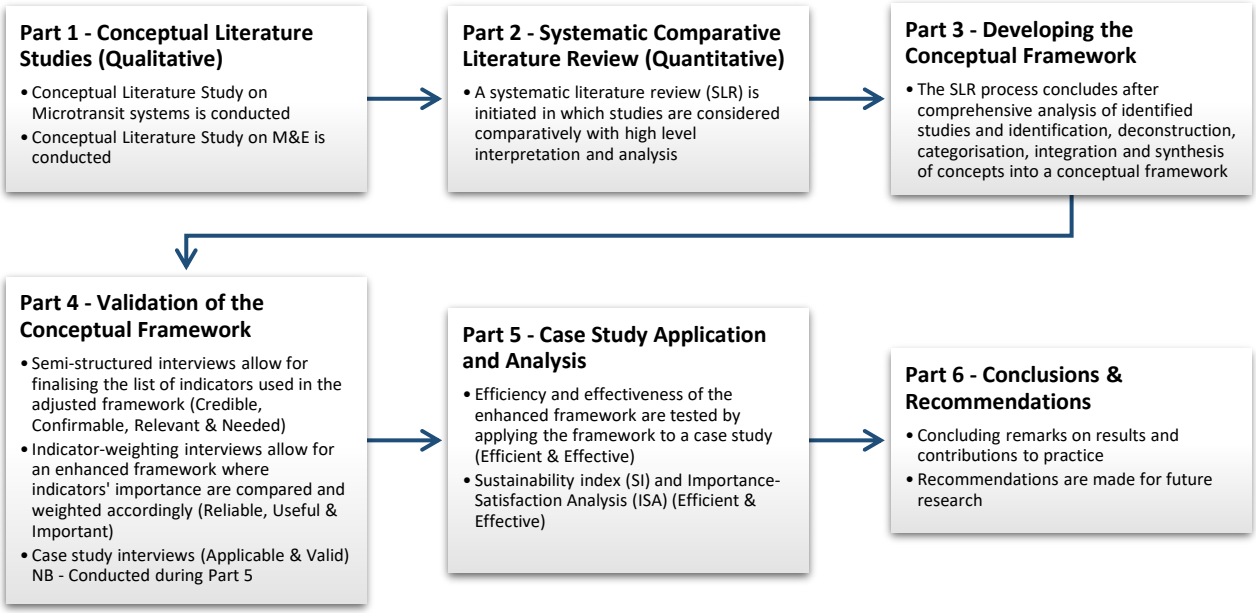


Figure 2-9 Research Plan

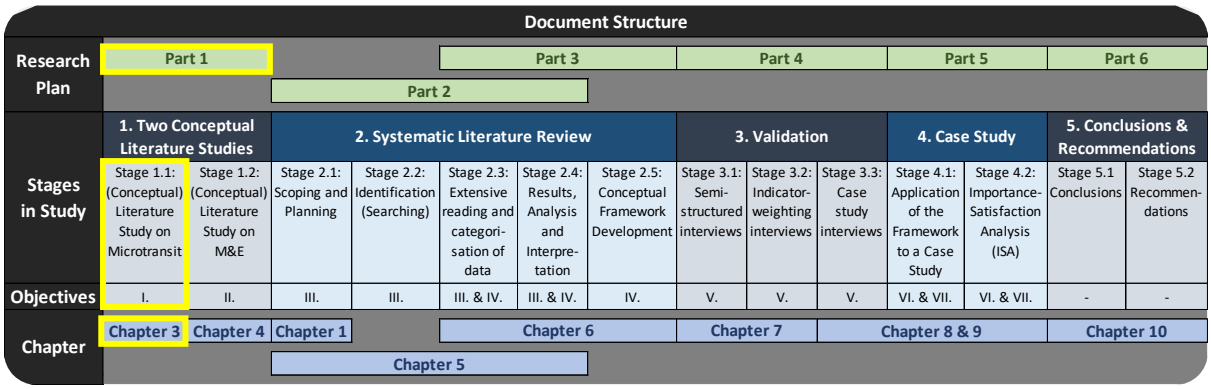
2.5 Chapter 2: Summary of Research Strategy and Design

A final brief summary of all the stages followed in this research study, the respective parts of the research plan, and the corresponding chapters and objectives are presented in Table 2-4. This table will be used at the start of each chapter to indicate the corresponding stage(s) of the research design executed and part(s) of the research plan considered.

Table 2-4 Document structure

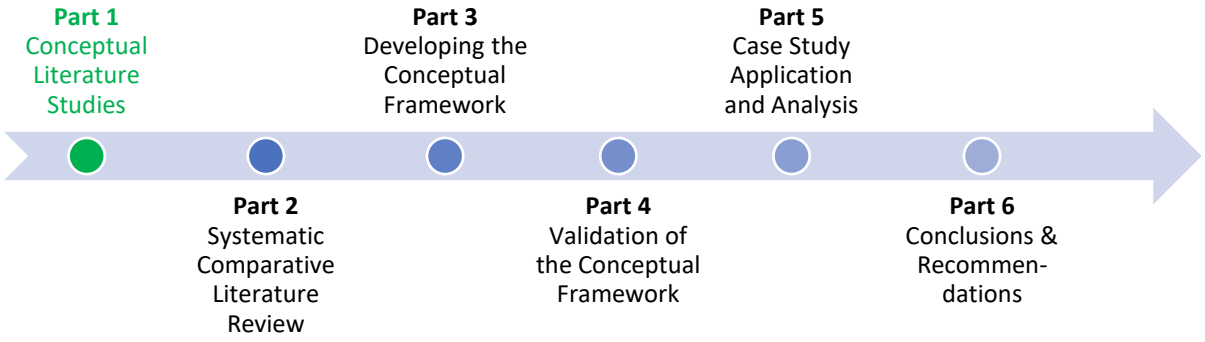
Document Structure														
Research Plan	Part 1				Part 3			Part 4			Part 5		Part 6	
			Part 2											
Stages in Study	1. Two Conceptual Literature Studies		2. Systematic Literature Review					3. Validation			4. Case Study		5. Conclusions & Recommendations	
	Stage 1.1: (Conceptual) Literature Study on Microtransit	Stage 1.2: (Conceptual) Literature Study on M&E	Stage 2.1: Scoping and Planning	Stage 2.2: Identification (Searching)	Stage 2.3: Extensive reading and categori-sation of data	Stage 2.4: Results, Analysis and Interpre-tation	Stage 2.5: Conceptual Framework Development	Stage 3.1: Semi-structured interviews	Stage 3.2: Indicator-weighting interviews	Stage 3.3: Case study interviews	Stage 4.1: Application of the Framework to a Case Study	Stage 4.2: Importance-Satisfaction Analysis (ISA)	Stage 5.1 Conclusions	Stage 5.2 Recommen-dations
Objectives	I.	II.	III.	III.	III. & IV.	III. & IV.	IV.	V.	V.	V.	VI.	VI.	-	-
Chapter	Chapter 3	Chapter 4	Chapter 1		Chapter 6			Chapter 7		Chapter 8			Chapter 9	
			Chapter 5											

Chapter 3 A Conceptual Review of Microtransit Systems



This chapter proceeds with the qualitative literature study (conceptual review) of microtransit systems. In the first section the concept of sustainability is defined followed by an overview and discussion on sustainable transport systems to provide context. Secondly, the concept of shared mobility within the sharing economy is discussed and defined towards the introduction to microtransit systems. A detailed definition of microtransit is provided and the concept is discussed comprehensively, including a brief SWOT analysis. Finally, the plan towards developing a management tool and its application to a case study is discussed.

Chapter key outcomes	Contextualisation through defining sustainability/sustainable development
	Define transport sustainability and provide an overview
	Discussing the route towards a sustainable transport M&E framework
	Introduction to and elucidation of shared mobility within sharing economy
	Define and comprehensively discuss the concept of microtransit systems
	Consideration of microtransit strengths and weaknesses through a brief SWOT analysis
	Consideration of route towards a framework for microtransit system evaluation



3.1 Sustainability

This section provides background information regarding sustainability to set the context towards the introduction of shared transport and microtransit systems in sections 3.2 and 3.3. Sustainable development is defined in section 3.1.1 followed by a definition of sustainable transport in section 3.1.2 towards an introductory discussion on a monitoring and evaluation framework for sustainable transport in section 3.1.3.

3.1.1 Defining sustainability/sustainable development

Countries today consider sustainability as an integral part of every development aspect (Munira and Santoso, 2017). The World Commission on Environment and Development provides the following definition of sustainable development: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). The UK government defines sustainability or sustainable development (used interchangeably) in their 1998 policy statement by the Department of the Environment, Transport and the Regions (DETR, 1998):

- "Social progress which recognises the needs of everyone;
- Effective protection of the environment, limiting global effects;
- Prudent use of natural resources; and
- Maintenance of high and stable levels of economic growth and employment."

The three pillars of sustainability: social, environmental, and economic (also referred to as "people, planet, profit" or the "triple bottom line") are commonly known and referred to as the fundamental spheres of sustainability. It should be noted that sustainability issues regarding these three domains are however often in conflict with one another which Low and Gleeson (2003) refer to as the "paradox of sustainability" (Low and Gleeson, 2003). This is discussed further along with examples in the following section.

3.1.2 Sustainable transport systems

According to the National Development Plan (NDP) of South Africa, the development and maintenance of an efficient and competitive transport system is a key objective for the country's development (National Planning Commission, 2011). Striving for a sustainable city is an elusive goal without a sustainable transport network since there will always be a need for mobility, making discussions on transport sustainability essential (Holden, 2008; Litman, 2016; Munira and Santoso, 2017). Sustainability within the context of transport does not however merely refer to sustaining the transport system, but also to the broader impacts the transport system could have (Zheng *et al.*, 2013). Hall (2002) goes even further, stating that when we consider sustainable transport we should not just

consider the broader impacts of the modes of transport, but also the implications that enhanced mobility might bring (Hall, 2002).

The Asian Development Bank (ADB) Sustainable Transport Initiative (2010) states that "sustainable transport supports a competitive economy and balanced regional development. It also promotes equity, including gender equity, affordability, minimum use of land and resources, consequently reducing emissions, waste, and noise" (ADB, 2010). The Centre for Sustainable Transportation (1998) provides a more detailed definition which is widely accepted (Gilbert and Myrans, 2002; Cormier and Gilbert, 2005; Munira and Santoso, 2017) stating that a sustainable transport system…

> *"1) …allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.*
>
> *2) It is affordable, operates efficiently, offers the choice of transport mode, and supports a vibrant economy.*
>
> *3) It limits emissions and waste within the planet's ability to absorb them, minimises consumption of nonrenewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise."* (CST, 1998)

The Ministers of Transport of the 15 European Union countries have adopted this definition almost word for word. It is due to this reason that the European arm of the Rand Corporation and several partners believe that this definition of sustainable transport should be favoured since it "has been reviewed by political mechanisms and received general political acceptance" (Cormier and Gilbert, 2005).

Goals towards environmental conservation, social responsibility, and economic viability often overlap or are in conflict with one another making it difficult to operationalize the concept of sustainability (Low and Gleeson, 2003; Olofsson *et al.*, 2011; Litman, 2016). Munira and Santosa (2017) provide some examples: Although air pollution is an environmental issue, it also has effects on human health (social) and agricultural activities (economic). Traffic congestion also impacts all three spheres since it adds stress to people's lives (social), causes increased pollution (environmental), and results in GDP losses in lost productivity and hours worked (economic) (Munira and Santoso, 2017). These overlapping issues are illustrated with a Venn diagram in Figure 3-1.

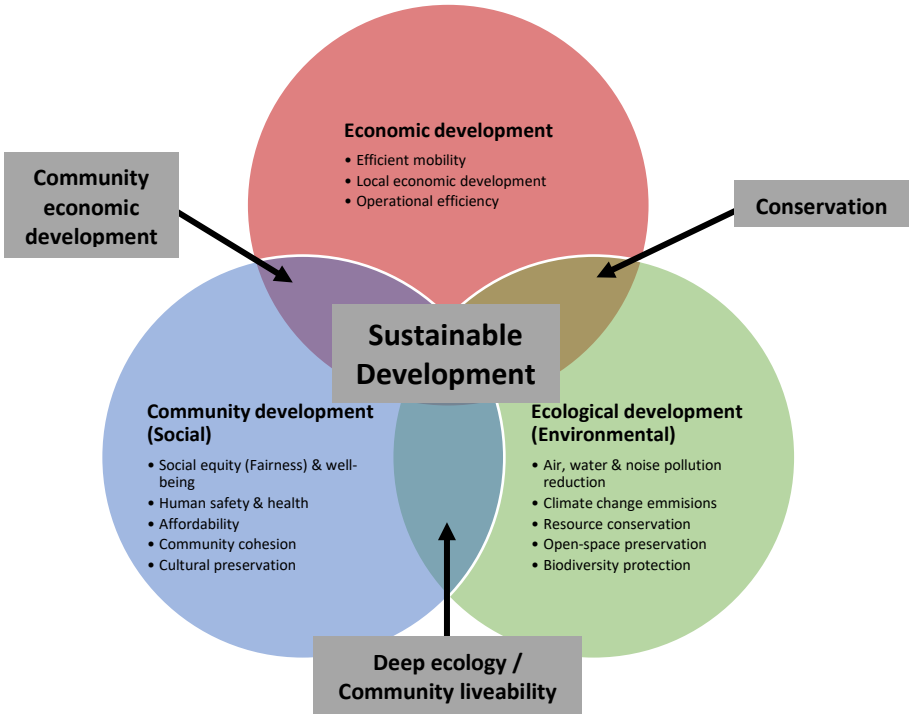


Figure 3-1 Illustration of the overlapping fundamental spheres of sustainability (Adapted from: (Zuidgeest, Witbreuk and Maarseveen, 2000; Litman, 2016)**)**

The need for and importance of transportation systems are evident. Transportation has contributed significantly to economic, political and social development in the past as it enables trade through carrying people and goods from one place to another, creates jobs, and promotes personal freedom. Without transportation, there would be no mass production, distribution of goods, or trade. Transportation is thus one of the primary drivers of economic growth since the demand for and production of goods increase substantially. Existing markets can be expanded and new markets created (Cheyne and Imran, 2016). Without it markets would be limited to local areas and only local demands will be satisfied without consideration of global demands. The economy of every country will not be able to grow and will stay in an isolated neutral state (Business-Marketing, 2012).

Aside from the economic value that it adds transportation also contributes towards social, political, and cultural development. Globalisation is encouraged as modes of transport are becoming faster, cheaper and more effective thus shrinking geographical distance. Relationships with foreign countries can be established and people experience more personal freedom. The development of autonomous driving would for example enable senior citizens, children and physically challenged individuals to travel more easily without assistance. Other benefits include circulation of knowledge, uniformity and the strengthening of national security (Business-Marketing, 2012). However, as populations continue to grow in urban environments and cities grow in land-use, urban transport systems experience increased pressure to provide sustainable, efficient and reliable services (Noland and Polak, 2002).

Although there is no consensus on the definition for sustainable transport and many definitions have been formulated, the previously stated definition from The Centre for Sustainable Transportation (1998) seems to be the most widely recognised in the literature reviewed (Gilbert and Myrans, 2002; Cormier and Gilbert, 2005; Munira and Santoso, 2017). Although the definition seems lengthy, it is

argued that the definition is still broad. The difficulty of pinning down an exact definition lies in the fact that the fundamental three pillars of sustainability (social, environmental, and economic) encompass a multitude of factors that should be considered for its definition. To consider all factors concerning transport sustainability, numerous publications address this through developing conceptual (theoretical and practical) frameworks and the identification of indicators (Mihyeon Jeon and Amekudzi, 2005; Miranda and Rodrigues da Silva, 2012; Zheng *et al.*, 2013; Litman, 2016; Munira and Santoso, 2017).

3.1.3 Towards a framework for transport sustainability evaluation

Since the sustainable operation of a transport system is crucial in developing a sustainable city (Olofsson *et al.*, 2011), transport policies and the travel patterns of people significantly impact social, economic, and environmental development of the city and ultimately the country. It is thus vital to monitor transport systems in order to determine whether it is contributing to sustainable social, economic, and environmental development and whether policies are achieving their goals (Munira and Santoso, 2017). The majority of researchers in the field of evaluating sustainable transport performance are in agreement that a system of indicators provides the most effective way of quantifying and assessing its sustainability performance (Olofsson *et al.*, 2011; Litman, 2016). A wide variety of indicators regarding the triple bottom line has been developed and utilised to this purpose based on the context of the research and the mode of transport under consideration (Gilbert and Myrans, 2002; Cormier and Gilbert, 2005; Mihyeon Jeon and Amekudzi, 2005; Olofsson *et al.*, 2011; Miranda and Rodrigues da Silva, 2012; Zheng *et al.*, 2013; Litman, 2016; Munira and Santoso, 2017). These indicators are used to evaluate sustainability, guide decision-making processes, and assist planners and administrators by determining how effective policies are in progressing sustainable development (Litman, 2016; Yang, Lee and Chen, 2016). The key principles to apply when selecting adequate transport indicators are summarised in Table 3-1 (Litman, 2016).

Table 3-1 Key principles for adequate transport indicator selection (Adapted from: (Litman, 2016)**)**

Principle	*Description*
Comprehensive	Various impacts (social, environmental, and economic) and various transport activities (e.g. human and freight transport) should be reflected by the indicators.
Quality	Ensure consistent and accurate information through a process of data collection reflecting high standards.
Comparable	Clearly defined and standardised data collection will enable comparison between various times, groups, and jurisdictions.
Understandable	Decision-makers and stakeholders should easily understand clearly defined indicators. More information condensed into a single indicator would give it less meaning for specific decisions.
Accessible and transparent	The indicators, the data they require, and the analysis details should be available to all stakeholders involved.
Cost effective	The collection of indicators should be cost-effective.
Net effects	The indicator should differentiate between total impacts (net) and shifts of impacts based on different times or settings.
Functional	Selected indicators must be appropriate for establishing useable performance targets.

After elucidation of the concept of shared mobility and microtransit as transport systems in the remainder of this chapter, and the concept of monitoring and evaluation in Chapter 4, the systematic literature review (SLR) will guide the process of indicator identification towards developing a monitoring and evaluation framework for microtransit systems.

3.2 Microtransit and shared mobility within the sharing economy

Recently there has been increased focus on alternative options of mobility (e.g. shuttles, carpools, and microtransit etc.) to the conventional modes of public transport services we know towards addressing several of today's sustainability concerns. This section firstly describes and defines the concept of shared mobility within the sharing economy and secondly defines the concept of microtransit. The section concludes with a discussion on potential impacts microtransit might bring and compares some of its major strengths and weaknesses.

3.2.1 Shared mobility and the sharing economy

The world's recent introduction into the sharing economy, described by Shaheen et al. (2015) as 'A developing phenomenon around renting and borrowing goods and services rather than owning them' (Shaheen *et al.*, 2015), has led to several new potential opportunities and business innovations based on 'collaborative consumption' (Botsman and Rogers, 2010). Cohen and Kietzmann (2014) describe it as people offering and sharing underutilised resources in creative and new ways (Cohen and Kietzmann, 2014). Cohen and Kietzmann believe that although some of these innovations were prompted by frugal spending after the 2008 global economic recession, its success can be attributed to growing environmental consciousness and the omnipresence of the Internet and similar ICTs making sharing possible on a large scale (Cohen and Kietzmann, 2014). These influences challenged traditional ideas on how resources could be offered and consumed, supporting claims that transforming our global economy towards sustainability cannot be accomplished sufficiently with incremental improvements in our current production and consumption systems (Lovins and Cohen, 2011; Stead and Stead, 2013). Developments towards a sharing economy have inevitably had effects on multiple industries including the transport industry, with its introduction to shared mobility.

Shaheen *et al.* (2015) describe shared mobility as 'the shared use of a vehicle, bicycle, or other low speed mode that enables users to have short-term access to transportation modes on an "as-needed" basis.' Shared mobility is considered an umbrella term that includes various forms of vehicle sharing, on-demand ride services as well as alternative transit services including shuttles and private transit services e.g. microtransit (Shaheen *et al.*, 2015). All current shared mobility models were identified and categorised into sections by Shaheen *et al.* (2015) of which an overview is presented in Figure 3-2.

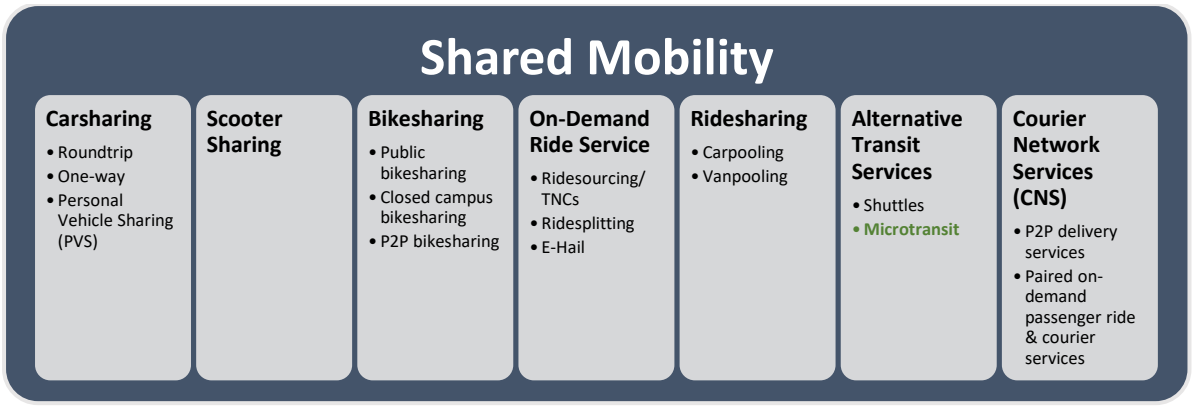


Figure 3-2 Key Areas of Shared Mobility (Adapted from: (Shaheen *et al.*, 2015)**)**

While traditional transportation policies focus on minimising congestion and travel times, Pucher and Dijkstra (2003) challenge this idea stating that trying to reduce travel time for single occupancy vehicles just exacerbates the use of private vehicles as well as the need for street maintenance and parking (Pucher and Dijkstra, 2003). Shared mobility supports this new sustainable mobility paradigm promoted by several scholars and public policy makers (Banister, 2008) of focusing on "optimal congestion" instead of minimal congestion (Lyons and Urry, 2005). Banister (2008) believes this can be achieved through four key objectives (Banister, 2008):

1. **Fewer trips** – Reduce the total trips taken or required by citizens e.g. Being able to make online purchases for local goods and services.
2. **Modal shift** – Transforming the hierarchy from single occupancy vehicles towards shared mobility, public transport, and cycling or walking.
3. **Distance reduction** – Increased densities and improved mixed-use development will lead to a reduction in total distance traveled per resident.
4. **Increased efficiency** – Concerned with more energy efficient public transport services and personal vehicles with lower footprints, the objective is to reduce adverse environmental impacts.

Shared transport is typically characterised by flexibility through demand-responsive transport (DRT) initiatives (Cheyne and Imran, 2016). Cheyne and Imran (2016) believe it is important to view shared transport not merely as a 'flexible transport service (FTS)', but rather recognise the spectrum of shared transport modes on a continuum based on number of passengers, which they believe is strongly associated with flexibility. This is illustrated in Figure 3-3.

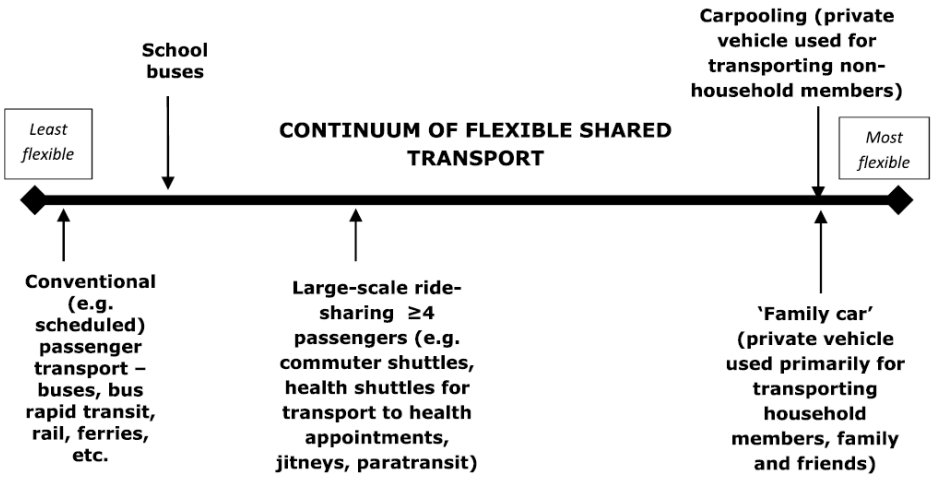


Figure 3-3 The continuum of shared transport (Source: (Cheyne and Imran, 2016)**)**

Cheyne and Imran (2016) also believe that new digital platforms today provide flexible shared mobility with opportunities to overcome several obstacles faced by public transport providers. They state that transport policy-makers and planners need to recognise and support the expansion of flexible shared transport due to its low carbon, and its social and economic inclusivity (Cheyne and Imran, 2016). Several benefits regarding the triple bottom line have been reported through the use of various modes of shared mobility. Numerous studies have observed a noticeable reduction in vehicle ownership, vehicle usage, and vehicle total distance travelled (Shaheen *et al.*, 2015). Shared transport could play a vital role in bridging the gaps in current transport systems. Encouraging multi-modality by providing 'first-and-last-mile' solutions to public transit could extend the catchment area of public transit (Shaheen *et al.*, 2015). Further research is however needed to better understand the impacts each of these wide variety of shared mobility modes could have on urban and regional development.

In this study, we consider microtransit systems as the mode of shared mobility. Although microtransit has been around for many years, a renewed consideration thereof as a mode of shared mobility within the "sharing economy" combined with ICT in an era of IoT will introduce a new understanding and definition thereof and bring forward new possibilities. When considering the term in this regard, microtransit is a contemporary concept of which little in-depth research has been conducted. Some grey literature does however exist and will also be considered in the following section where a definition is provided towards addressing the gap in literature regarding microtransit systems as a mode of shared mobility.

3.2.2 Defining Microtransit

According to Shaheen *et al.* (2015), microtransit has only recently emerged as a more technology-enabled alternative transit service incorporating flexible routing and/or flexible scheduling (Shaheen *et al.*, 2015). A key characteristic is connecting supply and demand through the use of ICT (Bos, 2015). Making use of smartphone technology enables microtransit to avoid conventional and expensive methods of booking rides. After considering various literature, some of the standout characteristics also include: Microtransit can be described by vehicles operating on demand usually within a short-distance range. This mode of transport lies somewhere between collective public transport and individual private transport as illustrated in Figure 3-4 (Bos, 2015) and typically provides flexible ride services for small-scale inner-city transport of either passengers or goods (Jaffe, 2015).

In Figure 3-4 we again observe the flexibility continuum previously introduced in Figure 3-3. A vertical axis is however introduced for number of passengers instead of assuming that it is directly correlated with flexibility as in Figure 3-3. We would still expect these to be strongly connected, meaning that fewer passengers would indicate a more flexible mode of transport and vice versa. This is suggested by the positive slope diagonal (refer to arrows) with microtransit somewhere in the middle.

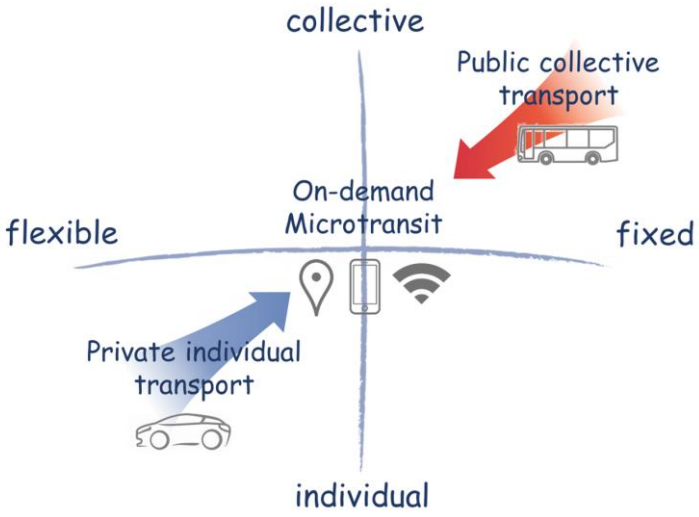


Figure 3-4 Graphical depiction of Microtransit systems (Source: (Bos, 2015)**)**

A more detailed list of characteristics was proposed by Shaheen *et al.* (2015) based on characteristics attributed to "flexible transit services" by the Transit Cooperative Research Program (TCRP, 2004). According to Shaheen *et al.* (2015), microtransit services typically include at least one of the following service characteristics (Shaheen *et al.*, 2015):

i. **Route deviation** – A vehicle can deviate from its route within a specific zone on a demand-responsive request
ii. **Point deviation** – A demand-responsive vehicle serves only a limited number of stops without a fixed route between stops
iii. **Demand-responsive connections** – Vehicles operate in a demand-responsive geographic zone with one or more fixed-route connections
iv. **Request stops** – A passenger can request an immediate unplanned stop along the predefined route
v. **Flexible-route segments** – The demand-responsive service is available within segments of a fixed route
vi. **Zone route** – The route alignment of the operating vehicles is often determined by user input with fixed departure and arrival times at one or more end points

Shaheen *et al.* (2015) also state that microtransit services can include variations of these two models: *I. Fixed (pre-determined) routes and fixed schedule* (typical of public transport services), and *II. Flexible routes and flexible (on-demand) schedule* discussed briefly using examples below.

I. Fixed (pre-determined) routes and fixed schedules

Chariot is an example of a fixed-route microtransit company. This company operates in a similar manner that public transit services do with 15-seater vans, shown in Figure 3-5, running on pre-

determined routes. They have however included a function where customers can request creating new routes based on customer demand via “crowdsourcing” (Shaheen *et al.*, 2015).

Figure 3-5 A Ford van used by Chariot (Source: (LeFebvre, 2017)**)**

These microtransit services presented by Chariot are somewhat similar to that of vanpools. The difference is that while vanpool passengers often have to share driving responsibilities, microtransit vehicles have employed drivers. This rigid form of microtransit (fixed routes and schedules) is also closer to public transit than a flexible transport system would be, thus also posing a bigger threat and close competition (Fehr & Peers, 2015). These microtransit services are however still operating on a small scale having limited impacts (Shaheen *et al.*, 2015).

II. Flexible routes and flexible (on-demand) schedules

Bridj is an example of a more flexible microtransit system offering on-demand services. Using a mobile application (similar to car-sharing services like Uber and Lyft), customers can request rides in selected areas from Bridj’s 14-seater vans, illustrated in Figure 3-6 (Zimbabwe, 2015). Using ICT and IoT, the Bridj system uses an algorithm to set a central meeting spot for passengers which is determined by the location of its most recent pickup request. Potential passengers can then simply walk to the central meeting spot and share a ride with passengers who the algorithm has determined are going in similar directions or have similar destinations (Shaheen *et al.*, 2015).

Figure 3-6 A van used by Bridj in Washington, DC (Source: (Zimbabwe, 2015)**)**

These services reroute its vehicles based on passenger demand and traffic situations. Since these services have no static routes or schedules, it is considered fully dynamic (Shaheen *et al.*, 2015). For a transport systems to be classified as a FTS (Flexible Transport System), the transport service has to have at least one of the following aspects of service not fixed: route, schedule, vehicle, passenger, and/or the payment system (Wright *et al.*, 2014).

Research by Cheyne and Imran (2016) has identified seven factors that have the biggest influence on the success of demand-responsive transport (DRT) services: Regulation and licensing, service planning and design, marketing, funding, costs, technology, and emissions (Cheyne and Imran, 2016).

After considering available literature it is clear that no formal definition of microtransit has to date been introduced regarding municipal policy or regulation. Literature is now pointing to policy-makers to see what definition set and associated rules will be established (MaRS Discovery District, 2016). A few definitions have however been attempted by different (grey) literature:

The Sacramento Area Council of Governments ("SACOG") defines microtransit systems as:

> *"...fleets of privately-owned vans and shuttle buses with flexible routes based on user demand. Most microtransit systems are focused on commuter routes…. For long-term planning in the region's more suburban communities, microtransit services could act as feeder routes that help connect people to destinations or major transit hubs."* (MaRS Discovery District, 2016)

Fehr and Peers (2017) give microtransit the following definition:

> *"Microtransit is an unsubsidized, privately operated shuttle or personalized rapid transit (PRT) service, enabled by technology that usually operates along a dynamically generated route. Microtransit services usually focus on commuters' experience and offer bus-stop similar service to individuals willing to pay the additional price above public transit."* (Fehr & Peers, 2017)

For the purpose of this study, we will use the definition of microtransit as defined by MaRS Discovery District (2016):

> *"…shared public/private sector transportation offerings that offer fixed or dynamically allocated routes and schedules in response to individual or aggregate consumer demand."* (MaRS Discovery District, 2016).

Under this definition, we include:

- Commuter shuttles, operating in specific areas based on passenger demand;
- Ride-sharing, including services that allow passengers to share rides with people having similar destinations/routes; and,
- These services can be offered by private companies and/or public sector transport agencies.

Simply put, the idea is for private vans/buses/small vehicles to offer rides along fixed or continuously-changing routes that cost just a little more than public transportation but are still far cheaper than Uber or taxi rides (Benning, 2015), and operate as a more technology-enabled shuttle in a demand-responsive manner by utilising ICT and IoT (Shaheen *et al.*, 2015). It should however be noted that microtransit systems could also be utilised as delivery vehicles for freight transport.

In conclusion, the role shared mobility and specifically microtransit systems will play cannot yet be fully comprehended. Only once these new business models have been fully deployed in the marketplace and have matured, can we know what their role will be. It could be to partially replace traditional transit modes, to supplement them through 'first-and-last-mile' transport, or it could initiate a systematic transformation of urban mobility where we see single-occupancy vehicles being replaced altogether (MaRS Discovery District, 2016).

3.2.3 SWOT Analysis of Microtransit

Following the introduction to and definition provided for microtransit, some of its potential main impacts are considered through a SWOT analysis. This was done to get an overview of the potential role microtransit could play and to present some of its major strengths and weaknesses. However, as mentioned before, to completely comprehend the impact microtransit will have can only be known once it is fully deployed and evaluated through consideration of all relevant indicators, as mentioned in Section 3.1.3. The brief SWOT analysis is presented in Table 3-2 (Cohen and Kietzmann, 2014; Benning, 2015; Shaheen *et al.*, 2015; Cheyne and Imran, 2016; MaRS Discovery District, 2016).

Table 3-2 SWOT analysis of Microtransit

Strengths	*Weaknesses*
• On demand availability and flexibility – personal freedom for young, elderly and disabled people • More personal time – do not have to drive a vehicle yourself • Fewer/no parking lots and spaces needed • Easily electrically powered since they are small vehicles operating on small scale – less pollution & less GHG emissions • Smaller eco-footprint and optimal land-use • Less traffic, reduced congestion • Cheaper than Uber/taxi services • Integrated payment services	• Will be similar to public transport – not the comfort of owning your own vehicle • More expensive than public transit
Opportunities	*Threats*
• Economic growth • Improved accessibility • Urban development • Integrated system could solve the "first-and-last-mile" problem • Investments and improvements in technology as microtransit scale • Incentive programmes for smarter travel • Able to rapidly adapt to changing technologies and address policies	• Public transport delivered by SOEs could be eradicated by privately owned microtransit companies • Collective transport decreases while individual transport increases • Safety might be a concern – both high risk of injury when in accident and personal safety against crime • Urban sprawl could lead to an increase in carbon footprint per household

Some impacts might be advantageous for the passenger, but require more responsibility of the microtransit service e.g. the service will be held responsible for traffic violations or incidents whereas customers will not be liable. Other factors to consider include: Although these options are generally associated with and established in large urban areas with high population densities, Cheyne and Imran (2016) argue that the need thereof is even greater in rural areas and smaller towns where there are no/limited public transport services (Cheyne and Imran, 2016). Using advanced technology could potentially lower operating costs for services targeting special groups such as senior citizens, women, disabled, youth, and low income groups (Shaheen *et al.*, 2015), who is considered the most 'transport disadvantaged' (Dodson, Gleeson and Sipe, 2004; Buchanan, Evans and Dodson, 2005).

3.3 Chapter 3: Conclusion

The concept of shared mobility and specifically microtransit systems poses several potential sustainability benefits, especially from an organisational and environmental perspective and in the context of the ever increasing rate of urbanisation that countries experience (Cohen and Kietzmann, 2014). Several drivers in these growing cities also support these innovations with a focus on sustainability (Hansen, Grosse-Dunker and Reichwald, 2009).

Since these innovations are relatively new, research on the relationship between sustainability theory and businesses in a sharing economy is scarce (Cohen and Kietzmann, 2014). Even though the demand and opportunities for sustainable mobility solutions are growing in the private sector, there seems to be a scarcity of research in public policy and management disciplines regarding what factors influence the success or failure of deploying such innovations. This is true especially with regard to the collaborative attempt of cities and the private sector in solving urban sustainability challenges (Alexandrescu *et al.*, 2014).

Modes of transport are thus continuously evolving and growing to adapt to changes and to find new and optimal ways of contributing to economic, social, and environmental development. It is clear that the consideration of the three pillars of sustainability is critical regarding the development of a necessity like transport. It is then undeniable that continuous research has to be conducted on transport and transport alternatives as it contributes to an enormous variety of areas.

Since Microtransit is a novel concept and not much research has been done on it, the need for research on this topic is essential. Once a microtransit system is deployed, it will require a framework to determine how the system is performing regarding its sustainability, and to continuously monitor and evaluate appropriate indicators as mentioned in Section 3.1.3. It is to this purpose and need that this research aims to develop a conceptual microtransit M&E framework that can be used by cities or private sector businesses as a management tool to assess its sustainability performance.

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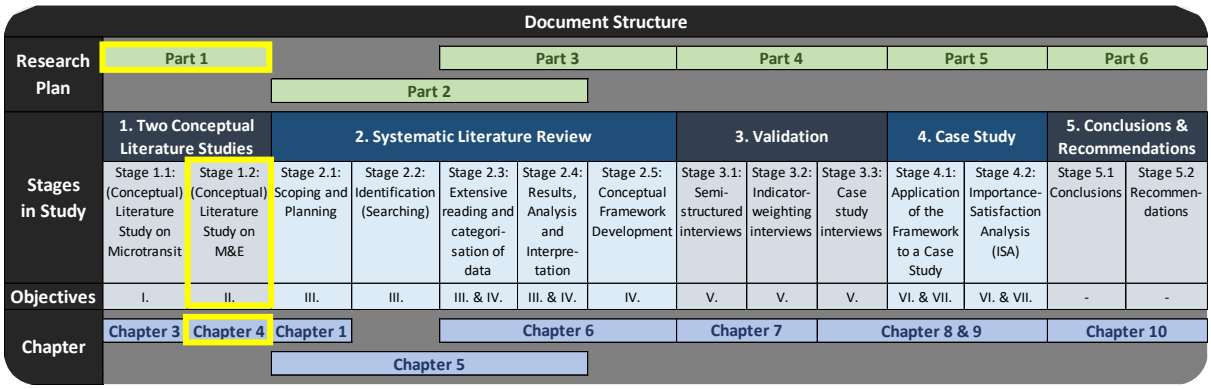
Chapter 4 A Conceptual Review of Monitoring and Evaluation



This chapter proceeds with the qualitative conceptual literature study on monitoring and evaluation (M&E). A brief history of evaluation is provided in the first section followed by an introduction to and discussion on intervention logic and its relation to evaluation. Based on the logic of interventions, the concept of evaluation is defined, its purposes described and the main evaluation paradigms are introduced to ensure a comprehensive overview and understanding thereof. The definition of monitoring is then provided towards the introduction to the concept of M&E. Following the conceptual literature study of M&E, the researcher will realise which one of the foundational evaluation approaches/theories to consider when developing the sustainable Microtransit M&E framework.

Chapter key outcomes	A brief introduction to and overview of the history of evaluation
	Elucidation of the concept of intervention logic
	Defining evaluation and discussion on the various evaluation types
	Elucidation of the purposes of evaluation
	Discussion on each of the leading evaluation theories/approaches and main paradigms
	Defining the concept of monitoring
	Towards the definition of Monitoring and Evaluation (M&E)
	Towards the development of a sustainability M&E framework for Microtransit systems

4.1 A brief history of Evaluation

According to Madaus, Stufflebeam, & Kellaghan (2000) it is essential for current evaluation practitioners and those interested in conceptualising evaluation to understand the history of programme evaluation. The importance lies in developing a fundamental understanding of the expanding purposes and processes that shape our current practice of evaluation and understanding how and why the field developed to its current state (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000).

Madaus *et al*. (2000) stated that although programme evaluation is often thought of as a recent phenomenon that started in the 1960s, its first documented use actually dates back to the late 1700s. Scriven (1996) stated that evaluation, although a very old practice, still is a young discipline (Scriven, 1996). In the development of programme evaluation from its roots up until present, Madaus *et al*. (2000) have identified seven significant time periods described in Table 4-1 (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000). Lance Hogan (2009) does however state that describing the historical development of evaluation is a difficult task due to its informal use by humans for thousands of years (Lance Hogan, 2009).

Table 4-1 Historical overview of Programme Evaluation

Time period	*Discussion*
1792 – 1900s: The Age of Reform	The year 1792 marks the date a quantitative mark was used for the first time by Willam Farish to assess the performance of students (Hoskin, 1979). Quantitative marking contributed to the realisation of evaluation as a discipline and was the first step in the development of psychometrics (Madaus and O'Dwyer, 1999). In Great Britain, education was reformed during this period using evaluation. An example is the recommendation of the Powis Commision to adopt a scheme in which teachers' salaries would partially depend on annual examination results (Kellaghan and Madaus, 1982). During 1815, the US military developed a system of policies by using formal evaluation for the first time to standardise production processes of their suppliers of arms (Smith, 1987). In 1845 in the Boston, US formal education evaluation was used for the first time to assess student achievement in order to evaluate the performance of a large school system. This led to a tradition of using tests scores of students to evaluate the effectiveness of school programmes. A similar evaluation was conducted from 1887-1898 by the educational reformer Joseph Rice, by using a standardised instrument to assess student spelling. This evaluation has been recognised as the first formal educational programme evaluation in the United States (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000).
1900 – 1930: The Age of Efficiency and Testing	During this period, Fredrick W. Taylor's work on scientific management that is based on systemisation, standardisation and especially efficiency became influential to educational administrators (Russell and Taylor, 1998). Taylor's work was used to develop objective tests to improve the educational district's efficiency. It is noteworthy that during this period, educators thought of the terms "measurement" and "evaluation" as synonymous with the latter merely meaning the summary of test performances and assignment of grades (Strayer and Whipple, 1916; Fitzpatrick, Sanders and Worthen, 2004). University institutes in field studies were formed and surveys were conducted for local school districts during the 1920s and 1930s. These institutes could be considered to be the start of university centres with programmes dedicated to evaluation (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000).

Time period	*Discussion*
1930 – 1945: The Tylerian Age	From 1932-1940, Ralph Tyler, considered by some as the father of educational evaluation, made significant contributions to evaluation through his "Eight-Year Study". This study evaluated the outcomes of high school programmes. He concluded that instructional objectives could be clarified by stating them in behavioural terms and then used to assess the effectiveness of instruction. This work by Tyler created the foundation for criterion-referenced testing (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000).
1946 – 1957: The Age of Innocence	Following World War II and the great depression, the American society experienced a time of great growth (improvements in educational offerings, personnel and facilities) and spending of national funds on education with little accountability (Madaus and Stufflebeam, 1984). Tyler's interpretation of evaluation was spreading quickly and adopted by many during the 1950s (Lance Hogan, 2009).
1958 – 1972: The Age of Development	The years of early 1960s sparked a boom in the development of evaluation and marked the end of an era in evaluation. In 1965 the War on Poverty was launched seeing billions of dollars poured into reforms to upgrade health, social, and educational opportunities for all citizens. Concern arose that this money could be wasted if no accountability requirements were implemented. This led to senator Robert Kennedy delaying passage of the Elementary and Secondary Education Act (ESEA) until an evaluation clause was included, marking the birth of contemporary programme evaluation. Evaluation requirements then became part of every federal grant (Weiss, 1998; Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000).
1973 – 1983: The Age of Professionalism	Evaluation became a profession during the 1970s and several new journals were published. Universities began offering courses in evaluation methodology since they realised the importance of evaluation. By 1976, two US-based professional evaluation associations emerged: The Evaluation Network and the Evaluation Research Society. These two organisations merged into the American Evaluation Association (AEA) in 1985 (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000).
1983 – present: The Age of Expansion and Integration	During this period, government reduced funding towards evaluation due to emphasis on cost cutting. Along with the economy, evaluation rebounded in the 1990s and became more integrated. Following the establishment of AEA in 1986, several other professional evaluation associations were developed throughout the world including the Canadian Evaluation Society, the Australasian Evaluation Society and the African Evaluation Association in 2002. Programme evaluation in education was influenced profoundly during this period by the expanding and integrated evaluation (Madaus, G.F., Stufflebeam, D.L., & Kellaghan, 2000; Lance Hogan, 2009).

4.2 Intervention Logic (Logic Model)

Before tackling the vast field of M&E and providing comprehensive definitions thereof, a look at the logic of interventions to understand the context in which the need for M&E arises is necessary. In this section, we define the logic of interventions and investigate its relation to evaluation.

Rossi et al. (2004) define a social intervention (or social programme) as "An organised, planned, and usually ongoing effort designed to ameliorate a social problem or improve social conditions" (such as programmes, policies, schemes) (Rossi, Lipsey and Freeman, 2004). As such, social services are intervened with when believed to be below an acceptable or expected standard. Interventions differ in terms of the following depending on its specific context (CREST, 2013):

- Scope – Degree of coverage
- Duration – Short vs long-term interventions
- Complexity – Different levels of delivery
- Domain of application – Intervention at a single site vs multiple sites

The European Network for Rural Development (ENRD) states an intervention logic "*represents a methodological instrument which establishes the logical link between programme objectives and the envisaged operational actions. It shows the conceptual link from an intervention's input to its output and, subsequently, to its results and impacts. Thus, an intervention logic allows an assessment of a measure's contribution to achieving its objectives*" (ENRD, 2018, p. 167). The definition is illustrated and mapped out in Figure 4-1, which includes all core dimensions and features that characterise interventions (UNDP, 2002; ENRD, 2014, 2018).

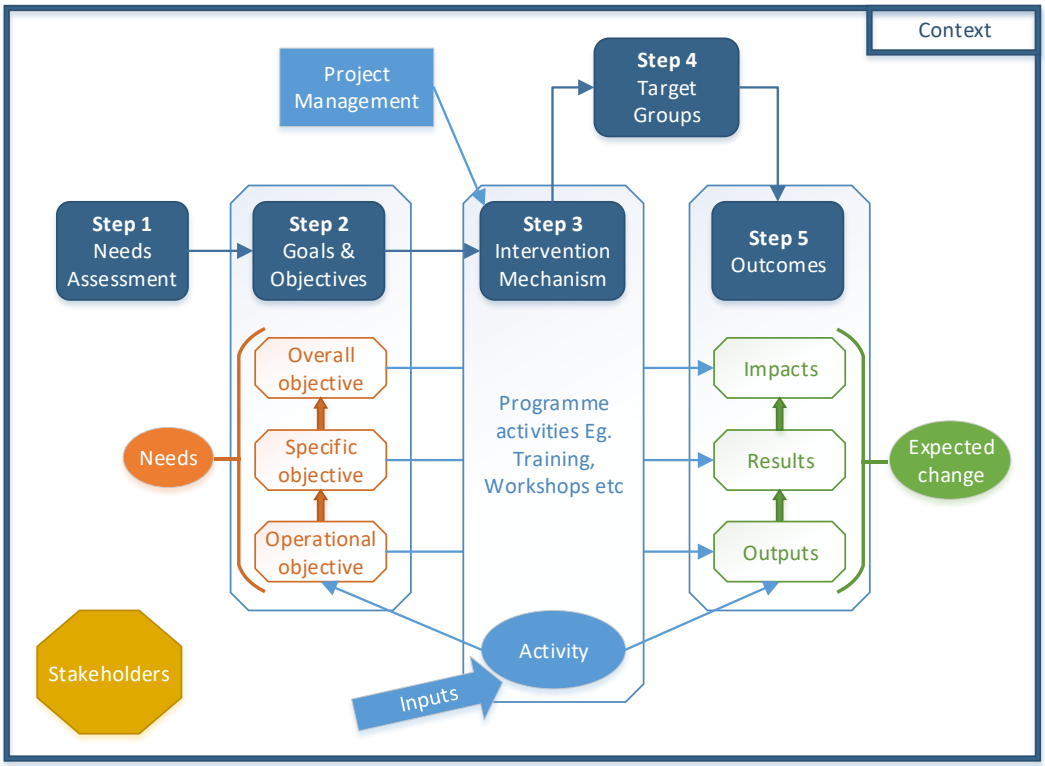


Figure 4-1 The logic of interventions (Adapted from: (ENRD, 2014)**)**

All elements from Figure 4-1 are core dimensions that characterise interventions. These dimensions are discussed in detail in Table 4-2 followed by a general discussion of the logic of interventions framework in Figure 4-1.

Table 4-2 Core dimensions characterising interventions

Core Dimensions	*Description/Discussion*
Needs Assessments	Questions about the need for a programme and the social conditions that the programme is meant to address are answered through conducting an evaluative study (Rossi, Lipsey and Freeman, 2004).

Core Dimensions	*Description/Discussion*
Goals and Objectives	Goals and objectives have to be defined clearly according to the identified needs. Objectives are formulated according to each level of intervention: • *Overall objectives* – Express broad qualitative change usually achieved over the long-term. Interventions contribute towards this change (ENRD, 2014). • *Specific objectives* – Express qualitative change in certain areas usually achieved in short-term. Interventions have to make this change happen (ENRD, 2014). • *Operational objectives* – Express quantitative change in certain measures or collection of activities. Interventions should provide these quantitative changes (ENRD, 2014).
Project Management	A "project" can be described as a temporary endeavour undertaken to create a unique product or service or a group of activities undertaken to produce a project purpose (Project Management Institute Inc, 2000). A "programme" includes a series of projects whose objectives together contribute to the overall objective. Programme management thus includes all systems, procedures, decisions, capacities and human resources that are necessary to implement and manage a programme including: administrative systems, monitoring systems, and information systems. A competent project team is required that are responsible for managing (including monitoring and evaluating) the intervention programme (Project Management Institute Inc, 2000).
Intervention Mechanism	All programme components and activities need to reach the stated objectives. It is essential that these components must be coherent internally and consistent with identified objectives. These components comprising the causal mechanisms must produce the desired outcomes and not be stated vaguely or potentially in line with objectives. Strong causal inferences from programme evaluation studies can only be made when we can prove that programme components and outcomes are causally linked (Tilley and Pawson, 2000).
Target Groups	The intended beneficiaries (individual, family, community etc.) from the intervention. The intervention programme is directed towards these groups in a specific area (i.e. the target population) according to their identified needs (Rossi, Lipsey and Freeman, 2004).
Stakeholders	Stakeholders include all individuals, groups, or organisations (besides the project team directly involved in managing the programme and the target groups) that might also have a significant direct or indirect interest in the performance (success/failure) of a programme. Stakeholders might include: sponsors, funders, founders, general public, administrators, personnel, clients, competitors or other specific interest groups (Rossi, Lipsey and Freeman, 2004).
Outcomes	Outcomes should comprise of explicit measures of success (outcome measures). Figure 4-1 illustrates that outcomes in this context are described by a collection of measurable outputs leading to specific results, and a collection of results causing desired impacts that lead to expected change.
Context (setting)	The context of the programme refers to the circumstance surrounding the programme that forms the setting thereof including: geographical location and

Core Dimensions	Description/Discussion
	environment, socio-political context, timing of implementation, duration of life cycle (CREST, 2013).

It should be noted that the target groups are by definition the determinants of the intervention programme's goals and objectives since the programme is ultimately designed according to and directed towards the identified needs of the particular target groups. The target group can be anything from a single individual or small group of people to a much larger group like a company or a country's whole population. The needs assessment should identify the perceived or real needs of the target group depending on the evidence, from which the programme goals are then formulated and conceptualised, indicating the need for an intervention (Rossi, Lipsey and Freeman, 2004)(CREST, 2013).

It is not uncommon for social programmes to initially outline goals too broadly and non-specific e.g. "improve business efficiency" or "provide quality service". These statements are too general and not clear enough to be able to measure or formulate into an observable goal. Although these statements might be the ideal, goals and objectives need to be formulated into clear and measurable outcomes. This is essential from both a programme evaluation and programme management point of view to effectively direct a programme according to its goals and objectives (CREST, 2013).

The logical framework approach (LFA) can be defined: An analytical process for objectives-oriented planning, managing and evaluating programmes and projects, using tools to enhance participation and transparency and to improve orientation towards objectives (NORAD, 1999). In this approach, a hierarchical results-oriented method is suggested focusing all project planning components towards the realisation of one project purpose. This hierarchical logic of the programme objectives is illustrated in Figure 4-2.

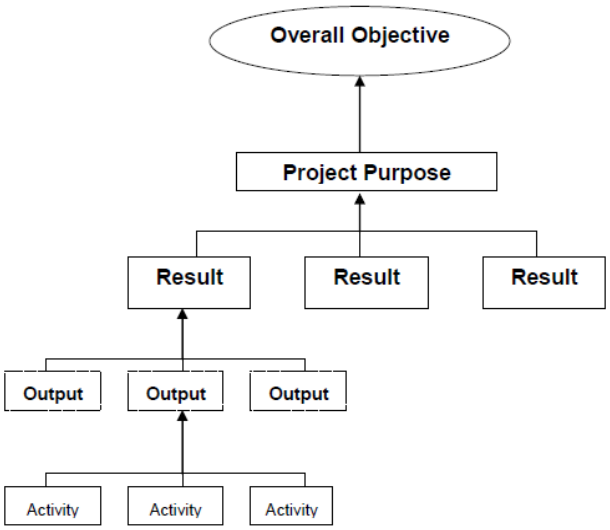


Figure 4-2 Hierarchical logic of the objectives of the LFA (Source: (Umhlaba Development Services, 2011)**)**

In the LFA the clearly defined overall objective should outline the purpose of the project and give it meaning by formulating it into measurable outcomes. Referring to Figure 4-1, the overall objective is divided into specific objectives which, if all are reached, the overall objective would be achieved. The specific objectives are then formulated into operational objectives on which all activities will focus. This means all input into various activities that are aimed at different operational objectives will lead

to reaching specific objectives and ultimately the overall objective. The operational objectives will be measurable by the outputs they present. Combinations of satisfactory outputs will lead to achieving certain results (which are in line with the specific objectives). Once all results are successful in having certain impacts, the project purpose will be reached and the overall objective achieved as seen in Figure 4-2. By breaking up the overall objective into smaller achievable objectives as explained, the overall objective is operationalised so that inputs can be focused on specific activities. Once all activities are executed effectively, it will thus result in achieving the overall objective. Figures 4-1 and 4-2 illustrate these hierarchies and relations clearly and conceptualise getting from identified needs to expected changes.

Bartholomew *et al*. (2016) propose a 6-step intervention mapping (IM) protocol describing the process from identification of the problem to problem solving as presented in Figure 4-3. The protocol aims to develop effective interventions for behavioural change. Each of the tasks within a step, which integrates both theory and evidence, once completed would serve as a guide towards the subsequent step. Successful completion of all steps would lead to the successful design, implementation and evaluation of an intervention based on theoretical, empirical and practical information (Bartholomew Eldrigde, L. K., Markham, C. M., Ruiter, R. A. C., Fernàndez, M. E., Kok, G., & Parcel, 2016).

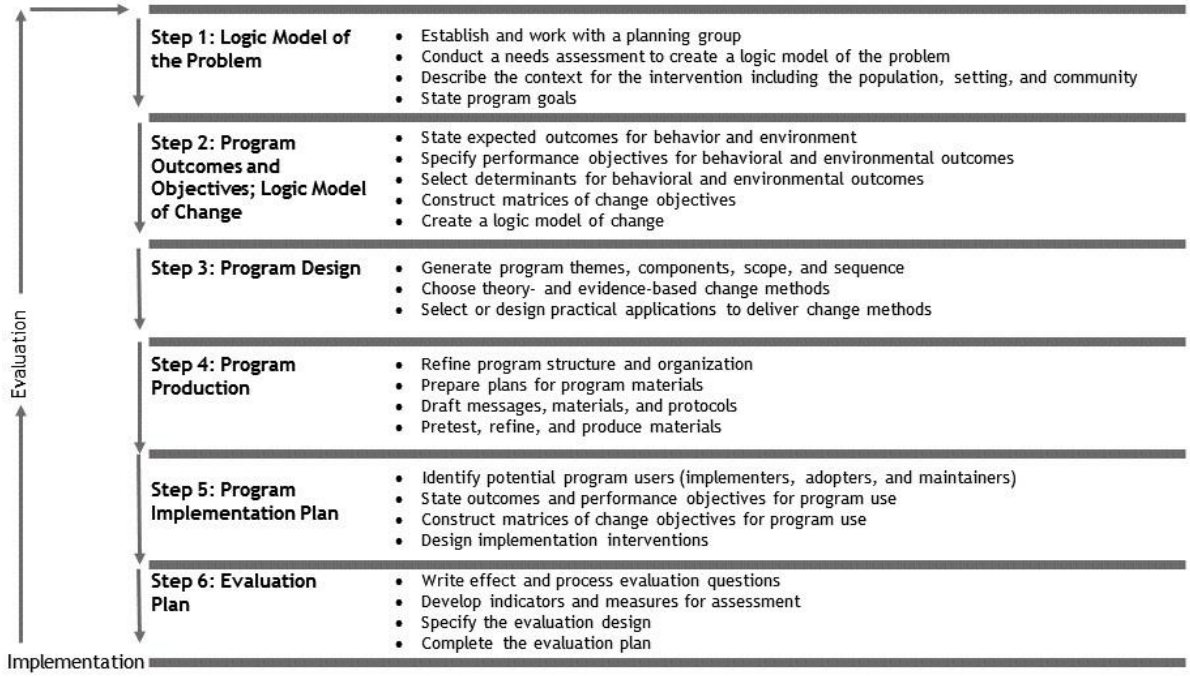


Figure 4-3 The 6 steps of Intervention Mapping (Source: Bartholomew *et al*. (2016))

Although the definition of evaluation is first discussed in detail in section 4.3, we now already note the relation between interventions and the need for evaluation. Figure 4-3 stipulates that evaluation is the final step in the intervention. As soon as the implementation of the intervention commences, the evaluation thereof starts as well. Bartholomew *et al*. (2016) illustrate in Figure 4-3 that evaluation is also an ongoing process circulating throughout all steps of an intervention.

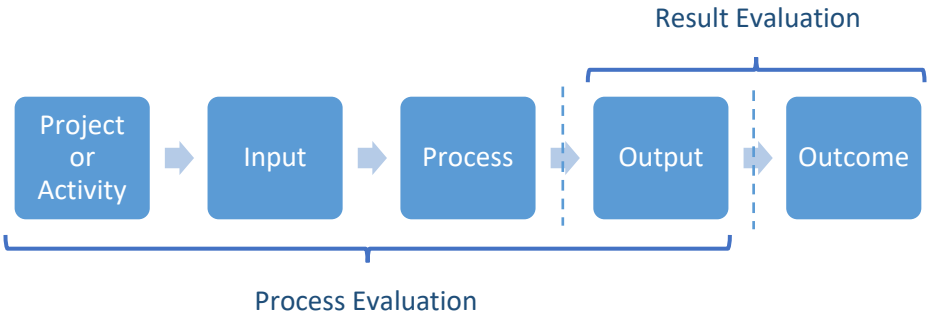


Figure 4-4 Evaluation throughout intervention logic (Adapted from: (Puoane, 2010)**)**

Evaluation of the process as well as the results shown in Figure 4-4 are both essential and should answer questions like:

- Is the real/right problem being addressed by the programme?
- Is the intervention complete or are additional interventions required to achieve the overall objective?
- Is the intervention suitable/correct?
- Is the implementation of the intervention as intended?
- Is the intervention addressing the problem in the most effective manner e.g. in terms of inputs and costs?

Evaluation is thus needed to assess the congruence of the intervention protocol's implementation with the 6-step model or the "programme fidelity". Mowbray *et al*. (2003) define programme fidelity evaluation as "(the) extent to which delivery of an intervention adheres to the protocols and program model originally developed" (Mowbray *et al.*, 2003). This means determining to what extent the realised intervention is true to the pre-stated interventions and whether the outcome measures are a result of the intervention or other factors (Holliday, 2014). Dane and Schneider (1998) suggest five dimensions comprising programme fidelity: adherence, exposure, quality of delivery, participant responsiveness, and program differentiation (Dane and Schneider, 1998). A brief discussion on each of these dimensions is provided in Table 4-3.

Table 4-3 Descriptions on the five dimensions to fidelity

Dimensions of fidelity	*Description*
Adherence	To what extent does the programme components (content, methods, activities etc.) follow the prescribed model (James Bell Associates, 2009).
Exposure	Programme exposure is the relation of the amount of actual programme deliverables to the amount prescribed by the model (James Bell Associates, 2009).
Quality of delivery	The way a programme is delivered. The theoretical ideal in terms of content and processes. It may serve as a moderator between the intervention and its outcomes. Examples include: readiness, enthusiasm,

Dimensions of fidelity	*Description*
	style of interaction, respectfulness, confidence etc. (James Bell Associates, 2009).
Participant responsiveness	The way participants react to a programme or engage in it e.g. level of interest, perceptions, level of engagement, enthusiasm, willingness etc. This might directly influence the outcomes or act as moderator between the intervention and program fidelity/service delivery quality (James Bell Associates, 2009).
Programme differentiation	The extent to which critical programme components are distinguishable from one another as well as from other programmes and identification of these unique features (James Bell Associates, 2009).

According to Dane and Schneider (1998) the focus of fidelity research has been on adherence and exposure. Evaluation should however examine all five dimensions of fidelity if it wants to provide the most comprehensive depiction of the programme implementation and identify the dimension(s) that have the biggest impact on the outcomes (Dane and Schneider, 1998).

4.3 Evaluation

In this section, a clear definition is given to evaluation and the various types of evaluation, followed by a discussion on the three main purposes of evaluation. The section concludes with a summary of the main paradigms and theories of evaluation to understand the different schools of thought thereof.

4.3.1 Defining Evaluation

Before unpacking the term into various types of evaluation, a formal definition is provided. Due to the prominence of Scriven in the field of evaluation his simplified definition will be used as starting point. In an article by Scriven released in the Yearbook of the National Society for the Study of Education in 1991 he provides the following definition:

> *"Evaluation is the process of determining the merit, worth, and value of things, and evaluations are the products of that process."* (McLaughlin and Phillips, 1991)

By unpacking Scrivens definition a complete understanding thereof is ensured. According to Johnson (2008) by *merit* Scriven refers to the "intrinsic value" of the evaluand (the evaluation object). By *worth*, he refers to the evaluand's "market value" or value to an organisation or stakeholder. Finally, by *value*, Johnson indicates that Scriven believes evaluation will always require the making of value judgements (Johnson, 2008). A more detailed definition of evaluation suggested by the OECD (2002) reads:

> *"The systematic and objective assessment of an ongoing or completed project, program, or policy, including its design, implementation, and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact, and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision-making process of both recipients and donors."* (OECD, 2002)

Evaluation in the context of Scriven's definition refers to **(programme) evaluation** which is the definition typically used in the practical endeavour of evaluating the processes and impacts of a programme. Freeman and Rossi define (programme) evaluation as "the use of social research procedures to systematically investigate the effectiveness of social intervention programmes that are

adapted to their political and organisational environments and designed to inform social action in ways that improve social conditions" (Rossi, Lipsey and Freeman, 2004). Evaluation in this context should not be confused with "**evaluation research**", defined by Freeman and Rossi as "the systematic application of social research procedures for assessing the conceptualisation, design, implementation and utility of social intervention programmes" (Rossi, Lipsey and Freeman, 2004). Confusion between these terms might arise as evaluation researchers and scholars use the term in a different way than M&E practitioners typically would. The main difference can be ascribed to (programme) evaluation specifically focusing on the effectiveness and efficiency of a programme/policy in the practical sense (involving some form of value-judgement) whereas "research evaluation" is primarily defined in typical academic terms and has a bigger scientific focus rather than on the practical endeavour of evaluating the processes and impacts of a programme (Patton, 2002). From here on when using the term 'evaluation', '(programme) evaluation' will be referred to.

According to the United Nations Development Programme, evaluation is a selective independent assessment of a completed project or current activity (or a stage within a project) in a systematic and objective manner in order to assess the progress that is made towards an outcome. An evaluation consists of various assessments of different scopes and depths as they are required and deliver data and information which are used to improve future projects and inform strategic decisions. (UNDP, 2009) Within the evaluation process errors are identified that must not be repeated in current or similar future projects while stronger features are also identified and highlighted. Activities are typically evaluated according to the following main aspects ('What is Monitoring and Evaluation?', 2017):

- Relevance
- Effectiveness
- Efficiency
- Impact
- Sustainability

The primary distinction between types of evaluations pertaining to its purpose was identified by Scriven in 1967. He stated that evaluations could be divided into formative and summative evaluations. Scriven's (1991) definitions of formative and summative evaluation follows:

> *"**Formative** evaluation is evaluation designed, done, and intended to support the process of improvement, and normally commissioned or done by, and delivered to, someone who can make improvements. **Summative** evaluation is the rest of evaluation: in terms of intentions, it is evaluation done for, or by, any observers or decision makers (by contrast with developers) who need evaluative conclusions for any reasons besides development."* (Scriven, 1991)

Rossi *et al*. (2004) define **formative** evaluation as "evaluative activities undertaken to furnish information that will guide programme improvement" and **summative** evaluation as "evaluative activities undertaken to render a summary judgement on certain critical aspects of the programme's performance, for instance, to determine if specific goals and objectives were met" (Rossi, Lipsey and Freeman, 2004).

Formative evaluation ensures that a programme and its activities are feasible, appropriate, and acceptable before it is implemented completely. It is usually conducted during the development of a new programme/activity or when an existing programme is modified or used in a new setting or with a new population (Salabarría-Peña, Apt and Walsh, 2007). Formative evaluations improve that which is evaluated by examining programme delivery, implementation quality, and assessing the organisational context, personnel, procedures, and inputs. Summative evaluation on the other hand examines the outcomes and effects of a programme. A description is provided of what occurs after the programme has been conducted. It determines whether the outcome is a direct result of the programme, the overall impact the programme has besides its target outcomes, and the estimated resource costs involved. Broadly, formative evaluation focuses on what leads to an intervention working and its process whereas summative evaluation focuses on the outcomes on the target group.

Depending on that which is evaluated and the purpose of the evaluation, different types of evaluations exist. Formative and summative evaluation can be further subdivided into various evaluation types. These evaluation types are discussed in Table 4-4.

Table 4-4 Evaluation Types (Adapted from (Salabarría-Peña, Apt and Walsh, 2007)**)**

Evaluation types		*Description/Definition*	*When to use it?*	*Why is it useful?*
Formative	*Needs Assessment/ Proactive*	Determining who needs the programme (target group) and how great the need is. Also, some solutions/approaches towards meeting the need are suggested.	• Pre-project • During the development of a new programme • When an existing programme is modified/ used in a new setting or with a new population	• To enable modifications to be made if necessary before the plan is implemented and will also increase the chance of the plan to succeed.
	Evaluability Assessment	Determine whether an evaluation is feasible and to what extent it is possible (considering the goals and objectives). How can stakeholders contribute to shape its usefulness?		
	Structured Conceptualisation	This will help the stakeholders to define the programme, the target population, and the possible outcomes.		
	Implementation Evaluation/Programme Monitoring	Monitoring the programme fidelity/delivery of the technology.	• During project implementation (as soon as implementation commences) • During operation of existing programmes	• To provide early warnings to possible problems that might arise • To determine why a programme has changed over time • To address inefficiencies in programme delivery and ensure effective and efficient delivery of future activities • It enables a programme to continuously monitor how well its plans and activities are working
	Process Evaluation	Investigating the process of delivering the programme (is it implemented and working as planned?) including alternative delivery procedures. It is thus used to measure the activities of the programme, programme quality, and who it is reaching (target group). Also, determining if the programme is accessible and acceptable to the target group.		
	Outcome Evaluation/ Objectives-Based Evaluation	To determine if the programme has had demonstrable effects on the identified programme goal/target outcomes. To what degree does the	• After the implemented programme has made	• To assess whether the programme has met its goals and is effective in meeting its objectives, whether there were any

Evaluation types		Description/Definition	When to use it?	Why is it useful?
		programme have an effect on the target group's behaviours? It focuses on changes in comprehension, attitudes, behaviours, and practices that result from programme activities. Both long and short term results can be considered.	contact with the target group • Post-project	unintended consequences, what the learnings were, and how to improve them. • To determine whether the programme activities affect the participants' outcomes • To indicate benefits of the programme and assess them
Summative	*Impact Evaluation*	Impact evaluation must be aligned with the programme's objectives and is used to measure the immediate effect of the programme. It determines to what extent the programme meets its overall objective. It is thus broader as it assesses the overall/net effects (intended and unintended; positive and negative) of the whole programme.	• During operation of existing programmes (at appropriate intervals) • Post-project (end of programme)	• It provides evidence that can be used in making decisions regarding policies and funding and influencing them • To see impact in longitudinal studies with comparison groups
	Economic Evaluation: ➢ *Cost Analysis* ➢ *Cost-Effectiveness Evaluation* ➢ *Cost-Benefit Analysis* ➢ *Cost-Utility Analysis*	Questions regarding efficiency are addressed by standardising outcomes in terms of their monetary values and costs. The resources that are used in the programme and their costs (direct and indirect) are determined and compared to the outcomes.	• During project implementation (as soon as implementation commences) • During operation of existing programmes	• It provides a way for the programme managers and funders to assess cost relative to effects.
	Secondary Analysis	Secondary analysis re-examines existing data to address new questions or use methods that have not previously been used.	• During operation of existing programmes • Post-project (end of programme)	• To identify new relevant questions not previously considered and make improvements

Evaluation types		Description/Definition	When to use it?	Why is it useful?
	Meta-Analysis	Meta-Analysis uses the outcome estimates of multiple studies and integrates them to arrive at a summary judgement on a specific evaluation question.	• Post-project (end of programme)	• It takes a variety of studies into consideration and thus avoids subjectivity and bias when using only one study.

It is important to realise that process evaluation should ideally be conducted while also implementing outcome evaluation. If the outcome evaluation delivers unsatisfactory results, it can then be ensured that it is not because of programme implementation issues. Out of all evaluation types process, impact, and outcome evaluation are amongst the most common evaluation types (Salabarría-Peña, Apt and Walsh, 2007).

4.3.2 Purposes of Evaluation

It was suggested in the previous section that different types of evaluations exist to different purposes. All scholars do not agree on the main purposes of evaluation. Both Fitzpatrick *et al*. (2004) and Scriven (1967) agree on the basic purpose of evaluation: to determine the worth/merit of that which is evaluated to render judgements (Scriven, 1967; Fitzpatrick, Sanders and Worthen, 2004). Scriven (1967) does however state that although he believes evaluation to have only one purpose, it can have numerous uses over a variety of specific contexts (Scriven, 1967). Today, Scriven's views on evaluation are widely accepted with the exception of a few scholars:

Talmage (1982) believes evaluation has three main purposes (Talmage, 1982):

i. Evaluation is concerned with the worth of a programme
ii. Evaluation assists in decision-making on future programme policies
iii. Evaluation has a key political aspect

Rallis and Rossman (2000) identify only two purposes. A noteworthy remark is that since decision makers can learn more from evaluators about their programmes, they should be more capable of understanding and interpreting observations (Rallis and Rossman, 2000).

According to Chelimsky (1997), there are four reasons as to why evaluations are made (Chelimsky and Shadish, 1997):

i. Improving programmes
ii. Accountability
iii. Generating knowledge
iv. Political uses and/or public relations

More recent evaluators have indicated that these definitions are too limited in scope since their purposes only deal with the direct and short-term impacts of evaluation and do not reflect the full extent of possible purposes. According to Mark *et al*. (1999) and Henry (2000) the ultimate goal of evaluation is to achieve social betterment by addressing social issues (Mark, Henry and Julnes, 1999; Henry, 2000). Mark *et al*. (1999) suggest four long-term purposes in order to achieve this (Mark, Henry and Julnes, 1999):

i. Determine the merit/worth of a programme
ii. Supervision and observation
iii. Programme and organisational improvement
iv. Development of new knowledge

Michael Patton (2008) suggests all aforementioned purposes can be combined into four main purposes/uses: to judge the merit or worth of something, to improve programmes, to generate knowledge, and for programme development (Patton, 2008). For the purpose of this study Michael Patton's combined view is accepted and discussed in Table 4-5 in further detail.

Table 4-5 Main purposes of Evaluation

Evaluation Purpose	*Main intended use*	*Primary user*	*Examples*
Value Judgement (*Summative*)	According to Patton (2008) the main use is: "To provide data for judging the overall value of a program and deciding whether it is worth continuing with it or not" (Patton, 2008). These evaluations are the most often-cited reason for undertaking evaluations.	Typical primary users include funders, directors, and stakeholders or anyone responsible for making major decisions.	• Accountability • Audits • Quality control • Cost-benefit decisions • Future programme planning • Accreditation
Improving Programmes (*Formative*)	According to Patton (2008) the main use is: "To provide data for programme improvement" (Patton, 2008).	Typical primary users include programme administrators, staff, and all individuals involved in routine management (Patton, 2008).	• Identification of strengths and weaknesses • Quality enhancement • Effective management • Responsive evaluation • Empowerment evaluation
Generating Knowledge	According to Patton (2008) the main use is: "To look across findings from different programmes to identify patterns of effectiveness" (Patton, 2008).	Typical primary users include programme designers, modellers, theorists, scholars, and policy-makers (Patton, 2008).	• Extrapolate working principles • Develop new models and theories • Informing policy
Ongoing Programme Development (*Developmental evaluation*)	Developmental evaluation focuses on continuously giving feedback to assist the programme to adapt in emergent and complex environment (Patton, 2012).	Typical primary users include innovators and individuals involved in altering major systems in a dynamic environment (Patton, 2008).	• Gather and analyse real-time data to inform decision making • Document and keep track of programme development

A key issue to consider during any form of judgement-oriented evaluation is the criteria used in making the judgement. Different stakeholders will employ different criteria and should thus be considered carefully. Programme funders would typically apply more "economic" or "financial" criteria as mentioned in Table 4-5 e.g. efficiency, cost-effectiveness etc. whereas political stakeholders might focus on public accountability and programme managers might focus on achieving goals/objectives.

In contrast to the deductive process used by judgement-oriented evaluations, improvement-oriented evaluations use more inductive strategies. Improvement-oriented type of evaluations typically involves collecting data for periods of time during the start-up phases of an intervention/early stages in implementation to assist with suggestions on improvements and identify and solve unforeseen problems. Improvement-oriented evaluation utilises information systems to track implementation,

monitor programmes, and deliver feedback to programme managers on a regular basis (Patton, 2008, 2012).

Figure 4-5 provides a very brief overview of the evaluation approaches according to their respective purposes and shows in which life stage of an initiative they are typically conducted.

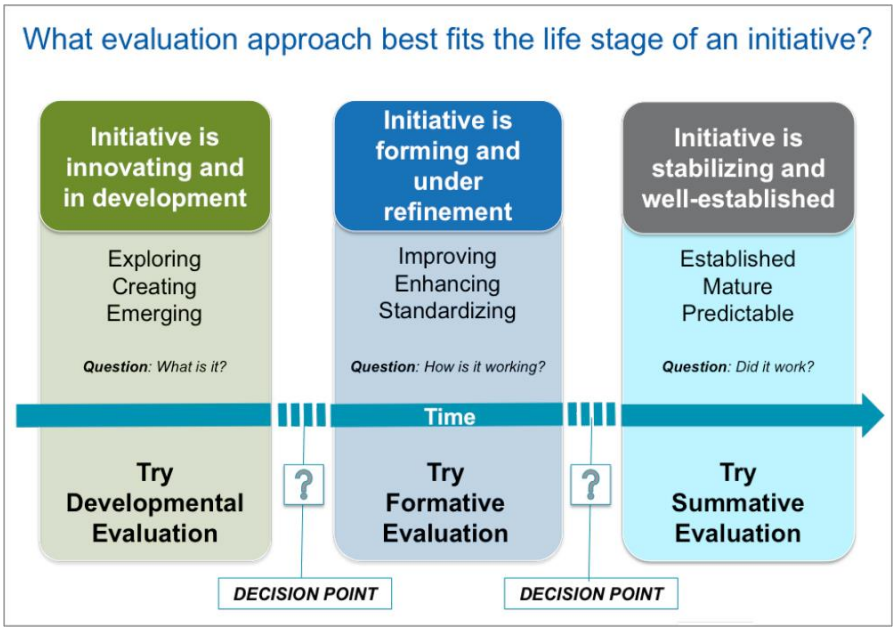


Figure 4-5 Evaluation approaches during different life stages of an initiative (Source: (Patton, 2011)**)**

Unlike the aforementioned evaluations that are driven by use and application in order to arrive at some sort of decision or action as end-result, some evaluations' purpose is to improve understanding of how programmes work and how interventions change people's behaviour – called knowledge-oriented evaluation. Knowledge that is generated can be very specific (e.g. clarify programme model or elaborate policy options) or only have a general aim (e.g. understand programme better or reduce uncertainty and risk) (CREST, 2013).

4.3.3 Evaluation theories (approaches) and main paradigms

Over the short history of evaluation several methodologies and theories have already been developed under two main paradigms namely the quantitative and qualitative paradigms. Alkin (2004), and Stufflebeam and Shinkfield (2007) all believe that most descriptions of evaluation "theories" under these two paradigms should rather be labelled "approaches/models/traditions" since they lack in comprehensiveness and validation that are required for sound theories. For that reason the main traditions or approaches developed by theorists from multiple disciplines over its short history will thus be looked at (Alkin and Christie, 2004; Stufflebeam and Shinkfield, 2007). Alkin and Christie (2004) depict the historical roots of evaluation with a metaphorical tree illustrated in Figure 4-6 which describes the development of the various theories/approaches (Alkin and Christie, 2004).

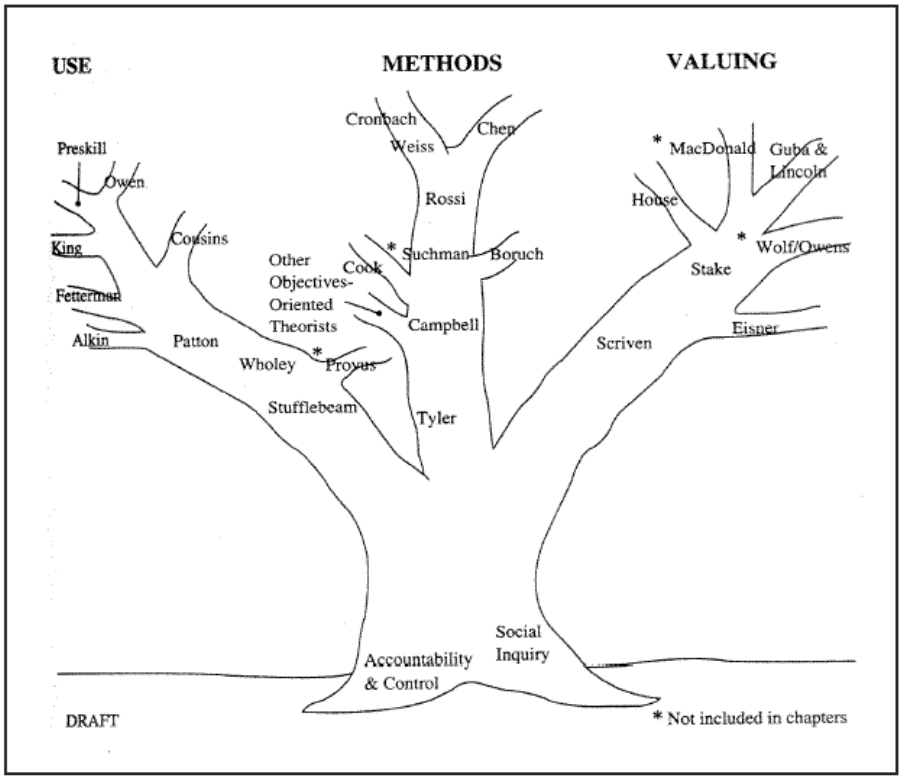


Figure 4-6 Alkin and Christie's Evaluation Theory Tree (Source: (Alkin and Christie, 2004)**)**

The tree is rooted in the foundation of social accountability, fiscal control, and social inquiry (Mertens and Wilson, 2012). These notions are closely connected as accountability is linked to responsibility and aims at improving programmes while social inquiry determines what methods can be employed to determine accountability. The historical and contemporary theoretical perspectives within evaluation are illustrated with three major branches (trunks) of the tree that depict method-, use-, and value-based theories (or approaches/models/traditions) (Mertens and Wilson, 2012). Each major theorist was categorised according to their most significant/distinctive contribution. At the bottom of each trunk is the pioneer in that specific area followed by subsequent theorists sprouting into further branches. Social inquiry extends into the "Methods" branch inspired by Tyler and Campbell which focuses primarily on quantitative designs. The evaluator's role in valuing and making judgements is iterated by the "Valuing" branch led by Michael Scriven. This branch focuses primarily on identifying values and perspectives through qualitative methods. Finally, the "Use" branch advocates the use of mixed methods and focuses primarily on data that is useful for stakeholders and to design evaluations that will inform decision-making. This branch includes all theorists with a concern for the use of findings and are also referred to as decision-oriented theorists (Alkin and Christie, 2004).

Some critics question whether a tree is the best depiction of the theoretical perspectives in evaluation since some of the perspectives flow into each other and the boundaries are not necessarily that clear. Patton (2008) has suggested that these branches should rather be resembled by distributary river channels – giving them opportunity to flow into each other and intermingle thus being a more inclusive metaphor (Patton, 2008; Mertens and Wilson, 2012).

The various approaches/models/traditions in Figure 4-6 can be summed up into five general traditions (CREST, 2013):

I. The (quasi)-experimental tradition
II. The naturalistic or qualitative tradition
III. The participatory/responsive/empowerment tradition
IV. The utilization-focused tradition
V. The realist tradition

A brief discussion on each of the five traditions will now be provided.

I. The (quasi)-experimental tradition

The first efforts in measuring programme effectiveness came from the experimental era in which the neighbouring disciplines of evaluation such as psychology and sociology applied classic experiments as their model designs. There is general consensus that significant contributions were made during the 1960s and 1970s by pioneers Ralph Tyler, Donald Campbell and later Thomas Cook and Robert Boruch, revolutionising the tradition and marking the end of an era in evaluation. These pioneers extend the "Methods" branch in Figure 4-6 primarily focusing on quantitative designs. Classic works include *Experimental and quasi-experimental evaluations in social research* by Campbell and Stanley (1963) and the more extensive *Quasi-experimentation* by Thomas Cook and Donald Campbell (1979) (Campbell and Stanley, 1963; Campbell and Cook, 1979).

Ralph Tyler contributed by means of indicating the importance of evaluation against predetermined objectives when he attempted to enhance the curriculum development process at the Bureau of Educational Research and Service. His research showed that teachers can improve their curriculum by expressing their objectives in terms of students' behaviour change. Tyler's revolutionary "Eight-year study" publication emphasised the importance of setting behavioural objectives and contributed to a better understanding of programme goals. Tyler's work laid the foundation for other methodology theorists to build on (Madaus and Stufflebeam, 2000).

After Tyler, **Donald Campbell** made influential contributions with defining terms such as internal validation (cause and effect), external validation (generalisability) and randomised assignment. The quasi-instrumental design was introduced in later years along with Stanley where the classic experiment was not possible (Shadish, Cook and Leviton, 1991). The epistemic dimension to Campbell's work was clarified later on when stating that he viewed knowledge attainment as a process of formulating and testing hypotheses and then keeping those that solved the problem. This approach is similar to that of Popper's trial and error approach in which interventions are tested on a small scale to determine the overall effects (intended and unintended) when applying certain changes (Tilley and Pawson, 2000).

Lastly, the contribution of **Robert Boruch** is considered. Boruch considered how the data produced from technology of randomised tests could be used to inform policy. He used comparative studies between diverse disciplines to indicate the conditions under which the use of randomised tests is appropriate and proved that inadequacies in field experiments were not specific to certain disciplines. The idea of using randomised experiments together with approximations to experiments in programme evaluation was also encouraged by Boruch (Boruch, 1975).

After the uproar in the 1960s and 1970s of this paradigm in the US, towards the end of the 1970s criticism escalated due to the "black box"-like mentality and atheoretical nature of the results. This pathed the way for the dawn of a new evaluation tradition of a more qualitative nature.

II. The qualitative/naturalistic tradition

During the late 1970s a shift occurred from the experimental tradition in evaluation research towards qualitative evaluation (Patton, 1980), also referred to by various theorists as: naturalistic evaluation (David D. Williams, 1986), fourth-generation evaluation (Guba and Lincoln, 1981), and ethnographic evaluation (Fetterman and Pitman, 1986). The reason for the transmission to a more qualitative nature can be ascribed to the fact that qualitative research in general became more prominent in the late 1970s that led to several studies raising criticism on the usefulness of experimental approaches in evaluation research. Increasing numbers of studies exposed several big social reform experiments as failures and not showing any clear successes. Also, critics believed evaluation research results did not lead directly to improved decision-making or were used in any useful way. As a result, responsive and participatory evaluation eventually emerged (discussed in the following section).

Naturalistic/qualitative evaluation share the epistemic principles and methods of qualitative research. David Williams (1986) formulated some questions on an evaluation project and suggested that depending on the answers to those questions, it should be obvious whether a naturalistic or experimental approach would be appropriate (David D Williams, 1986).

The prominence of Scriven in the field of evaluation is commonly known. Along with him on the "Valuing" branch are a few other forerunners (Stake and Guba & Lincoln) generally referred to as the fourth-generation evaluation theorists of the late 1970s and early 1980s. The fourth-generation evaluation falls within the broader naturalistic tradition. According to **Guba and Lincoln**, the first generation of evaluation had to do with measurement, the second generation with description, and the third generation with judgement. The fourth generation of evaluation however, according to them, "involves evaluations that are negotiated co-creations of social reality" (Guba and Lincoln, 1989) Mod1. It is vital to empower the evaluated groups (stakeholders) to encourage co-creative participation in the evaluation. The goal is to deepen understanding for all parties involved (stakeholders, investigators, evaluators, evaluees etc.) in the issue as the evaluation progresses. Evaluators help the evaluees to focus their constructions of reality and they act in a responsive manner to evaluee concerns, criticisms, and suggestions. This should result in mutual learning, improved awareness, and an increase in motivation to act upon the evaluation results (Guba and Lincoln, 1989) Mod1. The evaluation process is strengthened by considering that human interactions could possibly have adverse effects on the validity and addressing this concern by replacing it with the inclusion of the research subject's significance of situations and needs. Guba and Lincoln's approach also reconsiders the idea of causality and causal inferences in experimental traditions and defines the term "mutual causality". They recognise that human dynamics and events occur in a web-like structure of multiple pathways and not sequentially. Guba and Lincoln also suggest that the trustworthiness of a research study is important to evaluating its worth and are concerned with establishing (Lincoln and Guba, 1986):

- *Credibility* – level of confidence in the "truth" of the findings
- *Transferability* – indicating that the findings are applicable in other contexts
- *Dependability* – indicating that the findings are repeatable and consistent

- *Confirmability* – indicating the extent to which the findings are shaped by the respondents rather than a researcher's motivations, personal interest or biases.

This trustworthiness criteria were developed within what Guba and Lincoln called naturalistic evaluation. Later on, Guba & Lincoln formulated what they called the "ten commandments" of their evaluation approach and stated that evaluations (Guba, 1987):

1. 'produce constructions/constructed realities'
2. 'are value-laden processes'
3. 'are local processes'
4. 'are socio-political processes'
5. 'are divergent and continuous processes'
6. 'are emergent processes'
7. 'share accountability – they don't fix it'
8. 'involve evaluators and stakeholders in a hermeneutic relationship'
9. 'Evaluators play multiple roles'
10. 'Evaluators require a variety of skills/qualities'

In summary, during the 1980s the dominance of the experimental tradition came to a close with the provision of the corrective naturalistic and fourth generation evaluation approaches. This was accomplished through a renewed focus on the constructed nature of social programmes, the contexts of social intervention, focusing on implementation processes, and assessing programme outcomes.

Again, criticisms arose regarding the usefulness of findings due to various reasons; one of the most prevalent reasons being that evaluations did not involve the various stakeholders of their programmes in their studies. This led to the emergence of a new range of evaluation approaches focusing on consultation and participation (CREST, 2013).

III. The responsive/participatory/empowerment tradition

As mentioned under the previous heading, critics indicated a lack of usefulness in findings that did not lead to improved decision-making as well as a lack of stakeholder involvement. As a result, responsive and participatory (empowerment) evaluation eventually emerged.

The educational evaluator **Robert Stake**, who is considered the pioneer of **responsive evaluation** according to Shadish, Leviton and Cook, aided in legitimising qualitative evaluation. Stake expressed the importance of a responsive approach to programme activities and being responsive to stakeholder concerns. This would ultimately provide stakeholders with the ability to do value judgements on their programmes and also provide values that are expressed in such a manner that they have a clear influence on decision-making processes (Shadish, Cook and Leviton, 1991). Responsive evaluation thus has an important emphasis on the usefulness of evaluations and understanding the programme as a whole. Instead of a linear model, Stake opts for a "democratic" model whereby evaluation results can induce specific personal experiences which can lead to a change in practices. Stake believes the crucial feature of the approach is to act responsively to key problems – especially those that are identified by individuals at site. The design of the approach is a slow process of continuously changing and adapting evaluation goals and data-gathering methods as the evaluators become more familiar with the programme and its context. Besides being responsive to the participants' problems and context, this approach is also responsive to possible users of the evaluation findings.

Within the same generic paradigm, we consider participatory and empowerment evaluation. Various authors responded to the critique that claims evaluation findings were not useful or contributed to decision-making by identifying the main issue: a lack of stakeholder involvement and participation during the evaluation design and implementation processes. The term **participatory evaluation** can be described by some key principles:

- Evaluators methodologically consult on and facilitate the evaluation process. The intervention's target groups (beneficiaries) and evaluators decide together when and how an evaluation should be conducted, what it is that should be evaluated, and what the findings will be used for (CREST, 2013). This approach enables recognition of shared interest amongst the involved parties.
- The participatory evaluation approach is an educational process in which social groups gain knowledge about their reality that are action-oriented. The social groups then come to an agreement on the actions that should be taken (CREST, 2013).
- Participatory evaluation is a learning process in which the evaluators may have to teach other individuals from the evaluation team what to do. As the project develops however, the evaluation team will gain knowledge and become more informed and efficient. A progression in the change of attitudes, skills, and behaviour should be recognised (CREST, 2013).

Empowerment evaluation is considered one of the most popular traditions amongst participatory evaluation approaches. David Fetterman (1996) defines empowerment evaluation: "The use of evaluation concepts, techniques, and findings to foster improvement and self-determination". The only part about this definition that is novel is the focus on fostering self-determinisation which is the defining factor of empowerment evaluation. According to Fetterman there are five facets of empowerment evaluation (Fetterman, Kaftarian and Wandersman, 1996):

- Participants are trained to conduct their own evaluation thus building capacity
- Instead of acting like judges, evaluators act as facilitators and coaches
- Evaluators support disempowered groups by advocating for them or by enabling them to advocate for themselves
- Illumination
- The liberation of all involved parties

The liberation/emancipation dimension to the empowerment evaluation tradition can be considered the defining characteristic of empowerment evaluation. The facilitation and illumination dimensions to Fettermans facets are however not unique to empowerment evaluation, but also play a role in the participatory and utilisation-focused traditions (Fetterman, Kaftarian and Wandersman, 1996).

IV. The utilisation-focused tradition

Pioneer **Michael Patton** conceptualised another theory under the qualitative paradigm called utilisation-focused evaluation. According to Patton, utilisation-focused evaluation advocates for the careful consideration of the intended use of evaluations and should primarily be judged by their utility and usefulness.

This approach is personal and situational and not bound to a specific type of theory, methodology, model, or purpose. Rather than being knowledge-orientated utilisation-focused evaluation should, according to Patton, be action-orientated. Patton also suggests that utilisation-focused evaluation

starts with the premise that the evaluation should be judged according to its utility and use. This means evaluators should facilitate and design the evaluation process by especially considering what effects every step of the process will have on use (Patton, 2008). Each step must support what the results will be used for – this would thus require a highly participative and collaborative process. It should then be more likely that the end users of the evaluation take ownership of the results and find improved uses (Patton, 2002). Finally, Patton suggests a fundamental change in the traditional use of findings. He advises on moving beyond judgement towards a learning environment where accountability is achieved from the use of findings:

> *"In the context of learning organizations, accountability focuses not on the findings but upon the changes that are made as a result of the findings. This is accountability that is achieved from the use of findings."* (Patton, 2002)

Some alternative uses of the results due to heightened involvement in the programme's process through participation and collaboration include: greater shared understanding, programme intervention support and reinforcement, programme and organisational development, and increasing self-determination and ownership (Patton, 2002).

V. The realist tradition (realistic evaluation)

The final tradition as advocated by Ray **Pawson** and Nick **Tilley** serves as an extension of Campbell and Stanley's experimental tradition and is called the realist tradition. This tradition essentially questions the usefulness of evaluation findings in improving policies. Pawson and Tilley believe the realist tradition is more appropriate than the other traditions in the formulation and refinement of social policies and practices. These policies and practices do however need informed and critical but also sensitive application regarding the detail of the local context (Tilley and Pawson, 2000; Kazi and Rostila, 2002). The realist tradition is not, however, depicted in Alkin & Christie's Evaluation Theory Tree.

Similar to Campbell and Popper's view, Pawson and Tilley also see the purpose of evaluation research as informing the development of policies and practices. Their disagreement originates from the way in which Campbell's theory on experimentation is interpreted by some and the mechanical way in which it is applied (Tilley and Pawson, 2000). Realistic evaluation's view on what experimentation entails differs from the orthodox custom in evaluation circles. The orthodox view is that experimentation involves:

(1) Creating equivalent experimental and control groups,
(2) Applying interventions to only the experimental group, and
(3) Comparing the changes that have occurred in the experimental and control groups as a way of determining if and how the intervention has had an effect.

Random allocation would ensure that there are no differences between the groups before the intervention is carried out. This means that once the experimental intervention has been applied, any difference observed between the two groups after can be ascribed to the implemented action (the applied experimental measure). It is however not always possible to have random allocation. Under such circumstances, the experimental and control groups are selected as similar as possible through quasi experimental methods. Once applied, it can be assumed that the measures are effective if the following are evident in the findings (Tilley and Pawson, 2000):

(1) The intervention measure is associated with the expected change in the experimental condition but not in the control condition, and
(2) No unwanted side effects arose with the experimental group (but not with the control group)

Pawson and Tilley are however highly sceptical of this interpretation of experimentation and do not believe it sufficient in indicating which programmes do and which programmes do not cause the expected changes (both intended and unintended). Instead of asking the traditional experimentation questions of "Does this work?" or "What works?", realistic evaluation asks the question: "What works for whom in what circumstances?" (Tilley and Pawson, 2000). This question is asked since what may work in some conditions may not work in different conditions. A key problem in traditional experimental evaluation regarding causality is the expectation that "this" will always lead to "that" (no matter the circumstances). The main contribution of realistic evaluation is therefore to understand causal mechanisms and the specific conditions under which they are activated to produce certain outcomes. Realistic evaluation assumes that a theory exists which underpins the mechanisms of intervention programmes and explains how the programme caused the measured change. While science is concerned with understanding context, mechanism, and regularity as depicted in Figure 4-7, the elements of the realist's underpinning theory are: context, mechanism, and outcome as depicted in Figure 4-8. The context of the programme, defined as the precise circumstances in which a specific intervention is applied, can be considered as the most important aspect of realist evaluation. The mechanism can be defined as the exact way in which the measure works within its context towards producing a specific outcome.

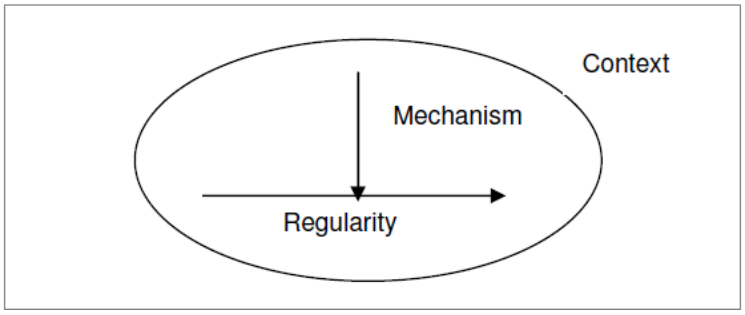


Figure 4-7 Context, mechanism & regularity (Source: (Tilley and Pawson, 2000)**)**

Figure 4-7 shows that the regularity is generated by the mechanism within a specific context. A social intervention programme aims to affect and cause a change in a regularity that is considered problematic such as poverty, unemployment etc. Realistic evaluation is thus concerned with understanding how regularities are altered towards a certain outcome as seen in Figure 4-8, whereas science is just concerned with understanding regularities.

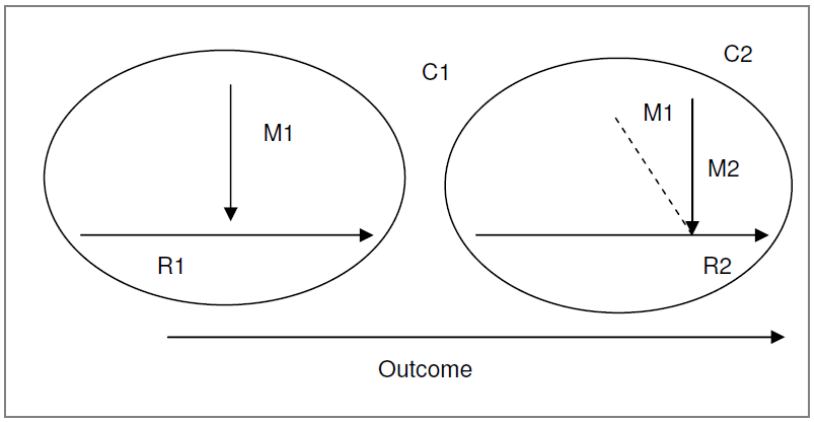


Figure 4-8 Changes in regularities due to realistic evaluation programmes (Source: (Tilley and Pawson, 2000)**)**

Figure 4-8 illustrates two ovals. The first oval is identical to the one in Figure 4-7. The second oval shows how the mechanism in the first oval (M1) is applied differently or a complete new mechanism is applied (M2) to produce an altered regularity (from R1 to R2). Since this was done in a new context (C2) we understand that an altered or different mechanism would cause a different outcome.

Following the question of "What works for whom in what circumstances (contexts)?" the realist effectiveness cycle of Kazi & Rostila (2002) in Figure 4-9 emphasises the commitment towards theory development while considering contexts and different populations.

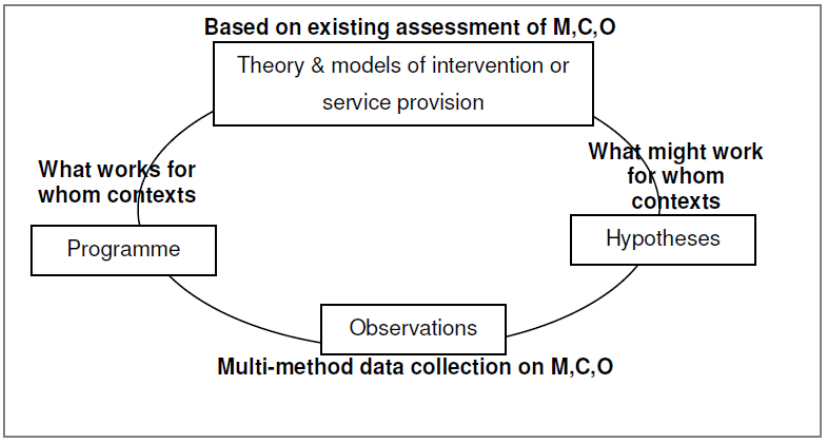


Figure 4-9 Realist effectiveness cycle (Source: (Kazi and Rostila, 2002)**)**

In conclusion, the realist tradition offers a new theory addressing an intervention's inner workings. The theory concludes that programmes do not cause change. Instead, it suggests that the target group of an evaluation initiates mechanisms in a particular context, as a reaction to the intervention programme which brings about change (Chokshi, Carter and Gupta, 1995).

Following the introduction to and consideration of the five main evaluation paradigms/approaches and their respective epistemological and methodological issues from the past five decades or so, the realist tradition appears most applicable to this study and comprehensive in general. The monitoring and evaluation approach employed in this research study is thus broadly based on that of Pawson and Tilley's realist tradition (Tilley and Pawson, 2000). We agree on the concerns regarding programme theory and the approach of realists to identify which causal mechanisms produce successful outcomes

in certain contexts. However, we also take into consideration the main assumptions of utilization-focused and responsive evaluation, subscribing to the idea of conducting evaluations that encompass a participatory and collaborative design and method. An evaluation should also be responsive to stakeholders and useful to policy-makers and funders. This means adopting pluralism with regard to methodology and design.

Essentially, both the purpose of the evaluation and the nature of the programme must be key considerations for a successful evaluation design. The evaluator must have a deep understanding of the programme, its structure and internal logic, its context and history, and its desired impacts and outcomes for a successful evaluation (CREST, 2013).

4.4 Monitoring

In this section, a clear definition is given to the term 'monitoring'. The various types of monitoring are then discussed briefly, followed by a discussion on the differences between monitoring and evaluation.

4.4.1 Defining Monitoring

A detailed definition of monitoring suggested by the Organization for Economic Co-operative Development (OECD, 2002) reads:

> *"Monitoring is a continuous function that uses the systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds."* (OECD, 2002)

Besides the definition of monitoring by OECD (2002), a simplified explanation thereof would be: Monitoring is a continuous process in which information is systematically collected from projects and programmes on routine basis by observation, supervision, measuring, and testing in order to:

- Provide management and stakeholders with regular feedback on the progress or delay of a project or programme towards reaching it goals; (UNDP, 2009)
- Improve future activities and practices by learning from experience;
- Have resource usage accountability of internal and external parties;
- Provide informed decision support on what actions should be taken on initiatives;
- And to empower all stakeholders involved in a certain initiative. ('What is Monitoring and Evaluation?', 2017)

According to UNDP (2009), merely reviewing the progress that is made in taking the actions as planned is an inadequate definition of monitoring. They strongly advise that the focus should be on reviewing the progress that is made towards achieving end goals that were set. The difference lies in focusing on the end goals rather than just ticking boxes or taking actions that were decided on previously while the path towards the end goal might have changed. (UNDP, 2009) It is important that the continuous monitoring process should start in the planning stage of a project already. The data obtained through monitoring the project is then used for evaluation.

The biggest obstacles in achieving successful monitoring of programmes are cultural and organisational (Field *et al.*, 2007). Strong collaboration is needed between managers and data scientists without being hindered by organisational boundaries in order to achieve successful monitoring. Other obstacles include too short funding cycles and the common practice of allowing data to pile up without rigorous analyses which could assist in improving monitoring methods. (Reynolds *et al.*, 2016).

4.4.2 Monitoring types

Reynolds *et al.* (2016) distinguish between four types of monitoring depending on their relationship to management actions for guiding design decisions (Reynolds *et al.*, 2016). These four monitoring types are described in Table 4-6.

Table 4-6 Monitoring types

Monitoring type	*Description*	*When to use?*
Status and trends monitoring	Monitor to understand the system with no action being taken (Reynolds *et al.*, 2016)	When no specific action is being considered and the purpose is merely to characterise the state of a system over time (Reynolds *et al.*, 2016)
Threshold monitoring	Monitor in order to decide when to act with no initial action being taken (Reynolds *et al.*, 2016)	When the monitoring information will cause a specific action (Reynolds *et al.*, 2016)
Effectiveness monitoring	Monitor in order to assess the outcomes of certain actions (Reynolds *et al.*, 2016)	When the timing of a certain action is planned and the expected response to the action has a relatively low uncertainty (Reynolds *et al.*, 2016)
Monitoring in an adaptive management framework	Monitor to assess the outcomes of multiple actions in a framework in order to inform what actions must be taken next (Reynolds *et al.*, 2016)	When the timing of a certain action is planned and the expected response to the action has a medium to high uncertainty. Comparisons with alternative actions will inform improved future decisions (Reynolds *et al.*, 2016)

4.4.3 Differences between monitoring and evaluation

A key difference between evaluation and monitoring is that evaluations provide managers with more objective judgements on whether they are still on the right track towards their goals since it is done independently. Another difference is that evaluations usually have more precise and thorough procedures and methodologies in order to do an extensive analysis of the project. The aim is however still quite similar to that of monitoring: information is provided that will assist in decision-making, improve performance and reach goals that were identified (UNDP, 2009). The School of Public Health from UWC has identified the main differences between monitoring and evaluation as described in Table 4-7 (Puoane, 2010).

Table 4-7 Differences between monitoring and evaluation (Source: (Puoane, 2010)**)**

Monitoring	*Evaluation*
Continuous	Periodic; at important milestones e.g. mid-term, end of term.

Keeps track of activities and documents progress	In-depth analysis; compares planned versus achieved (objectives versus outputs, outcomes and impact).
Focuses on inputs, activities and outputs, and implementation processes, for example participatory.	Focuses on outputs in relation to inputs, results in relation to cost, processes used to achieve results; overall relevance; outcomes, impact and sustainability.
Answers what inputs and activities were implemented and results achieved.	Answers why and how results were achieved; and why not. Contributes to building theories and models for change.
Focuses on planned results	Captures on planned and unplanned results
Alerts managers to problems and provides options for corrective actions.	Provides managers with strategy and policy options
Self-assessment by programme managers supervisors, community stakeholders and donors.	Internal and/or external analysis by programme managers, supervisors, community stakeholders, donors and or external evaluators.
Usually accepts design	Usually free to challenge design

The well-known embedded concept of Monitoring and Evaluation (M&E) is discussed in the following section.

4.5 Monitoring & Evaluation (M&E)

According to the NDP of South Africa planning and implementation should be informed by evidence-based monitoring and evaluation (National Planning Commission, 2011). Monitoring and Evaluation (M&E) is a method used to increase performance and succeed in reaching goals and achieving results by assessing the performance of activities and projects of organisations and state-owned enterprises (SOEs). The major goal of M&E is to improve the management of outcomes and outputs by establishing links between past, present and future procedures and decisions (UNDP, 2009).

UNDP (2002) and UNDP (2009) have identified the following as key objectives of results-oriented M&E:

- To promote organizational and development learning from results and evaluative thinking;
- To guarantee that informed decisions can be made;
- To align the M&E model with results-based management;
- To collect valuable information from current or past activities that can be used for future planning, and reorientation and adjustment of current policies and strategies;
- To simplify current procedures and strategies;
- To generate evidence of accountability and create transparency;
- To ensure consistency in long-term planning.

UNDP (2002) states that the overall purpose of M&E is to measure and assess performance in order to increase the effectiveness of managing outputs and outcomes. UNDP (2002) was however replaced by UNDP (2009) for the reason that UNDP realised planning to be an essential prerequisite for developing an effective M&E system and incorporated planning throughout the handbook (UNDP, 2009).

According to the Joint Committee on Standards for Educational Evaluation (JCSEE) there are four standard criteria for assessing the quality of M&E, described in Table 4-8 below (Yarbrough, D. B., Shulha, L. M., Hopson, R. K., & Caruthers, 2011).

Table 4-8 Criteria for assessing the quality of M&E

Criteria	*Description*
Utility	The M&E framework serves the practical information needs of its intended users.
Feasibility	The M&E methods, timing, sequences and procedures for processing are realistic, prudent, and cost-effective and thus both efficient and effective.
Propriety	All M&E activities are conducted legally and ethically. The welfare of those affected by the results are also considered.
Accuracy	The outputs from the M&E system will reveal and convey information that is technically adequate, trustworthy, and dependable.

4.6 Towards developing a sustainability M&E framework for Microtransit systems

Determining whether work is moving in the right direction, whether progress is made effectively or whether future work can be improved upon is nearly impossible without applying M&E. It is thus important to have some sort of support tool or model that can assist in determining these outcomes. An M&E framework, also referred to as an Evaluation Matrix, is ideal to utilise in such circumstances. This framework, used as a management tool, will guide users towards achieving their end goal through achieving key objectives by assisting the user (management) in improving certain outputs, outcomes, and impacts. Some training will be needed to enable all staff members to adhere to the framework and work towards a common goal. The framework should be simple enough to understand and implement with some degree of experience in management.

The purpose of the M&E framework to be developed in this research is to provide a decision support tool for small scale transportation organisations and similar companies to build a realistic and profitable value proposition economically, socially and environmentally and will enable the validation of decisions through continuous M&E. Combining this idea of an M&E framework with the ideas expressed in Sections 3.1.3 and 3.3 regarding the sustainability of transport and microtransit systems specifically will enable the development of this management tool that can be utilised to assess the sustainability performance of any particular microtransit system. The systematic literature review will now guide the process of indicator identification towards developing an M&E framework for microtransit systems.

4.7 Chapter 4: Conclusion

In conclusion, the concept of intervention logic and its need for evaluation have been elucidated. Several evaluation paradigms were introduced and their respective epistemological and methodological issues were discussed. It was concluded that Pawson and Tilley's realist tradition was most comprehensive in general and applicable to this research. This tradition offered a new theory for addressing an intervention's inner workings. It suggests that programmes do not cause change but rather that the target group of an evaluation initiates mechanisms in a particular context, as a reaction to the intervention programme which brings about change. In addition to realistic evaluation where causal mechanisms are identified which produce successful outcomes in specific contexts, the idea of encompassing participatory and collaborative design and methods into the evaluation, like utilisation-

focused and responsive evaluation, is also appreciated. An evaluation should also be responsive to stakeholders and useful to policy-makers and funders. This means adopting pluralism with regard to evaluation methodology and design. Supplementing evaluation is the concept of continuously conducting monitoring through systematic gathering of data on specified indicators to provide managers with an ongoing intervention to provide an indication of the extent to which activities and ultimately objectives are being reached. The evaluation's structure, context, history, purpose, desired impacts, the nature of the programme and the evaluators' understanding thereof should therefore be clear for successful evaluation design.

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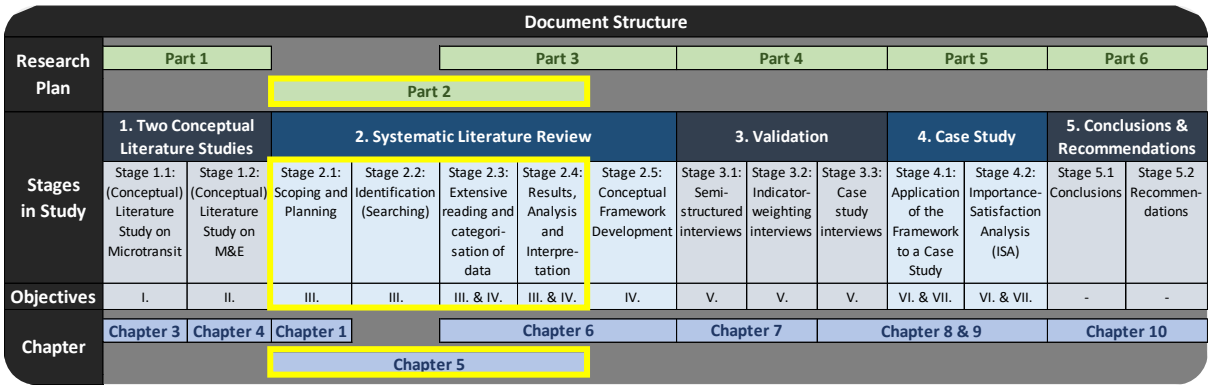
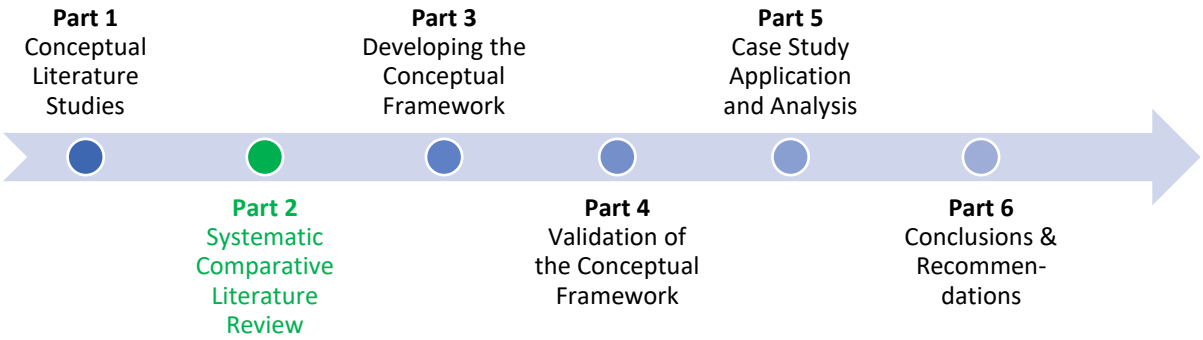
Chapter 5 Conducting the Systematic Comparative Literature Review



Following the description of the process of conducting a systematic literature review in Table 2-3 from section 2.3.2, this chapter now proceeds with presenting review stages 2.1-2.4 to conduct the systematic comparative literature review part thereof.

Chapter key outcomes	
	Confirm the gap in literature and need for the review
	Identify SLR research questions, keywords, and inclusion and exclusion terms
	Identify related research and narrow it down to a final set of relevant studies
	Gain an overview understanding of the final set of relevant studies through high-level reading
	Categorise data according to main components and recurring themes
	Conduct descriptive statistical analysis on relevant publications to analyse data



This chapter commences with Part 2 (Systematic Comparative Literature Review) of this research study as illustrated above. This was done by completing the following stages of the systematic literature review method as illustrated in Figure 5-1 with the shapes highlighted in green. The grey shapes will be completed in the following chapter.

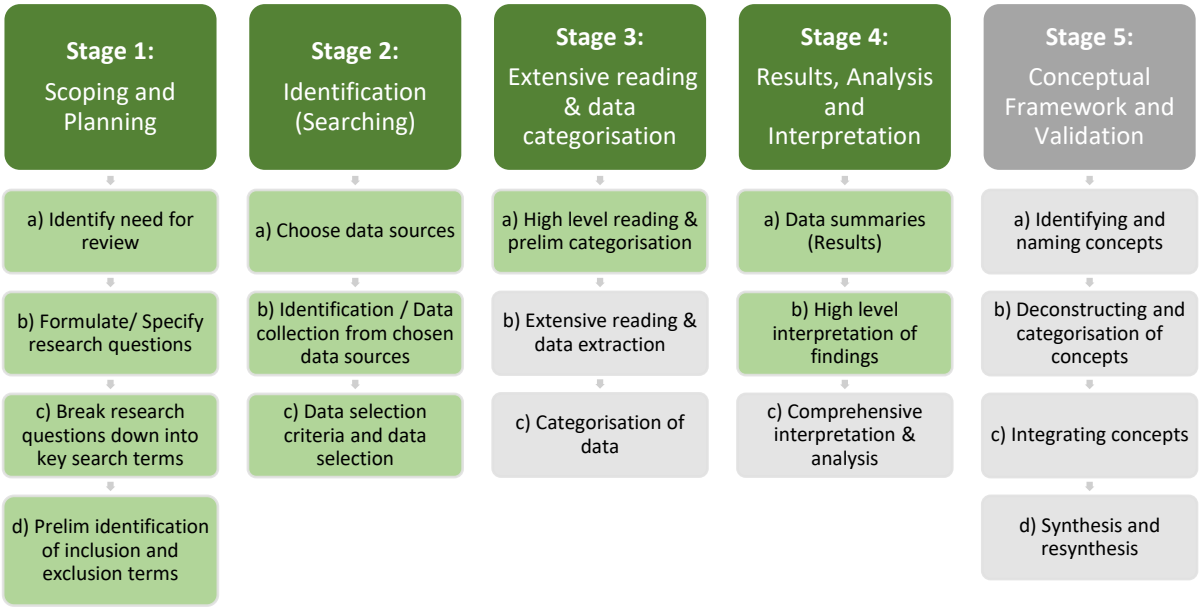


Figure 5-1 Systematic comparative literature review methodology

5.1 Stage 2.1 – Scoping and Planning

The first stage of the systematic literature review aims to determine both whether the review has been conducted previously and to confirm that a gap exists in the body of knowledge regarding the proposed topic of monitoring and evaluation of microtransit systems. To do this, focal research questions are firstly defined pertaining to the SLR in Table 5-1 based on the problem statement and objectives of this study defined earlier in Chapter 2 of this study. Secondary questions are also included in addition to the primary research questions. Although the need and importance for the research have been expressed in sections 3.3 and 4.6, the outcome of the systematic comparative literature review should be the confirmation that this gap exists. The research questions will also guide the SLR towards development of the M&E framework.

Table 5-1 Primary and secondary research questions

Primary research questions	*Secondary research questions*
A. What is microtransit?	i. What are **defining characteristics** of microtransit? ii. Does a **gap** exist in the body of knowledge of contemporary microtransit and how can this gap be filled? iii. What **benefits/threats/potential impacts** does microtransit present?
B. What is a monitoring and evaluation (M&E) framework?	i. How is monitoring and evaluation **defined**? ii. What are the **purposes** and key objectives of monitoring and evaluation? iii. What are the major M&E **types/theories/approaches/main paradigms**?
C. What research has been conducted regarding M&E of microtransit systems?	i. From research conducted relevant to M&E of microtransit systems, what are the **main (recurring) themes** identified regarding transportation?

Primary research questions	*Secondary research questions*
	ii. From research conducted relevant to M&E of microtransit systems, what are the **main (recurring) themes** identified regarding monitoring and evaluation? iii. What **impacts** regarding M&E of microtransit systems have been researched? iv. What are the current **methods/tools/models/policies** that exist for the monitoring and evaluation of transport systems? v. What are the **key indicators** and measures for evaluating current transport systems?
D. How can an effective M&E framework be developed concerning microtransit using all available literature?	i. Considering the key indicators identified in all relevant transport publications, what **indicators** should microtransit systems use for its evaluation? ii. How can the **effectiveness** of the M&E framework be tested towards **validation** of the framework? iii. How can data from the developed M&E framework be **analysed** to present useful information and provide **decision support** as a management tool?

Research questions A and B have been addressed and answered in Chapters 3 and 4. Answering question C through the comparative literature review should confirm the gap and need for the development of a microtransit M&E framework. Question D and Section 2.3.2 will then guide the process towards developing a conceptual framework.

Keywords are identified from the research questions describing the main themes. These keywords are typically used as search terms when documents relevant to the scope of the research are gathered from data sources. The derived keywords include: Microtransit; Monitoring and Evaluation (M&E) framework; Evaluation model; Transport system; Decision support; and Urban.

To guide the research, the scope of the study is established by identifying limitations and assumptions of the study. In the final step of stage 1 the limitations for this research are set by identifying including and excluding terms/concepts. The including and excluding terms are presented in Table 5-2.

Table 5-2 Limitations: Including and excluding terms

Themes	*Including terms*	*Excluding terms*
Microtransit	• Micro-transport • Micro transportation • Small scale transport • Urban/Inner city • Electric • Sustainable	• Micro-Transport Protocol (µTP) • Electrodes, Electro thermal • Fluid • Autonomous Driving
Monitoring and Evaluation (M&E) Framework	• Evaluation Matrix • Model • Decision support • Planning, Assessing, Reporting	• Agricultural & Rural development • Food • Health & Safety • Software

Themes	*Including terms*	*Excluding terms*
	• Transportation • Sustainable • Development • Results-based Management (RBM)	

5.2 Stage 2.2 – Identification (Searching)

The second stage of conducting the systematic comparative literature review includes developing a process to keep record of obtained research data in a systematic manner, ensuring all relevant published and unpublished data is located and considered, and to assess the quality and relevance of the obtained data.

Initially, five sources of research publications databases were identified to be used for collecting publications. These five internet sources include academic databases ScienceDirect, Scopus, Emerald Insight and ResearchGate as well as search engine Google Scholar.

An initial literature search of the internet sources revealed that ResearchGate did not provide any additional useful or topic-related data. This source was eliminated and not considered for any further research. The remaining sources were explored with search terms derived from previously identified keywords as shown in Table 5-3. The table shows the number of search results found through the respective data sources when the search terms indicated below were used.

Table 5-3 Search results for different internet data sources

Search terms	*ScienceDirect*	*Scopus*	*Google Scholar*	*Emerald Insight*
Micro + Transit	23 163	698	411 000	6019
Microtransit	**3**	**2**	79	0
Monitoring + Evaluation + Framework	163 857	5 700	3 190 000	25 155
Monitoring + Evaluation + Framework + Transportation	22 249	**119**	859 000	5 560
Monitoring + Evaluation + Framework + Model + Decision support + Transit + Transportation + Urban + System	1104 (refined search: **176**)	1 (irrelevant)	39 100	417 (access to and refined search: 123)
Monitoring + Evaluation + Framework + Microtransit	0	0	78	0
Monitoring + Evaluation + Framework + Microtransport	**3**	0	141	0

As indicated in Table 5-3, initial search results yielded several thousands of research documents. The need to establish a data selection criteria model is essential to ensure the work to be as objective as possible and systematic. Figure 5-2 illustrates a framework developed for eliminating data from the search results that are both unrelated and irrelevant to the scope of study.

Referring to Figure 5-2, using different combinations of search terms and refining the initial searches delivered a total of 869 documents from the four chosen internet sources. Google Scholar results consisted of a wide variety of papers of which several are irrelevant. Due to this factor and the inability to export documents from Google Scholar and Emerald Insight, these results were eliminated from

consideration. A total of 301 results from ScienceDirect and Scopus thus remained that are related to the research topic.

The 301 related documents were analysed in an excel spreadsheet. The abstracts and keywords of each of these documents were studied to further classify the related documents as 'relevant', 'somewhat relevant', or 'not relevant' to the scope of the study. A total of 71 publications were identified as relevant (See Appendix A for the complete list). The comparative analysis was based mainly on these 71 publications and in some cases the 'somewhat relevant' publications were also included for the descriptive analysis of the sample.

Exclusion criteria were applied to the remaining relevant documents to exclude all papers that are inaccessible, duplicates, or in a foreign language. Finally, a final set of 62 relevant publications was identified with the possibility of adding any additional papers at a later stage. No grey literature was added at this stage. The data selection criteria do however allow the addition of grey literature that is related to and relevant to the scope of study at a later stage, if necessary. Figure 5-2 displays "???" in the cases where no papers were added but the option exists should the process be repeated. The high-level descriptive analysis, results and interpretations are completed during stage 2.4 in Section 5.4 of this chapter.

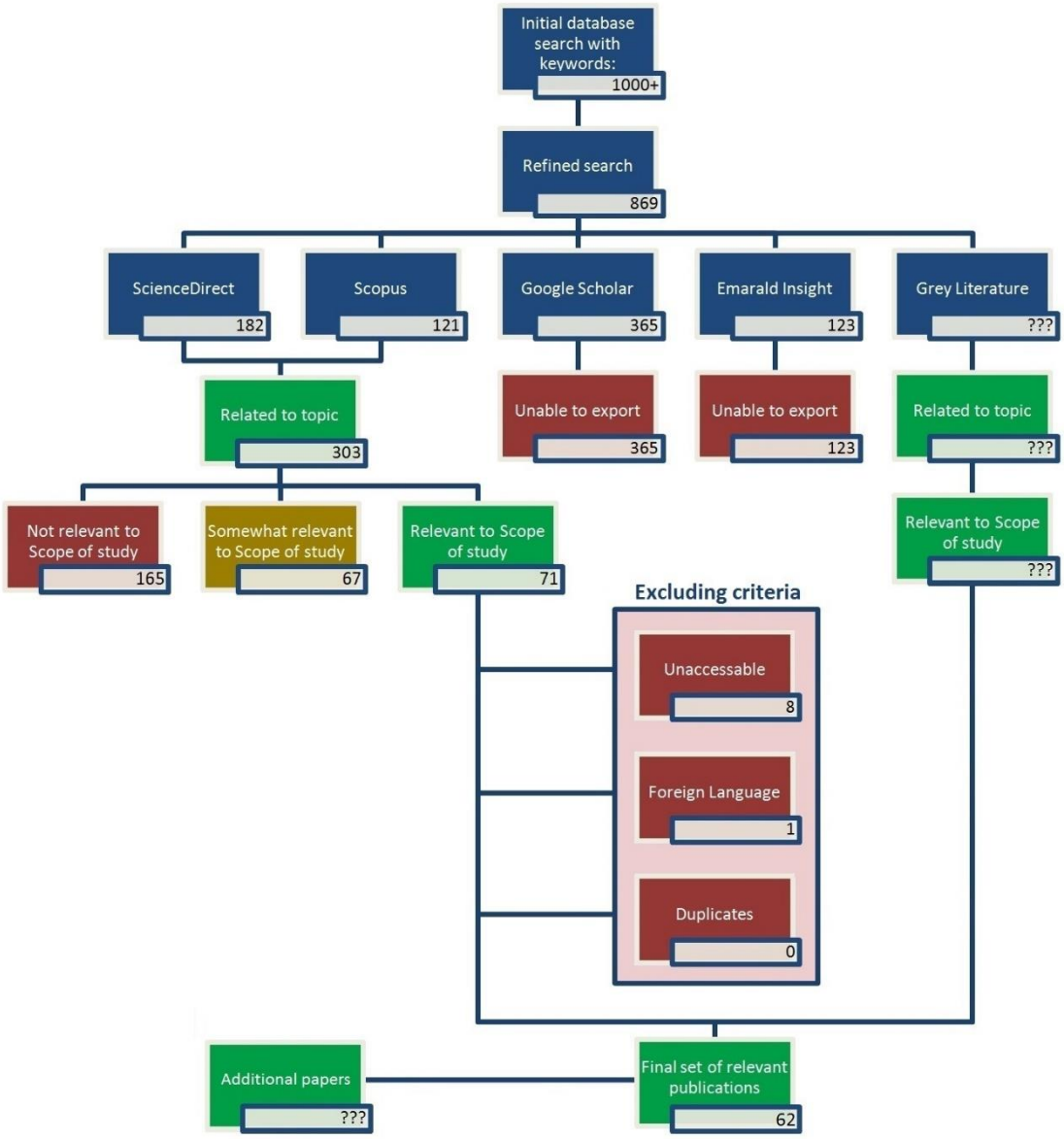


Figure 5-2 Data selection criteria and process

5.3 Stage 2.3 – Extensive reading and Categorisation of data

Before properly analysing the data from the identified relevant studies however, high-level reading is necessary for the systematic comparative literature review part to gain an overview understanding of the research outline. An in-depth qualitative analysis of the abstracts and the detailed exported information allowed for classification of the papers into four main categories specified in Table 5-4. The main components were identified for Category I and the main recurring themes were identified for Categories II – IV.

Table 5-4 Data collection main categories and components/recurring themes

Main Categories	*Components/Recurring themes*
I. Publication paper characteristics	• Document Title • Author(s) • Year of publication • Document type

Main Categories	*Components/Recurring themes*
	• Source of document • Citations • Language • Geographic focus • Relevance of paper • Focus of paper
II. Transportation	• Urban • Public Transport • Sustainable • Congestion & Travel time • Pollution (GHG emissions) • Railway • Bus • Safety/Security • On demand/Flexible • Shared Mobility • GIS & GPS • Land-use • Freight • Microtransit • Bike • Inclusivity • ITS • Battery/Electric Vehicle
III. Monitoring & Evaluation	• Framework • Strategies, Tools & Planning • Policies/Government • Monitoring • Service Quality & Customer perception/satisfaction • Decision support • (Key performance) Indicators • Model • Survey/Interviews • Cost Benefit Analysis (CBA)
IV. Impacts	• Social • Economic • Environmental • Political

5.4 Stage 2.4 – Data Analysis, Results and Interpretation

During this stage, descriptive analysis is done on aspects of the documents regarding publication document type, year of publishing, geography, relevance, and the main recurring themes that were identified.

5.4.1 Number of publications per document type

The analysis of the publications per document type was done on all the papers that were deemed relevant and somewhat relevant equalling a total of 138 papers. Of these papers, the majority (84%) are journal articles followed by conference papers (10%) as shown in Figure 5-3.

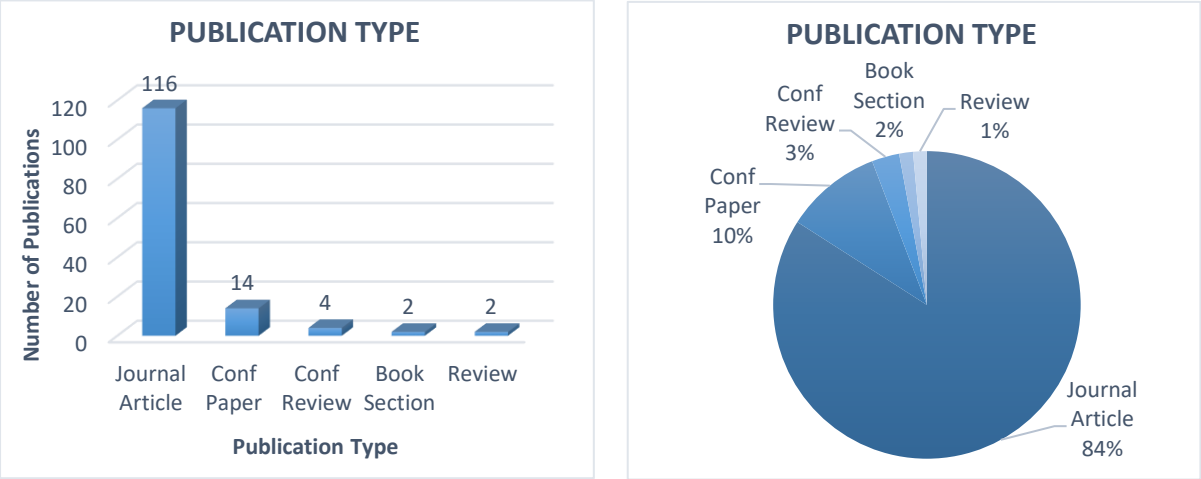


Figure 5-3 Number of and percentage publications per document type

5.4.2 Literature publications timeline

Both the relevant as well as the somewhat relevant papers were included in the analysis of the publication timeline seen in Figure 5-4. We conclude from the timeline an almost exponential increase in publications have been published each year until 2016 with the exception of 2014 and 2015. This escalation in research publications each year provides evidence of an increase in interest in the topic in recent years. However, since this literature study was conducted in 2017 and an increase in articles relevant to this study was observed, recent publications between 2018 and 2019 also had to be considered to ensure that all relevant publications were considered and to confirm that this research is still relevant.

To ensure that all elements of sustainability were covered comprehensively, the literature review in this study was done systematically. The comprehensive approach ensured that all necessary elements were identified and no stone left unturned. This systematic and comprehensive approach toward developing the framework took more than a year to complete. Repeating the whole process for studies identified between 2018 and 2019 seemed impractical due to the time it would take to again complete the systematic approach after which new studies would again have to be considered from 2020, resulting in a circular process. A total of 37 studies between 2017 and 2019 were however identified that were related to this research by repeating Stage 2 of the systematic literature review. These were narrowed down to 13 studies that were identified as relevant to this research. While some these 13 studies contained indicators, none of these were new to the researcher. All indicators were already covered when the systematic literature review was conducted in 2017. Although microtransit is a novel field, no M&E framework for the sustainability assessment of microtransit systems was developed in 2018 or 2019, neither was any indicators identified toward this end. The newly identified relevant articles did thus not provide any additional or new information on how microtransit

sustainability could be measured, but rather just used already identified indicators in different ways or toward different purposes.

It was noted that even though microtransit is an emerging field, very little research on microtransit has still been done in 2018 and 2019. The gap that was identified in this study still existed and this research was thus still relevant. The articles identified during 2018 and 2019 could thus be excluded from further consideration.

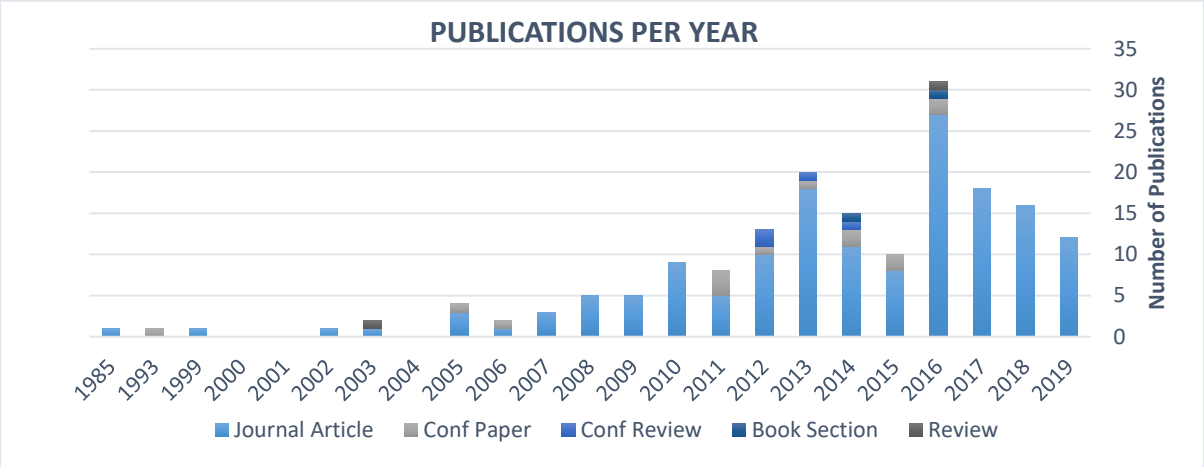


Figure 5-4 Publications timeline for all document types

5.4.3 Geographic analysis

A geographic analysis was done on the various nationalities of the relevant publications' authors. A summary of the geographic analysis is illustrated in Figure 5-5 where the numbers in the bottom left corner equal the number of studies published by authors from the corresponding countries.

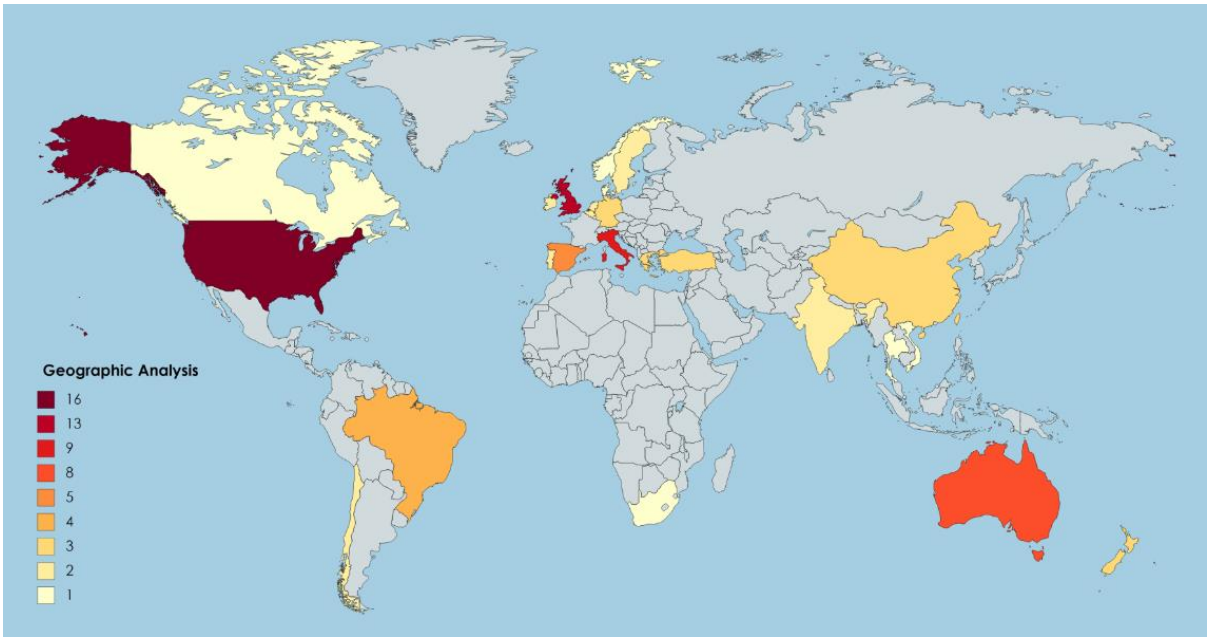


Figure 5-5 Geographical representation of researcher nationalities

The number of publications that have been published by authors from a specific country is shown for every country in Figure 5-6. The 71 identified relevant publications were conducted by researchers from 25 countries globally. Of the 25 countries, 16 (64%) of these are developed countries and 9 (36%) are developing countries. The 16 developed countries have published more research documents, contributing 78% of the identified relevant publications, regarding the identified topic than developing countries, contributing only 22% of the identified relevant publications. Authors from the top five countries are all located in developed countries. The top contributor is the United States of America with a total of 16 publications. The highest contributor from developing countries is Brazil with a total of 4 publications.

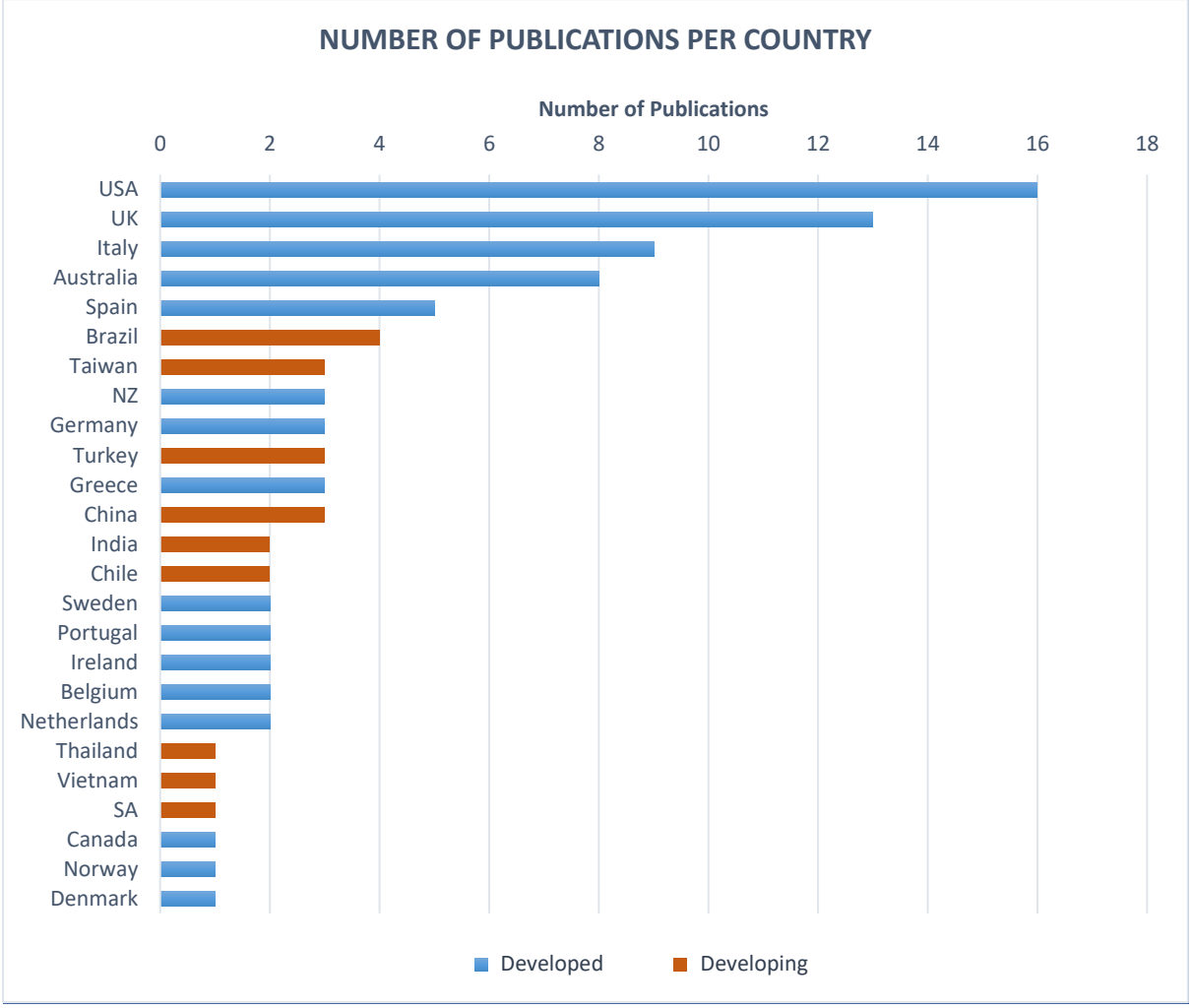


Figure 5-6 Countries ranked according to number of publications per country

From these figures, we can deduce that authors from developed countries are more focused than authors from developing countries on researching innovative ways in which they can improve their countries' transport systems which should indirectly have positive economic, social and environmental impacts. Since developing countries are still in development, this type of research could however prove to be particularly beneficial towards making sustainable economic, social and environmental improvements.

5.4.4 Relevance of publications

The abstracts of the 71 relevant documents were considered carefully and the relevance of each was rated according to a Likert scale of between 1 and 5, where 1 represents the least relevant documents and 5 the most relevant documents. This was done to narrow the search down to a lower number of publications for detailed review and analysis. The results are displayed in Figure 5-7 as a percentage distribution.

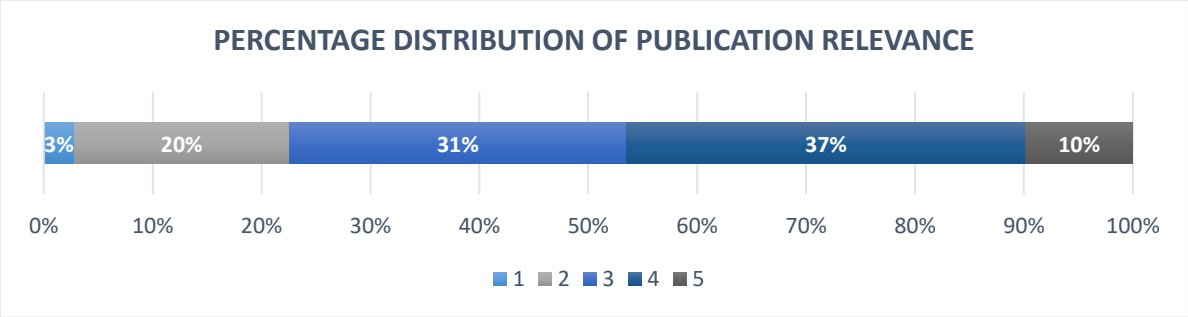


Figure 5-7 Percentage distribution of publications according to their relevance

5.4.5 Publications per theme

The 71 relevant publications were given unique identification (ID) numbers as illustrated in Appendix A to be able to easily distinguish between them.

A comprehensive analysis of every paper's abstract and keywords enabled the identification of main components/themes under each of the following three categories: Transportation, Monitoring and Evaluation, and Impacts as mentioned in Section 5.3. A matrix was then created to indicate which of the main recurring themes were identified in each of the 71 relevant publications. Referring to Figure 5-8, the papers are firstly ranked according to their respective relevance ratings. Thereafter, the themes were ranked in each of the three categories according to frequency of appearances with the most common themes listed first.

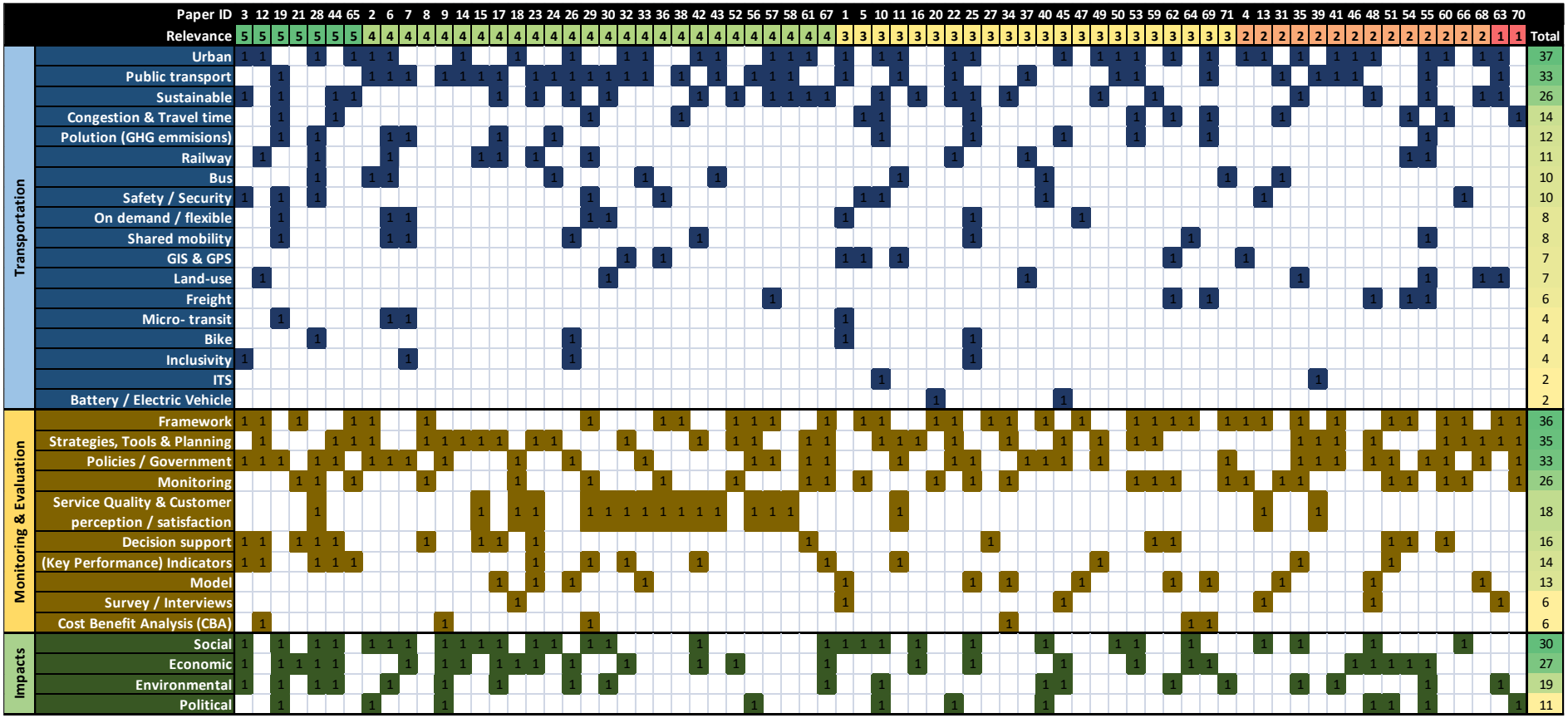


Figure 5-8 Summary of publications analysis regarding relevance and main recurring themes

In Figure 5-9 the main themes in the 'Transportation' category are ranked according to frequency of appearance. The dominant three main themes are identified: 'Urban', 'Public transport' and 'Sustainable'. The fact that microtransit appears in only four publications supports the notion that a large gap exists in the literature of transportation regarding microtransit. Several of the publications entail other modes of transport including buses, railways, and bikes, or general city mobility. It is interesting to note that 26 publications had sustainability as a main theme even though the term was not used as a keyword/search term for paper identification. This gives an indication that applying M&E to transport systems typically results in looking at the sustainability of the transport system for its evaluation.

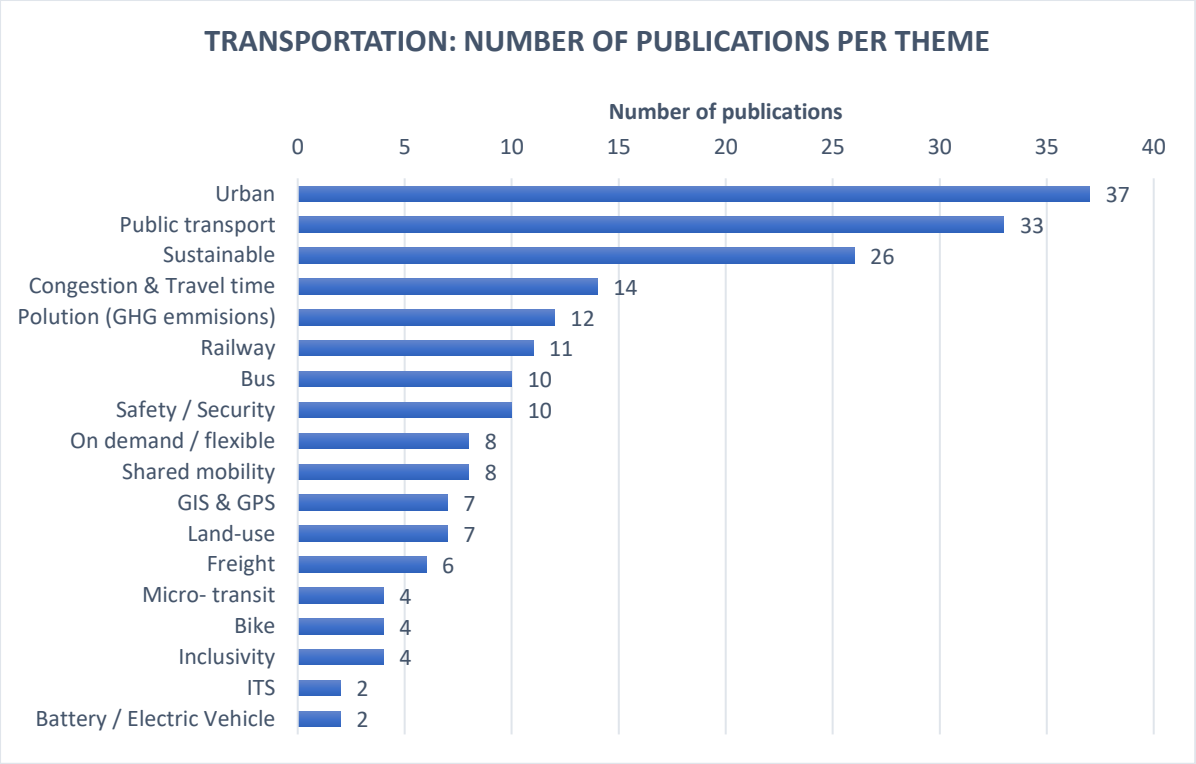


Figure 5-9 Transportation: Number of publications containing each recurring theme

In Figure 5-10 the main themes in the 'Monitoring and Evaluation' category are again ranked according to frequency of appearance. The dominant three main themes identified as 'Framework', 'Strategies, Tools & Planning' and 'Policies/Government' each appears in about 50% of the 71 relevant publications. The theme 'Monitoring' is also quite common as it appears in 37% of publications.

It is however expected that themes 'Monitoring' and 'Framework' will be in several of the publications since they form part of the keywords used as search terms. Overall, a bigger variety of themes were identified in the 'Transportation' category than in the 'Monitoring and Evaluation' category.

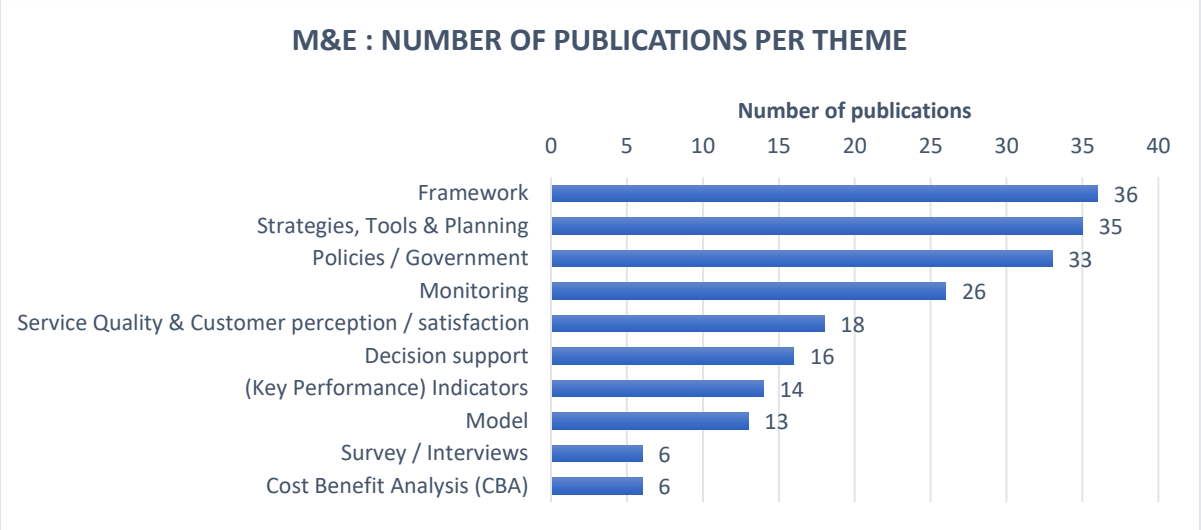


Figure 5-10 Monitoring and Evaluation: Number of publications containing each recurring theme

In Figure 5-11 the main themes in the 'Impacts' category are ranked according to frequency of appearance. The dominant theme is 'Social' impacts appearing in 30 publications (42%) following 'Economic' impacts in 27 publications (38%).

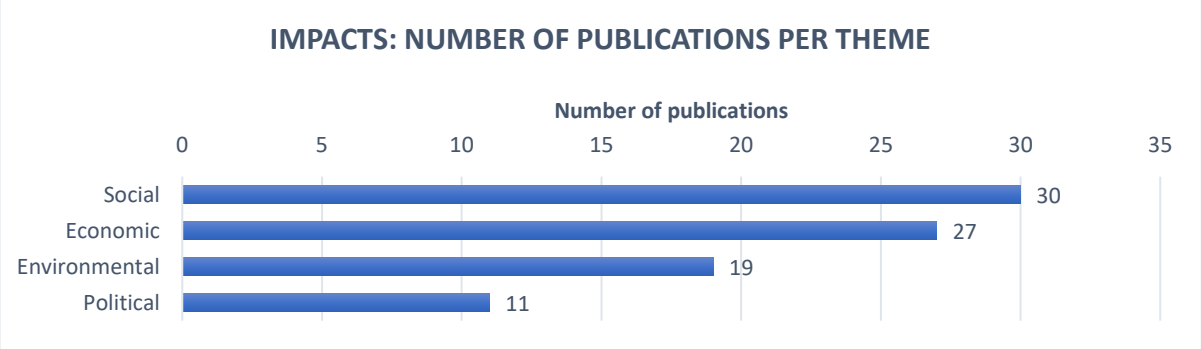


Figure 5-11 Impacts: Number of publications containing each recurring theme

5.4.6 Citation count per publication (relevant articles)

It is often assumed that highly cited publications are more influential then less cited ones. The citation count of publications are also often used as a proxy for publication quality (Aksnes, 2003). It is also referred to as the most objective measure of a material's scientific importance (Garfield, 1996).

The sources used for this study have however only provided the citation counts for 17 out of the 71 identified relevant publications. Citation count can thus not be properly used to distinguish between articles in this study. The articles of which the citation counts were available are illustrated in Figure 5-12. One article in particular (ID: 67) has a large number of citations (157 citations) and will thus be given preference when being considered. Since only 17 articles had citation counts readily available with merely five articles having more than 10 citations, the citation count will not be considered further in this study, but rather the quality of the work itself. It should however be noted that recent publications would not have many citings which would explain the small citation counts since most publications considered in this study are relatively recent as was illustrated in Figure 5-4.

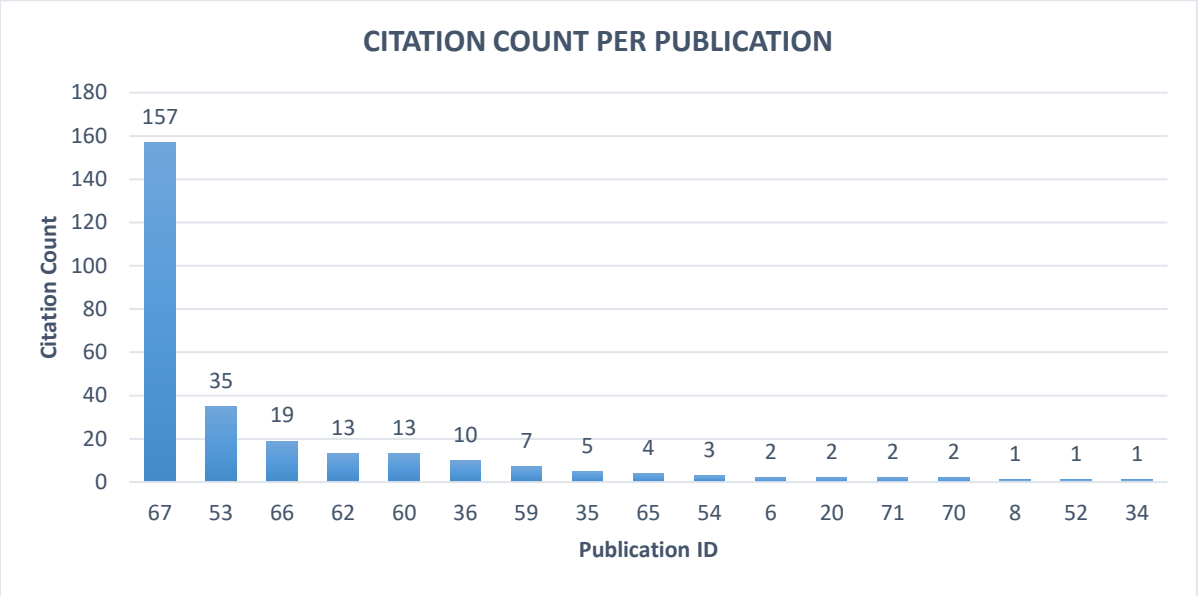


Figure 5-12 Citation counts for 17 relevant articles

5.5 Chapter 5: Conclusion

Following completion of the first part of the SLR and high-level qualitative data analysis of the gathered literature papers, the notion is proved that microtransit is a novel field of which not much research has been done to date (refer to Figure 5-9). The development of an M&E framework is therefore beneficial and contributes to fill the gap in the body of knowledge of transport systems.

Now that the search for papers relevant to the scope of study has been narrowed down and organised, the data analysed, and an introductory comprehensive overview has been given on microtransit and monitoring and evaluation, the next step would be to determine how to extract data from the relevant publications in order to link the two focal concepts of microtransit and M&E towards creating a conceptual framework. This will be done through extensive qualitative data analysis and completion of the second part of the SLR in the following chapter.

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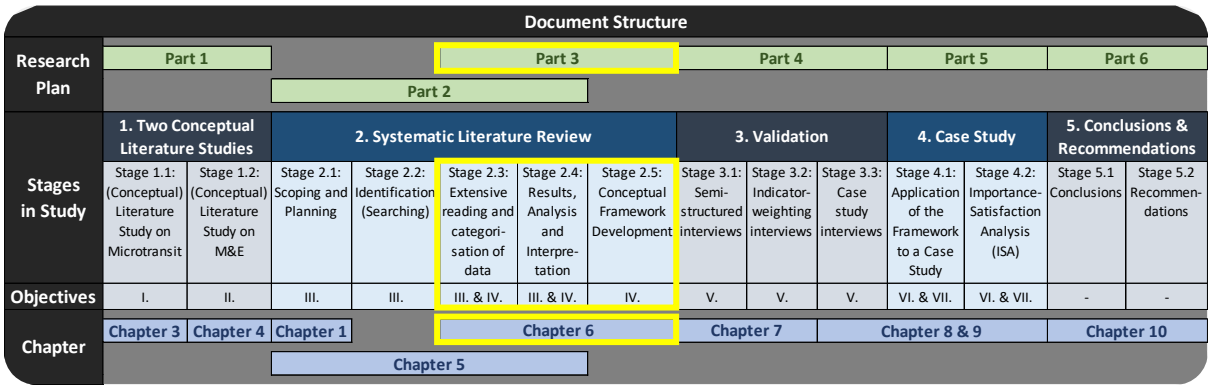
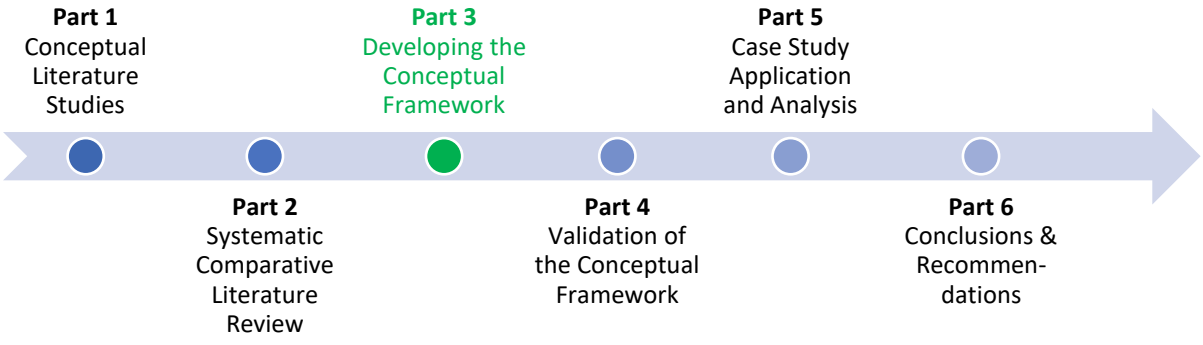
Chapter 6 Developing the Microtransit M&E Conceptual Framework



Following completion of the systematic comparative literature review part in the previous chapter, this chapter continues with the second part of the SLR towards developing the initial subjective conceptual microtransit M&E framework.

Chapter key outcomes	Gain a comprehensive understanding of the final set of all relevant articles through extensive reading
	Conduct in-depth data extraction and categorisation from relevant articles
	Use extracted data to conduct a comprehensive data analysis comprising approach analysis and the application of new relevance ratings
	Identification, deconstruction, categorisation, and integration of concepts
	Concept occurrence analysis per article and per type of transport
	Initial subjective conceptual framework



This chapter commences with Part 3 (Developing the Conceptual Framework) of this research study as illustrated above. This was done by completing the following stages of the systematic literature review method as illustrated in Figure 6-1 with the shapes highlighted in blue. The grey shapes have been completed in the previous chapter.

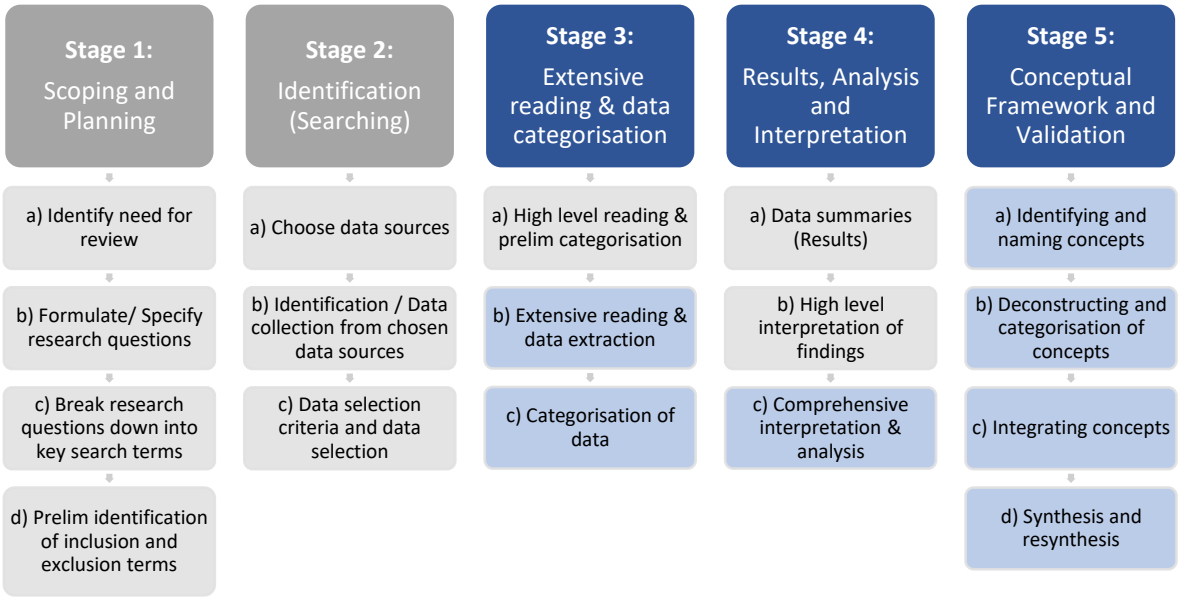


Figure 6-1 Conceptual framework development methodology

6.1 Stage 2.3 – Extensive reading and Categorisation of data (continued)

Through extensive reading of all relevant publications, a comprehensive understanding of all papers considered in the SLR was obtained. During the extensive reading process, specific data of each paper was identified, extracted, and categorised as seen in Table B-1 from Appendix B into the following categories:

- Relevance rating
- New relevance rating
- Main goal/objective of paper (Distinctive contribution)
- Number of KPIs
- KPIs of study
- Impacts
- Quantitative/Qualitative
- Methodology (Analysis Process)
- Approach (Type of Analysis/Theoretical lens)

The KPIs identified in each publication were also extracted and put into table format for easier analysis thereof later on. For the sake of brevity, the KPIs of all articles were not included since they amount to a total of 807 indicators/criteria/areas of sustainability/evaluation category/variables/metrics depending on the author's view. For this reason only the number of KPIs identified in each article is given in Table B-1. The complete Excel spreadsheet with all information has been included on CD format and is available for viewing.

6.2 Stage 2.4 – Data Analysis, Results and Interpretation (continued)

A more comprehensive understanding was gained when completing the extensive reading process. This enabled the researcher to apply new relevance ratings that were not only based on the abstracts and keywords as was done previously, but rather based on the articles as a whole. The new relevance ratings were mainly based on the ability of the article to contribute relevant transport system indicators, its main goal/objective of the paper (distinctive contribution), its methodology/analysis

process, and its approach (type of analysis/theoretical lens). The updated relevance ratings are available in Table B-1.

In addition to the relevance rating analysis, the approaches followed by each article were also analysed (see Table C-1 in Appendix C). Although these approaches are not all on the same level, the occurrence of every approach among the relevant articles was established. A summary thereof is provided in Figure 6-2.

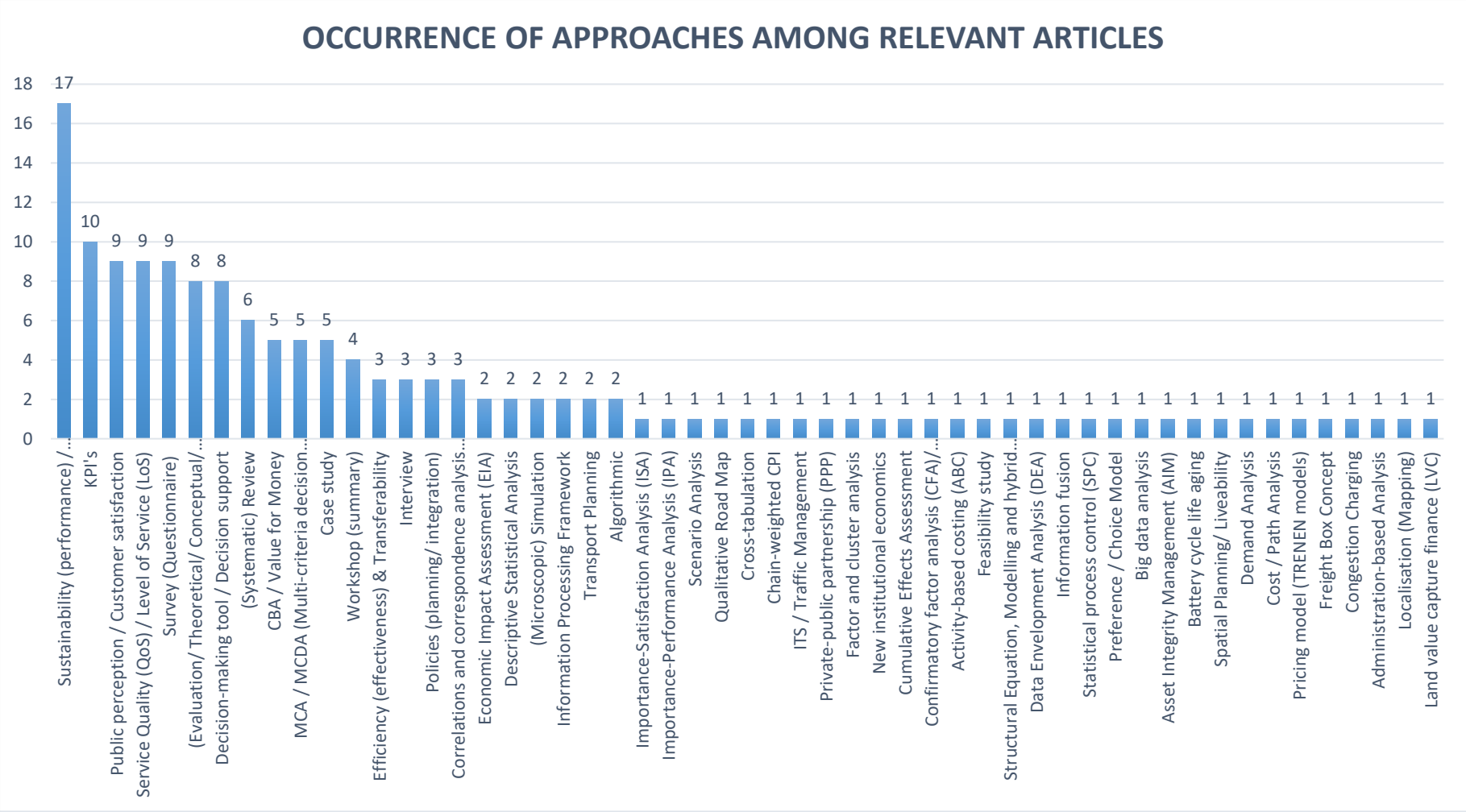


Figure 6-2 Occurrence of approaches amongst relevant articles

From Figure 6-2 and the analysis done (refer to Table C-1 in Appendix C), the approaches followed in the reviewed articles that occurred at least twice were listed in Table 6-1 including the IDs of the articles containing the respective approach. Also included in the list, are the following similar approaches: Importance-Satisfaction Analysis (ISA) and Importance-Performance Analysis (IPA). These were identified as possibilities to be used as a management tool for this study and will be considered again in Chapter 8

Table 6-1 List of approaches followed by relevant articles

Approach	*Articles [ID] following the approach*
Sustainability (performance)/Performance measurement	[3], [10], [17], [25], [29], [30], [36], [44], [48], [49], [52], [55], [58], [59], [63], [67], [68]
KPIs	[3], [12], [24], [28], [29], [42], [44], [49], [57], [67]
Public perception/Customer satisfaction	[2], [3], [7], [13], [18], [29], [38], [43], [50]
Service Quality (QoS)/Level of Service (LoS)	[11], [18], [23], [29], [33], [38], [43], [57], [58]
Survey (Questionnaire)	[1], [7], [13], [18], [29], [45], [47], [54], [63]
(Evaluation/Theoretical/Conceptual/Analytical) Framework	[2], [18], [21], [36], [38], [52], [57], [66]
Decision-making tool/Decision support	[2], [16], [17], [21], [23], [27], [59], [60]
(Systematic) Review	[25], [27], [41], [45], [46], [48]
CBA/Value for Money	[9], [12], [21], [34], [40]
MCA/MCDA (Multi-criteria decision analysis)/MAMCA (Multi-actor multi-criteria analysis)	[12], [17], [27], [40], [61]
Case study	[2], [7], [33], [60], [66]
Workshop (summary)	[9], [30], [37], [56]
Efficiency (effectiveness) and Transferability	[24], [32], [58]
Interview	[7], [58], [63]
Policies (planning/integration)	[2], [55], [68]
Correlations and correspondence analysis/Comparative analysis	[39], [50], [66]
Economic Impact Assessment (EIA)	[9], [63]
Descriptive Statistical Analysis	[7], [31]
(Microscopic) Simulation	[23], [53]
Information Processing Framework	[5], [59]
Transport Planning	[22], [59]
Algorithmic	[4], [53]
Importance-Satisfaction Analysis (ISA)	[43]
Importance-Performance Analysis (IPA)	[13]

From Table 6-1 we observe that the most common approach was to determine sustainability performance in some way. This was either done through qualitative analysis of its performance, or quantitative analysis through typically determining a sustainability index. The latter is closely connected to the second most common approach identified in the articles which is key performance indicator (KPI) identification. Also among the top five approaches are public perception/customer satisfaction, service quality/level of service (LoS), and surveys. In this study, several of the approaches from Table 6-1 are employed: Through the systematic review KPIs were identified in the next section towards conceptual framework development. Surveys (questionnaires) and interviews would allow for framework validation. The validated conceptual framework will be used as a management

(decision-making) tool by determining a sustainability index (which is also concerned with service quality/level of service), and to perform importance-satisfaction analysis (ISA). This will be done by means of a case study application. All of these approaches that are incorporated in this research study were all identified in relevant articles as Table 6-1 suggests.

Analysing the relevant articles' approaches regarding whether it is of a qualitative or quantitative nature or both, delivered the results found in Figure 6-3. Although more articles conducted research of a qualitative nature, the distribution is still fairly even. It is also noted that while some studies focused mostly on quantitative analysis, several studies also included some qualitative research along with its quantitative analysis. Referring to Section 2.1.1, it might even be argued that no study is purely quantitative, and will always contain some form of qualitative analysis.

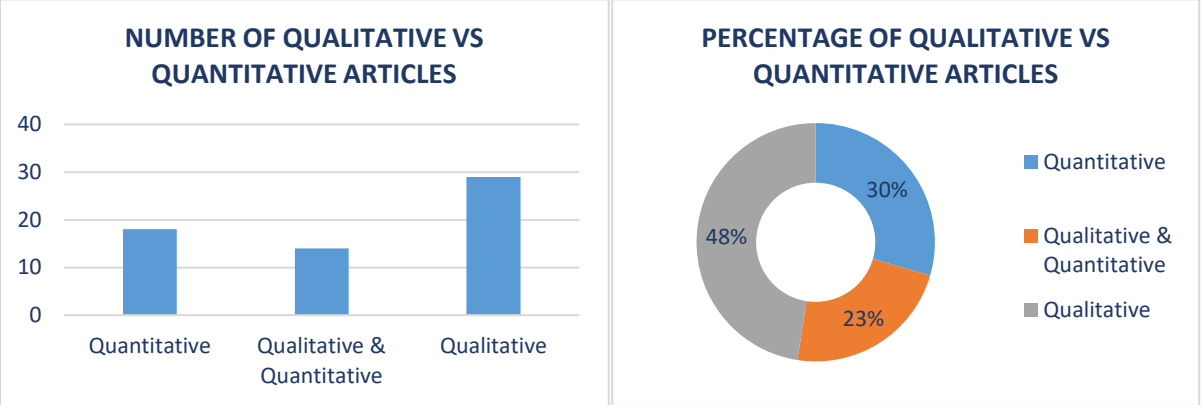


Figure 6-3 Number and percentage of articles with a qualitative, quantitative, or mixed approach

6.3 Stage 2.5 – Conceptual Framework Development

It should be noted that researchers sometimes classify concepts on different levels. While some researchers might classify a certain concept as an indicator, others might classify it as a variable or an area of sustainability or evaluation category. This was also true considering the identified set of relevant publications. Due to this reason all evaluation categories (areas of sustainability), indicators, metrics, and variables that were identified in the relevant publications were considered carefully and sifted thoroughly as illustrated in the process from Figure 6-4.

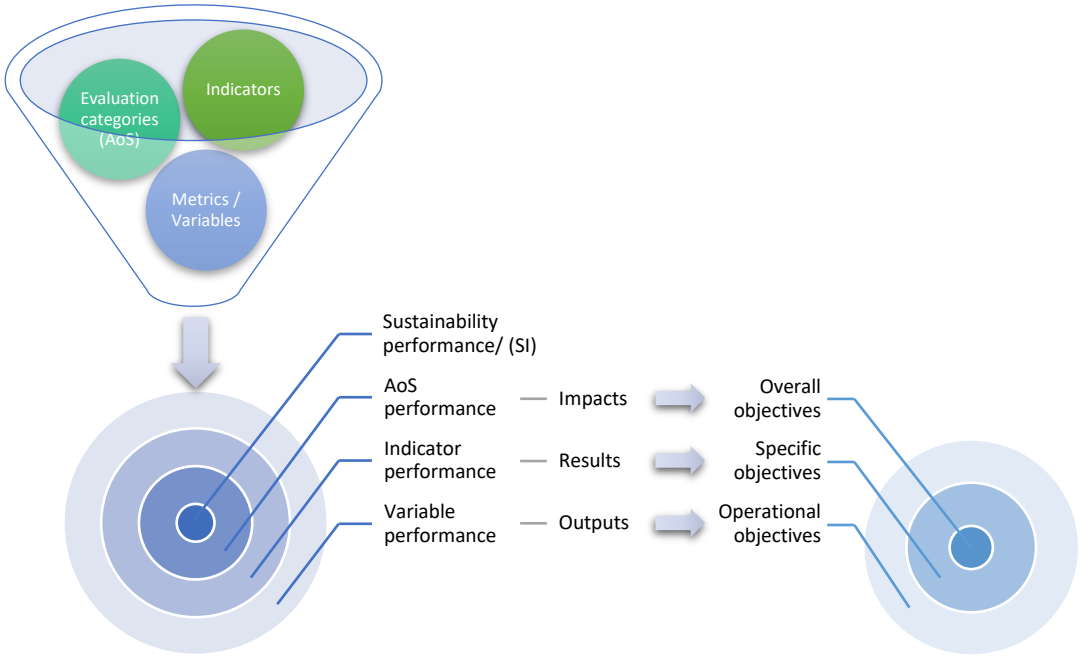


Figure 6-4 Process illustration of concept categorisation and integration

From Section 4.2, considering the logic of interventions as illustrated in Figure 4-1, it is clear that the goal is to reach objectives by applying activities towards achieving certain outputs. Achieving these outputs amounts to certain results, which ultimately results in desired impacts. These outputs, results and impacts are in line with operational, specific, and overall objectives respectively as shown in Figure 6-4. Keeping this in mind, concepts were identified, categorised and integrated into evaluation categories (areas of sustainability) consisting of indicators which again consist of variables. Evaluating the sustainability of a microtransit system is thus broken down into specific measurable variables as shown in Figure 6-5 where the hierarchical concept categories were established. Although several of the indicators overlap regarding the impact they have on different areas of sustainability, they were considered according to their direct impacts instead of the indirect impacts they could also have on other areas of sustainability. For a complete synthesis, the indicators and areas of sustainability will be weighted according to their relative contribution to each of the three pillars of sustainability, further considered in Chapter 7

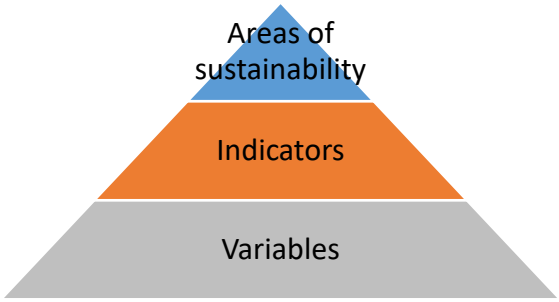


Figure 6-5 Concept category hierarchy

Following the process explained in Figure 6-4 and establishing the concept category hierarchy in Figure 6-5 the deconstruction, categorisation, and integration of the concepts were conducted by sifting through all of the 807 identified key concepts also referred to as 'KPIs'. The principles for transport indicator selection as specified in Table 3-1 were applied during this process. This lengthy process is

shown in Table 6-2. Also included in the table is the occurrence of each of the concepts per relevant article. The 'G' refers to grey literature. Since the concepts were mainly derived from 21 of the relevant articles, only these relevant articles are compared in the table. Each of these articles focused on one of the following: rail, bus, city mobility, general public transport (PT), or other. The usage of certain indicators per transport type could thus also be determined and is also listed. It is noted that the article (ID 67) that was previously identified as the one with most citations, also had the largest set of indicators. Since this article focused on city mobility, naturally there would be more indicators identified under this category. All papers were considered equally and the large list of 807 concepts or 'KPIs', was narrowed down to a total of 12 areas of sustainability, 50 indicators, and 198 variables that are relevant to and considered important for the evaluation of a microtransit system's sustainability.

Table 6-2 Deconstruction, categorisation, and integration of concepts regarding microtransit system sustainability

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
1. Pollution	x	x						x				x	x				x						x	-	x	x	-
Air Pollution	x			x				x			x		x	x	x				x		x		x	-	x	x	x
Carbon dioxide (CO2) emissions per capita								x		x			x								x		-	-	x	-	x
Sulphur dioxide (SO2) emissions per capita								x			x		x										-	-	x	-	-
Carbon monoxide (CO) emissions per capita								x		x	x		x								x		-	-	x	-	x
Particulates (PM10) per capita								x			x										x		-	-	x	-	x
Volatile organic compounds (VOCs) per capita								x			x										x		-	-	x	-	x
Oxides of Nitrogen (NOx) emissions per capita											x		x								x		-	-	x	-	x
Old vehicles still in use (number) per capita								x															-	-	x	-	-
Black smoke (yes/no)													x										-	-	x	-	-
Lead emissions (yes/no)													x										-	-	x	-	-
Waste Pollution/Production	x												x				x						x	-	x	x	-
Transportation Solid Waste per capita (tonne)																						x	-	-	-	-	x
Number of vehicles scrapped annually													x										-	-	x	-	-
Hazardous materials incidents													x										-	-	x	-	-
Lead acid batteries in municipal solid waste streams													x										-	-	x	-	-
% recyclable/re-useable materials of vehicle													x										-	-	x	-	-
Water Pollution	x												x								x		x	-	x	-	x
Per capita vehicle fluid losses & oil spills incidents													x								x		-	-	x	-	x
Per capita hardened "impervious" surface area (e.g. highways & parking lots) leading to increase in stormwater runoff																					x		-	-	-	-	x
Management of used oil, leaks and stormwater																					x		-	-	-	-	x
Noise Pollution	x			x									x	x	x				x		x		x	-	x	x	x
Level of noise from urban transport (Decibels)								x															-	-	x	-	-
% Population exposed to transport related noise > 55 dB										x											x		-	-	x	-	x
Light Pollution																						x	-	-	-	-	x
Lumen (lm)																							-	-	-	-	-
2. Transport resource consumption (renewable & non-renewable)										x							x				x		-	-	x	x	x
Energy Consumption	x					x							x		x		x						x	x	x	x	-
Transport energy use per capita													x										-	-	x	-	-
Overall energy efficiency													x										-	-	x	-	-
How clean/green is the energy used?										x												x	-	-	x	-	x

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Infrastructure & Vehicle Materials Consumption																	x						-	-	-	x	-
Tonnes of materials used for vehicles & infrastructure(tonnes)																						x	-	-	-	-	x
Vehicle fuel consumption								x		x			x										-	-	x	-	-
Litres fossil fuel consumed per passenger													x									x	-	-	x	-	x
Litres non-fossil fuel consumed per passenger													x										-	-	x	-	-
Fuel efficiency													x										-	-	x	-	-
3. Ecological & Geographical damage/impacts	x												x		x		x						x	-	x	x	-
Ecological system																	x						-	-	-	x	-
Loss of wetlands/agricultural lands/deforestation (acres) per population growth													x								x		-	-	x	-	x
No of wild life/animal collisions per capita																							-	-	-	-	-
Fragmentation of ecosystems and habitats																					x		-	-	-	-	x
Vibration caused by transport system	x																						x	-	-	-	-
GHG emissions/Climate change	x										x		x				x				x		x	-	x	x	x
CO2 emissions per capita/Total emissions per capita								x		x			x								x		-	-	x	-	x
Change in earth's temperature																						x	-	-	-	-	x
Land-use	x			x									x		x		x				x		x	-	x	x	x
Land consumption (m2) for transport infrastructure (roads, parking)													x								x		-	-	x	-	x
Land area lost due to erosion caused (m2)																						x	-	-	-	-	x
4. Initiatives for environmental protection																							-	-	-	-	-
Studies of environmental impacts										x													-	-	x	-	-
Number of studies on environmental impacts																							-	-	-	-	-
Investments dedicated to environmental protection																							-	-	-	-	-
Total sum of investments																							-	-	-	-	-
Technological maturity of transport system															x								-	-	-	x	-
How technologically advanced & mature is the system?																							-	-	-	-	-
5. (Customer) Service Quality (Level of Service)	x	x				x	x	x						x	x						x		x	x	x	x	x
Comfort	x	x	x			x		x			x			x									x	x	x	x	-
Occupancy rate/availability of seating (Crowding)			x					x	x	x	x							x	x				x	-	x	x	x
Space in vehicle (per individual)		x																		x			x	-	-	-	x
Cleanliness of vehicle			x					x	x									x	x	x			x	-	x	x	x
Temperature inside vehicle (shelter, ventilation, air conditioning)			x					x	x										x	x			x	-	x	-	x

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Quaking level			x																				x	-	-	-	-
Noise level			x																x				x	-	-	-	x
Overall riding comfort						x								x									-	x	-	x	-
Comfort due to presence of information screens																							-	-	-	-	-
Comfort while waiting at bus/vehicle stops (including cleanliness)			x					x			x							x				x	-	x	x	-
Convenience	x																						x	-	-	-	-
Electronic fare payment option/Ease of buying tickets					x				x														-	x	x	-	-
Number and variety of shops, cafés and restaurants near stops																			x				-	-	-	-	x
Availability of Wi-Fi & cellphone signals																			x				-	-	-	-	x
Availability of cellphone charging facilities											x											x	-	-	x	-	x
Bathroom facilities in vehicle									x		x												-	-	x	-	-
Existence of differential services such as water, newspaper and blanket									x		x												-	-	x	-	-
Convenience of the vehicle schedules																		x					-	-	-	x	-
Reliability	x		x													x							x	-	-	x	-
Punctuality/delay/regularity						x		x	x		x					x		x	x	x			-	x	x	x	x
Uncertainty											x												-	-	x	-	-
Variability in time									x		x												-	-	x	-	-
Cancellations											x												-	-	x	-	-
Driver attitude & appearance						x		x															-	x	x	-	-
Awareness																x							-	-	-	x	-
Courtesy and helpfulness of staff/driver			x						x							x				x			x	-	x	x	x
Law-abidingness									x	x						x							-	-	x	x	-
Complaint handling and effective complaint resolution								x								x							-	-	x	x	-
Driver appearance									x														-	-	x	-	-
Image/Attractiveness/Aesthetics																			x				-	-	-	-	x
Customer perception of vehicle appearance/aesthetics						x													x				-	x	-	-	x
Customer perception of waiting areas/vehicle stops aesthetics																			x				-	-	-	-	x
Preservation of heritage rating	x																						x	-	-	-	-
General Customer Satisfaction								x	x														-	-	x	-	-
Overall Satisfaction with the service		x						x	x											x			x	-	x	-	x
I feel that taking public transit is consistent with my lifestyle		x																					x	-	-	-	-

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
How likely are you to recommend this service to others?		x																					x	-	-	-	-
How likely are you to use this service again?		x																					x	-	-	-	-
Percentage of complaints from all passengers								x															-	-	x	-	-
6. Accessibility & Availability		x		x								x	x	x			x		x		x		x	-	x	x	x
Customer accessibility to transport system	x		x							x			x								x		x	-	x	-	x
NMT facilities to transport system (Quality of surrounding walking and cycling conditions)								x				x	x	x							x		-	-	x	x	x
Accessibility to terminals/where vehicle stops from work/home								x						x									-	-	x	x	-
Easiness to get on/off the vehicle											x									x			-	-	x	-	x
Numbers of stations/stops											x												-	-	x	-	-
Transport system accessibility to other locations								x															-	-	x	-	-
Accessibility to public buildings										x													-	-	x	-	-
Accessibility to essential services										x													-	-	x	-	-
Accessibility to open spaces										x													-	-	x	-	-
Social Equity & Inclusion	x								x	x		x											x	-	x	-	-
Accessibility to women														x									-	-	-	x	-
Accessibility to users with special needs (disabilities)						x			x	x			x	x							x		-	x	x	x	x
Accessibility to those with low income										x			x								x		-	-	x	-	x
Accessibility to children																					x		-	-	-	-	x
Availability														x									-	-	-	x	-
Availability during peak hours														x									-	-	-	x	-
Number of vehicles in operation at any given time																							-	-	-	-	-
Frequency of vehicles (service)						x		x	x		x							x		x			-	x	x	x	x
Operating hours								x			x												-	-	x	-	-
Network coverage (km of network related to population or area)											x												-	-	x	-	-
Length of reserved PT routes related to area or population											x												-	-	x	-	-
Percentage of customers having direct journeys											x												-	-	x	-	-
7. Safety & Security	x	x	x				x	x	x					x		x			x	x	x		x	x	x	x	x
Accidents & Prevention	x									x	x		x	x							x		x	-	x	x	x
Number of (traffic & pedestrians) accidents (per km)								x		x	x		x	x							x		-	-	x	x	x
Number of fatalities and injuries (per km)								x			x		x								x		-	-	x	-	x
Use of seatbelts (%)								x															-	-	x	-	-
Use of crash helmets (%)								x															-	-	x	-	-

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Testing the crashworthiness of vehicles and rating (effectiveness)								x															-	-	x	-	-
Sufficient vehicle lighting & use of reflective devices								x											x				-	-	x	-	x
Crime											x		x										-	-	x	-	-
Incidences of stolen items reported by commuters																							-	-	-	-	-
Incidences of commuters being attacked by armed robbers (number)								x															-	-	x	-	-
Number of stolen vehicles																							-	-	-	-	-
Effective Police/Security patrol teams near service (number)								x															-	-	x	-	-
Emergency situation control																							-	-	-	-	-
Response time to emergency (minutes)								x															-	-	x	-	-
Availability of firefighting appliances								x															-	-	x	-	-
Information to improve your sense of security during emergency situations																			x				-	-	-	-	x
Passenger's perception of & satisfaction with safety level											x												-	-	x	-	-
Safety getting on and off transport																			x				-	-	-	-	x
Safety on board																			x				-	-	-	-	x
Feeling secure in transfer & waiting areas (during the day)																			x				-	-	-	-	x
Feeling secure in transfer & waiting areas (evening/night)																			x				-	-	-	-	x
Number of incidents of property damage (per total number of passengers)											x												-	-	x	-	-
Incidence of overloading (number)								x															-	-	x	-	-
Sufficient lighting at stops/station			x																x				x	-	-	-	x
Customer's perception of overall safety						x					x												-	x	x	-	-
Driver's level of capability								x															-	-	x	-	-
Frequency of driver assessment																						x	-	-	-	-	x
Drivers level of training/Percentage of trained/certified/experienced drivers (%)						x		x	x														-	x	x	-	-
Incidence of exceeding speed limit (numbers)								x															-	-	x	-	-
Incidence of driving under the influence of alcohol/drugs (number)								x															-	-	x	-	-
Incidence of red light running (traffic lights) (number)								x															-	-	x	-	-
Incidence of not stopping or yielding in junctions/pedestrian crossings/red lights (number)								x															-	-	x	-	-
Vehicle & Road condition									x														-	-	x	-	-

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Frequency of potholes (%)								x															-	-	x	-	-
Overall road quality (Satisfaction with road system condition)								x															-	-	x	-	-
Mechanically deficient vehicles still in use (%)								x															-	-	x	-	-
Old vehicles still in use (% or age of vehicles in use)								x	x		x												-	-	x	-	-
8. Government & Community Involvement																	x				x		-	-	-	x	x
Government Interoperability																	x						-	-	-	x	-
Government performance							x																-	x	-	-	-
Government financial support										x													-	-	x	-	-
Degree to which system complies with legislation (Contracts and limitations)										x												x	-	-	x	-	x
Community Involvement													x				x				x		-	-	x	x	x
Public participation in decision-taking (degree to which public influence decisions)										x			x				x						-	-	x	x	-
Public response to transit system							x						x										-	x	x	-	-
9. Mobility (Travel & Transfer)													x				x		x				-	-	x	x	x
Time	x									x			x						x	x	x		x	-	x	-	x
Average time making use of NMT before using the transport service																							-	-	-	-	-
Average waiting time at stop/pick-up/drop-off point			x								x								x				x	-	x	-	x
Average time taken to board vehicle											x												-	-	x	-	-
Average commuting/In-vehicle travel time (% of total trip)			x					x			x										x		x	-	x	-	x
Average parking search time								x															-	-	x	-	-
Delays due to congestion/Dwell time	x			x		x		x		x	x	x											x	x	x	-	-
Total average travel time to points of interest (per day)	x							x	x	x	x			x				x		x			x	-	x	x	x
Speed	x																	x					x	-	-	x	-
Average speed of using NMT service before getting to stop/pick-up/drop-off point																				x			-	-	-	-	x
Average commuting/In-vehicle speed						x				x	x									x			-	x	x	-	x
Total average transfer speed to points of interest								x															-	-	x	-	-
Distance								x		x			x										-	-	x	-	-
Average distance of using NMT service before getting to stop/pick-up/drop-off point								x											x				-	-	x	-	x
Average commuting distance								x					x										-	-	x	-	-
Total average transfer distance			x																				x	-	-	-	-

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Proximity of the stops in km													x						x	x			-	-	x	-	x
Modal split/Transit integration	x					x		x		x	x	x											x	x	x	-	-
Level of contributing to modal split & transit integration via "First & Last mile" transport						x		x		x		x											-	x	x	-	-
Intermodal terminals									x														-	-	x	-	-
Adequacy of NMT services near transit system								x				x		x							x		-	-	x	x	x
General mobility																	x						-	-	-	x	-
Number of public transport trips (Trips/vehicle)								x															-	-	x	-	-
Mobility of inhabitants (Trips/inhabitant)						x																	-	x	-	-	-
Contribution to a reduction in congestion (motorised traffic)				x						x			x								x		x	-	x	-	x
Overall ease of making transfers			x								x												x	-	x	-	-
10. Financial Perspective (Costs)								x															-	-	x	-	-
Affordability to customer	x							x									x				x		x	-	x	x	x
Commute cost/Fare of a ticket			x					x		x								x		x			x	-	x	x	x
Total travel cost (affordability of monthly travel expense)								x						x									-	-	x	x	-
The amount paid in relation to the service offered									x														-	-	x	-	-
Discounts and free rides										x													-	-	x	-	-
Costs to (private) company (Financial feasibility)															x								-	-	-	x	-
Total operating & maintenance costs	x					x		x					x		x								x	x	x	x	-
Total infrastructure costs										x					x								-	-	x	x	-
Total environmental costs															x								-	-	-	x	-
Total public service costs	x																						x	-	-	-	-
Governmental costs (Financial feasibility)								x															-	-	x	-	-
Public cost for transport service (Marginal costs of public funds)	x							x															x	-	x	-	-
Public transport investment expenditure in % of GDP								x															-	-	x	-	-
Road network expenditure in % of GDP								x															-	-	x	-	-
Resources efficiency (efficient use of government resource in city transport planning)														x									-	-	-	x	-
Financial security																	x						-	-	-	x	-
Fare revenue								x															-	-	x	-	-
Degree to which the transport system is economically self-sufficient																	x						-	-	-	x	-
Overall profitability																						x	-	-	-	-	x
11. Socio-economic	x																x						x	-	-	x	-

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Socio-economic development	x						x																x	x	-	-	-
Socio-economic growth	x																						x	-	-	-	-
Wider economic impacts	x																						x	-	-	-	-
Area property values	x																						x	-	-	-	-
Regional access to markets													x										-	-	x	-	-
Ease of reaching economically important assets													x										-	-	x	-	-
Support for local industries																					x						
Social development															x								-	-	-	x	-
Promotion of career opportunities/creation of jobs															x								-	-	-	x	-
Promotion of local tourism				x											x								x	-	-	x	-
Promotion of land-use															x								-	-	-	x	-
Land development	x																						x	-	-	-	-
Green space preservation	x																						x	-	-	-	-
Land development patterns (Sprawled vs. compact development)	x																						x	-	-	-	-
Regeneration	x																						x	-	-	-	-
12. (Economic) Productivity of the system						x																	-	x	-	-	-
Demand						x																	-	x	-	-	-
Passengers demand						x																	-	x	-	-	-
Demand for freight transport																						x	-	-	-	-	x
Capacity											x												-	-	x	-	-
Seat capacity (space per person)											x												-	-	x	-	-
Seating/Passenger capacity per vehicle						x					x												-	x	x	-	-
Network capacity of vehicles, terminals & stops											x		x										-	-	x	-	-
Storage area in vehicle capacity											x												-	-	x	-	-
Maintenance						x							x										-	x	x	-	-
Maintenance of facilities/stops								x															-	-	x	-	-
Maintenance of vehicles						x		x															-	x	x	-	-
Vehicle failure						x																	-	x	-	-	-
Ratio of non-working vehicles at any given time						x																	-	x	-	-	-
Information systems/Travel information		x								x						x			x	x			x	-	x	x	x
Availability & Accessibility of real time travel information						x													x				-	x	-	-	x
Availability & Accessibility of travel information before your trip (e.g. timetable of service)																			x	x			-	-	-	-	x
Accuracy and reliability of travel information displays																			x				-	-	-	-	x

Evaluation categories (Areas of Sustainability) / Indicators / *Variables*	Occurrence per paper (ID)																					Occurrence per theme				
	12	15	29	63	2	24	40	28	43	49	57	61	67	3	17	33	44	50	13	18	a2	G	Rail	Bus	City Mobility	General PT	Other
Ease of ticket purchasing																			x				-	-	-	-	x
Quality of information systems											x												-	-	x	-	-
Information announcements on board			x																				x	-	-	-	-
Way-finding information																			x				-	-	-	-	x
Information about vehicle routes clearly indicated (Signboards & Instructions)			x													x							x	-	-	x	-
Signposting of different facilities and services			x																x				x	-	-	-	x
Signposting for transfers between transport modes			x			x													x				x	x	-	-	x
Information and assistance provided by staff																			x				-	-	-	-	x
Overall efficiency																							-	-	-	-	-
Service efficiency						x																	-	x	-	-	-
Passengers/km										x													-	-	x	-	-
Annual number of passengers										x													-	-	x	-	-
Annual number of trips										x													-	-	x	-	-
Occupancy rate			x							x	x												x	-	x	-	-
TOTAL OCCURANCE:	37	11	22	7	1	28	5	74	23	38	47	8	52	19	15	9	20	9	35	17	38	12	64	33	160	62	88

For illustrative purposes the complexity and comprehensiveness of the initial subjective list of 12 areas of sustainability, 50 indicators, and 198 variables identified in Table 6-2 are illustrated in Figure 6-6 in a radial 'mind-map-like' diagram. Although this radial 'mind-map-like' diagram is clearly very comprehensive, it also shows the immense task of determining the performance values of 198 variables to assess a microtransit system's sustainability.

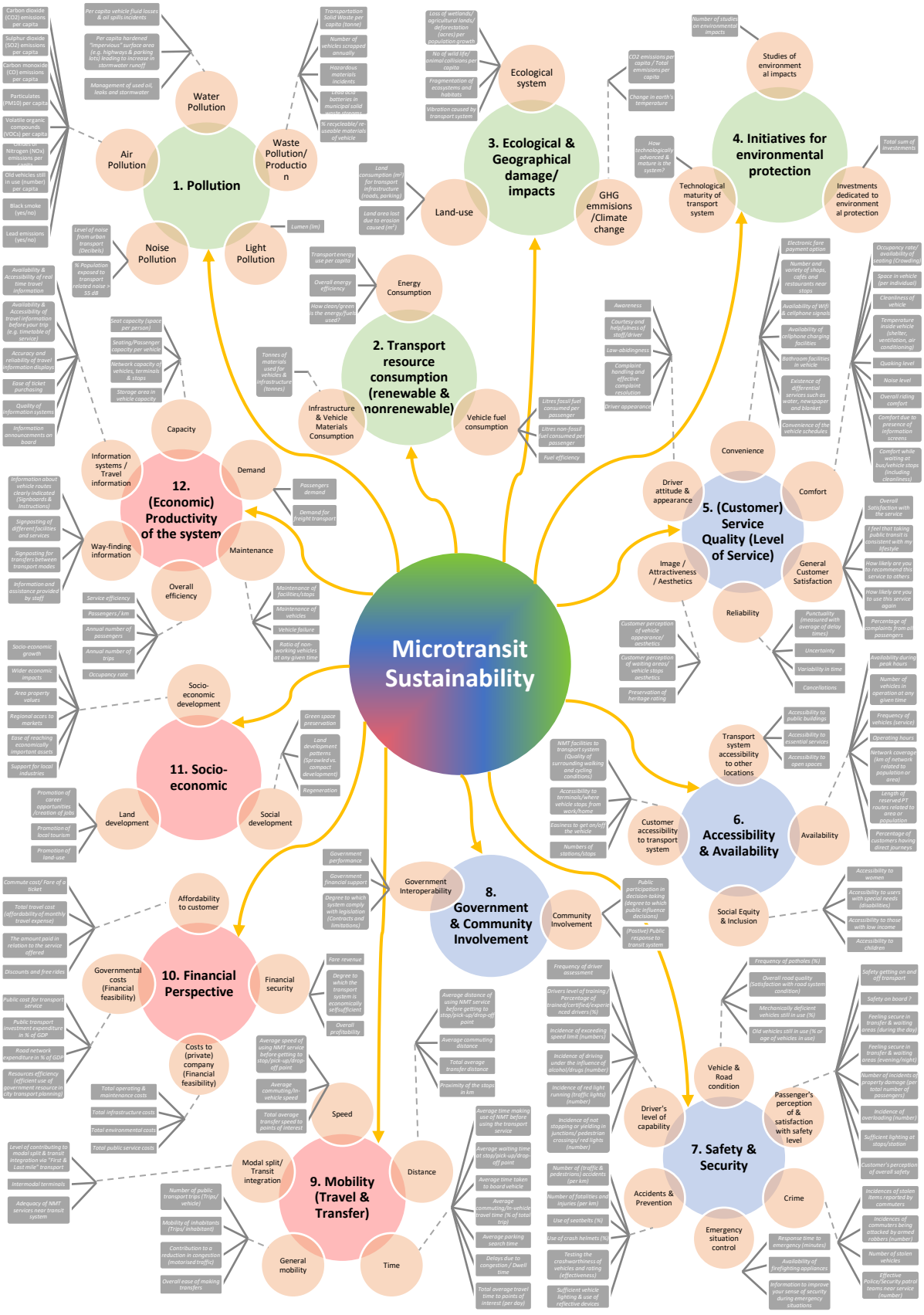


Figure 6-6 Conceptual radial 'mind-map-like' diagram of microtransit system sustainability considerations

Besides the principles for indicator selection in Table 3-1, the criteria followed when choosing the final list of 12 areas of sustainability, 50 indicators, and 198 variables were mainly based on each concept's *relevance* to microtransit systems and the *importance* of considering the concept for microtransit system sustainability to ensure they were representative. This approach gave preference to these criteria above the measurability of the concepts. The idea was thus to identify all factors that must be considered regardless of its measurability at this stage since some factors are still important to consider even though it is nearly impossible/difficult to measure. In such a case where an indicator is identified as important to consider but difficult to measure, instead of removing it from consideration, more research should be done to discover an effective way of measuring it.

The initial subjective conceptual framework is presented in Table 6-3. The 'D' in the last column stands for 'direction'. This column indicates whether an increase (>) or a decrease (<) is necessary for sustainability improvement.

Table 6-3 Initial subjective conceptual framework

N	*Evaluation categories*	C_N	*i*	*Indicators*	$I_{N,i}$	*n*	*Variables*	$x_{N,i,n}$	*D*
1	**Pollution**	C_1	1	Air Pollution	$I_{1,1}$	1	*Carbon dioxide (CO2) emissions per capita*	$x_{1,1,1}$	<
						2	*Sulphur dioxide (SO2) emissions per capita*	$x_{1,1,2}$	<
						3	*Carbon monoxide (CO) emissions per capita*	$x_{1,1,3}$	<
						4	*Particulates (PM10) per capita*	$x_{1,1,4}$	<
						5	*Volatile organic compounds (VOCs) per capita*	$x_{1,1,5}$	<
						6	*Oxides of Nitrogen (NOx) emissions per capita*	$x_{1,1,6}$	<
						7	*Old vehicles still in use (number) per capita*	$x_{1,1,7}$	<
						8	*Black smoke (yes/no)*	$x_{1,1,8}$	<
						9	*Lead emissions (yes/no)*	$x_{1,1,9}$	<
			2	Waste Pollution/ Production	$I_{1,2}$	10	*Transportation Solid Waste per capita (tonne)*	$x_{1,2,10}$	<
						11	*Number of vehicles scrapped annually*	$x_{1,2,11}$	<
						12	*Hazardous materials incidents*	$x_{1,2,12}$	<
						13	*Lead acid batteries in municipal solid waste streams*	$x_{1,2,13}$	<
						14	*% recyclable/re-useable materials of vehicle*	$x_{1,2,14}$	<
			3	Water Pollution	$I_{1,3}$	15	*Per capita vehicle fluid losses & oil spills incidents*	$x_{1,3,15}$	<
						16	*Per capita hardened "impervious" surface area (e.g. highways & parking lots) leading to increase in storm water runoff*	$x_{1,3,16}$	<
						17	*Management of used oil, leaks and storm water*	$x_{1,3,17}$	>
			4	Noise Pollution	$I_{1,4}$	18	*Level of noise from urban transport (Decibels)*	$x_{1,4,18}$	<
						19	*% Population exposed to transport related noise > 55 dB*	$x_{1,4,19}$	<
			5	Light Pollution	$I_{1,5}$	20	*Lumen (lm)*	$x_{1,5,20}$	<
2	**Transport resource consumption (renewable & non-renewable)**	C_2	6	Energy Consumption	$I_{2,6}$	21	*Transport energy use per capita*	$x_{2,6,21}$	<
						22	*Overall energy efficiency*	$x_{2,6,22}$	>
						23	*How clean/green is the energy/fuels used?*	$x_{2,6,23}$	>
			7	Infrastructure & Vehicle Materials Consumption	$I_{2,7}$	24	*Tonnes of materials used for vehicles & infrastructure(tonnes)*	$x_{2,7,24}$	<
			8	Vehicle fuel consumption	$I_{2,8}$	25	*Litres fossil fuel consumed per passenger*	$x_{2,8,25}$	<
						26	*Litres non-fossil fuel consumed per passenger*	$x_{2,8,26}$	<
						27	*Fuel efficiency*	$x_{2,8,27}$	>
3	**Ecological & Geographical damage/impacts**	C_3	9	Ecological system	$I_{3,9}$	28	*Loss of wetlands/agricultural lands/deforestation (acres) per population growth*	$x_{3,9,28}$	<
						29	*No of wild life/animal collisions per capita*	$x_{3,9,29}$	<
						30	*Fragmentation of ecosystems and habitats*	$x_{3,9,30}$	<
						31	*Vibration caused by transport system*	$x_{3,9,31}$	<
			10	GHG emissions/ Climate change	$I_{3,10}$	32	*CO2 emissions per capita/Total emissions per capita*	$x_{3,10,32}$	<
						33	*Change in earth's temperature*	$x_{3,10,33}$	<
			11	Land-use	$I_{3,11}$	34	*Land consumption (m^2) for transport infrastructure (roads, parking)*	$x_{3,11,34}$	<
						35	*Land area lost due to erosion caused (m^2)*	$x_{3,11,35}$	<

N	Evaluation categories	C_N	i	Indicators	$I_{N,i}$	n	Variables	$x_{N,i,n}$	D
4	**Initiatives for environmental protection**	C_4	12	Studies of environmental impacts	$I_{4,12}$	36	*Number of studies on environmental impacts*	$x_{4,12,36}$	>
			13	Investments dedicated to environmental protection	$I_{4,13}$	37	*Total sum of investments*	$x_{4,13,37}$	>
			14	Technological maturity of transport system	$I_{4,14}$	38	*How technologically advanced & mature is the system?*	$x_{4,14,38}$	>
5	**(Customer) Service Quality (Level of Service)**	C_5	15	Comfort	$I_{5,15}$	39	*Occupancy rate/availability of seating (Crowding)*	$x_{5,15,39}$	>
						40	*Space in vehicle (per individual)*	$x_{5,15,40}$	>
						41	*Cleanliness of vehicle*	$x_{5,15,41}$	>
						42	*Temperature inside vehicle (shelter, ventilation, air conditioning)*	$x_{5,15,42}$	>
						43	*Quaking level*	$x_{5,15,43}$	<
						44	*Noise level*	$x_{5,15,44}$	<
						45	*Overall riding comfort*	$x_{5,15,45}$	>
						46	*Comfort due to presence of information screens*	$x_{5,15,46}$	>
						47	*Comfort while waiting at bus/vehicle stops (including cleanliness)*	$x_{5,15,47}$	>
			16	Convenience	$I_{5,16}$	48	*Electronic fare payment option*	$x_{5,16,48}$	>
						49	*Number and variety of shops, cafés and restaurants near stops*	$x_{5,16,49}$	>
						50	*Availability of Wi-Fi & cellphone signals*	$x_{5,16,50}$	>
						51	*Availability of cellphone charging facilities*	$x_{5,16,51}$	>
						52	*Bathroom facilities in vehicle*	$x_{5,16,52}$	>
						53	*Existence of differential services such as water, newspaper and blanket*	$x_{5,16,53}$	>
						54	*Convenience of the vehicle schedules*	$x_{5,16,54}$	>
			17	Reliability	$I_{5,17}$	55	*Punctuality (measured with average of delay times)*	$x_{5,17,55}$	<
						56	*Uncertainty*	$x_{5,17,56}$	<
						57	*Variability in time*	$x_{5,17,57}$	<
						58	*Cancellations*	$x_{5,17,58}$	<
			18	Driver attitude & appearance	$I_{5,18}$	59	*Awareness*	$x_{5,18,59}$	>
						60	*Courtesy and helpfulness of staff/driver*	$x_{5,18,60}$	>
						61	*Law-abidingness*	$x_{5,18,61}$	>
						62	*Complaint handling and effective complaint resolution*	$x_{5,18,62}$	>
						63	*Driver appearance*	$x_{5,18,63}$	>
			19	Image/ Attractiveness/ Aesthetics	$I_{5,19}$	64	*Customer perception of vehicle appearance/aesthetics*	$x_{5,19,64}$	>
						65	*Customer perception of waiting areas/vehicle stops aesthetics*	$x_{5,19,65}$	>
						66	*Preservation of heritage rating*	$x_{5,19,66}$	>
			20	General Customer Satisfaction	$I_{5,20}$	67	*Overall Satisfaction with the service*	$x_{5,20,67}$	>
						68	*I feel that taking public transit is consistent with my lifestyle*	$x_{5,20,68}$	>
						69	*How likely are you to recommend this service to others?*	$x_{5,20,69}$	>
						70	*How likely are you to use this service again?*	$x_{5,20,70}$	>
						71	*Percentage of complaints from all passengers*	$x_{5,20,71}$	>
6	**Accessibility & Availability**	C_6	21	Customer accessibility to transport system	$I_{6,21}$	72	*NMT facilities to transport system (Quality of surrounding walking and cycling conditions)*	$x_{6,21,72}$	>
						73	*Accessibility to terminals/where vehicle stops from work/home*	$x_{6,21,73}$	>
						74	*Easiness to get on/off the vehicle*	$x_{6,21,74}$	>
						75	*Numbers of stations/stops*	$x_{6,21,75}$	>
			22	Transport system accessibility to other locations	$I_{6,22}$	76	*Accessibility to public buildings*	$x_{6,22,76}$	>
						77	*Accessibility to essential services*	$x_{6,22,77}$	>
						78	*Accessibility to open spaces*	$x_{6,22,78}$	>
			23	Social Equity & Inclusion	$I_{6,23}$	79	*Accessibility to women*	$x_{6,23,79}$	>
						80	*Accessibility to users with special needs (disabilities)*	$x_{6,23,80}$	>
						81	*Accessibility to those with low income*	$x_{6,23,81}$	>
						82	*Accessibility to children*	$x_{6,23,82}$	>
			24	Availability	$I_{6,24}$	83	*Availability during peak hours*	$x_{6,24,83}$	>
						84	*Number of vehicles in operation at any given time*	$x_{6,24,84}$	>
						85	*Frequency of vehicles (service)*	$x_{6,24,85}$	>

N	Evaluation categories	C_N	i	Indicators	$I_{N,i}$	n	Variables	$x_{N,i,n}$	D
						86	*Operating hours*	$x_{6,24,86}$	>
						87	*Network coverage (km of network related to population or area)*	$x_{6,24,87}$	>
						88	*Length of reserved PT routes related to area or population*	$x_{6,24,88}$	>
						89	*Percentage of customers having direct journeys*	$x_{6,24,89}$	>
7	**Safety & Security**	C_7	25	Accidents & Prevention	$I_{7,25}$	90	*Number of (traffic & pedestrians) accidents (per km)*	$x_{7,25,90}$	<
						91	*Number of fatalities and injuries (per km)*	$x_{7,25,91}$	<
						92	*Use of seatbelts (%)*	$x_{7,25,92}$	>
						93	*Use of crash helmets (%)*	$x_{7,25,93}$	>
						94	*Testing the crashworthiness of vehicles and rating (effectiveness)*	$x_{7,25,94}$	>
						95	*Sufficient vehicle lighting & use of reflective devices*	$x_{7,25,95}$	>
			26	Crime	$I_{7,26}$	96	*Incidences of stolen items reported by commuters*	$x_{7,26,96}$	<
						97	*Incidences of commuters being attacked by armed robbers (number)*	$x_{7,26,97}$	<
						98	*Number of stolen vehicles*	$x_{7,26,98}$	<
						99	*Effective Police/Security patrol teams near service (number)*	$x_{7,26,99}$	>
			27	Emergency situation control	$I_{7,27}$	100	*Response time to emergency (minutes)*	$x_{7,27,100}$	<
						101	*Availability of firefighting appliances*	$x_{7,27,101}$	>
						102	*Information to improve your sense of security during emergency situations*	$x_{7,27,102}$	>
			28	Passenger's perception of & satisfaction with safety level	$I_{7,28}$	103	*Safety getting on and off transport*	$x_{7,28,103}$	>
						104	*Safety on board*	$x_{7,28,104}$	>
						105	*Feeling secure in transfer & waiting areas (during the day)*	$x_{7,28,105}$	>
						106	*Feeling secure in transfer & waiting areas (evening/night)*	$x_{7,28,106}$	>
						107	*Number of incidents of property damage (per total number of passengers)*	$x_{7,28,107}$	<
						108	*Incidence of overloading (number)*	$x_{7,28,108}$	<
						109	*Sufficient lighting at stops/station*	$x_{7,28,109}$	>
						110	*Customer's perception of overall safety*	$x_{7,28,110}$	>
			29	Driver's level of capability	$I_{7,29}$	111	*Frequency of driver assessment*	$x_{7,29,111}$	>
						112	*Drivers level of training/Percentage of trained/certified/ experienced drivers (%)*	$x_{7,29,112}$	>
						113	*Incidence of exceeding speed limit (numbers)*	$x_{7,29,113}$	<
						114	*Incidence of driving under the influence of alcohol/drugs (number)*	$x_{7,29,114}$	<
						115	*Incidence of red light running (traffic lights) (number)*	$x_{7,29,115}$	<
						116	*Incidence of not stopping or yielding in junctions/pedestrian crossings/red lights (number)*	$x_{7,29,116}$	<
			30	Vehicle & Road condition	$I_{7,30}$	117	*Frequency of potholes (%)*	$x_{7,30,117}$	<
						118	*Overall road quality (Satisfaction with road system condition)*	$x_{7,30,118}$	>
						119	*Mechanically deficient vehicles still in use (%)*	$x_{7,30,119}$	<
						120	*Old vehicles still in use (% or age of vehicles in use)*	$x_{7,30,120}$	<
8	**Government & Community Involvement**	C_8	31	Government Interoperability	$I_{8,31}$	121	*Government performance*	$x_{8,31,121}$	>
						122	*Government financial support*	$x_{8,31,122}$	>
						123	*Degree to which system complies with legislation (Contracts and limitations)*	$x_{8,31,123}$	>
			32	Community Involvement	$I_{8,32}$	124	*Public participation in decision-taking (degree to which public influence decisions)*	$x_{8,32,124}$	>
						125	*(Positive) Public response to transit system*	$x_{8,32,125}$	>
9	**Mobility (Travel & Transfer)**	C_9	33	Time	$I_{9,33}$	126	*Average time making use of NMT before using the transport service*	$x_{9,33,126}$	<
						127	*Average waiting time at stop/pick-up/drop-off point*	$x_{9,33,127}$	<
						128	*Average time taken to board vehicle*	$x_{9,33,128}$	<
						129	*Average commuting/In-vehicle travel time (% of total trip)*	$x_{9,33,129}$	<
						130	*Average parking search time*	$x_{9,33,130}$	<
						131	*Delays due to congestion/Dwell time*	$x_{9,33,131}$	<
						132	*Total average travel time to points of interest (per day)*	$x_{9,33,132}$	<
			34	Speed	$I_{9,34}$	133	*Average speed of using NMT service before getting to stop/pick-up/drop-off point*	$x_{9,34,133}$	>
						134	*Average commuting/In-vehicle speed*	$x_{9,34,134}$	>
						135	*Total average transfer speed to points of interest*	$x_{9,34,135}$	>
			35	Distance	$I_{9,35}$	136	*Average distance of using NMT service before getting to stop/pick-up/drop-off point*	$x_{9,35,136}$	<
						137	*Average commuting distance*	$x_{9,35,137}$	<

N	Evaluation categories	C_N	i	Indicators	$I_{N,i}$	n	Variables	$x_{N,i,n}$	D
						138	*Total average transfer distance*	$x_{9,35,138}$	<
						139	*Proximity of the stops in km*	$x_{9,35,139}$	<
			36	Modal split/ Transit integration	$I_{9,36}$	140	*Level of contributing to modal split & transit integration via "First & Last mile" transport*	$x_{9,36,140}$	>
						141	*Intermodal terminals*	$x_{9,36,141}$	>
						142	*Adequacy of NMT services near transit system*	$x_{9,36,142}$	>
			37	General mobility	$I_{9,37}$	143	*Number of public transport trips (Trips/vehicle)*	$x_{9,37,143}$	>
						144	*Mobility of inhabitants (Trips/inhabitant)*	$x_{9,37,144}$	>
						145	*Contribution to a reduction in congestion (motorised traffic)*	$x_{9,37,145}$	>
						146	*Overall ease of making transfers*	$x_{9,37,146}$	>
10	**Financial Perspective (Costs)**	C_{10}	38	Affordability to customer	$I_{10,38}$	147	*Commute cost/Fare of a ticket*	$x_{10,38,147}$	<
						148	*Total travel cost (affordability of monthly travel expense)*	$x_{10,38,148}$	<
						149	*The amount paid in relation to the service offered*	$x_{10,38,149}$	<
						150	*Discounts and free rides*	$x_{10,38,150}$	>
			39	Costs to (private) company (Financial feasibility)	$I_{10,39}$	151	*Total operating & maintenance costs*	$x_{10,39,151}$	<
						152	*Total infrastructure costs*	$x_{10,39,152}$	<
						153	*Total environmental costs*	$x_{10,39,153}$	<
						154	*Total public service costs*	$x_{10,39,154}$	<
			40	Governmental costs (Financial feasibility)	$I_{10,40}$	155	*Public cost for transport service*	$x_{10,40,155}$	<
						156	*Public transport investment expenditure in % of GDP*	$x_{10,40,156}$	<
						157	*Road network expenditure in % of GDP*	$x_{10,40,157}$	<
						158	*Resources efficiency (efficient use of government resource in city transport planning)*	$x_{10,40,158}$	>
			41	Financial security	$I_{10,41}$	159	*Fare revenue*	$x_{10,41,159}$	>
						160	*Degree to which the transport system is economically self-sufficient*	$x_{10,41,160}$	>
						161	*Overall profitability*	$x_{10,41,161}$	>
11	**Socio-economic**	C_{11}	42	Socio-economic development	$I_{11,42}$	162	*Socio-economic growth*	$x_{11,42,162}$	>
						163	*Wider economic impacts*	$x_{11,42,163}$	-
						164	*Area property values*	$x_{11,42,164}$	>
						165	*Regional access to markets*	$x_{11,42,165}$	>
						166	*Ease of reaching economically important assets*	$x_{11,42,166}$	>
						167	*Support for local industries*	$x_{11,42,167}$	>
			43	Social development	$I_{11,43}$	168	*Promotion of career opportunities/creation of jobs*	$x_{11,43,168}$	>
						169	*Promotion of local tourism*	$x_{11,43,169}$	>
						170	*Promotion of land-use*	$x_{11,43,170}$	>
			44	Land development	$I_{11,44}$	171	*Green space preservation*	$x_{11,44,171}$	>
						172	*Land development patterns (Sprawled vs. compact development)*	$x_{11,44,172}$	>
						173	*Regeneration*	$x_{11,44,173}$	>
12	**(Economic) Productivity of the system**	C_{12}	45	Demand	$I_{12,45}$	174	*Passengers demand*	$x_{12,45,174}$	>
						175	*Demand for freight transport*	$x_{12,45,175}$	>
			46	Capacity	$I_{12,46}$	176	*Seat capacity (space per person)*	$x_{12,46,176}$	>
						177	*Seating/Passenger capacity per vehicle*	$x_{12,46,177}$	>
						178	*Network capacity of vehicles, terminals & stops*	$x_{12,46,178}$	>
						179	*Storage area in vehicle capacity*	$x_{12,46,179}$	>
			47	Maintenance	$I_{12,47}$	180	*Maintenance of facilities/stops*	$x_{12,47,180}$	>
						181	*Maintenance of vehicles*	$x_{12,47,181}$	>
						182	*Vehicle failure*	$x_{12,47,182}$	<
						183	*Ratio of non-working vehicles at any given time*	$x_{12,47,183}$	<
			48	Information systems/Travel information	$I_{12,48}$	184	*Availability & Accessibility of real time travel information*	$x_{12,48,184}$	>
						185	*Availability & Accessibility of travel information before your trip (e.g. timetable of service)*	$x_{12,48,185}$	>
						186	*Accuracy and reliability of travel information displays*	$x_{12,48,186}$	>
						187	*Ease of ticket purchasing*	$x_{12,48,187}$	>
						188	*Quality of information systems*	$x_{12,48,188}$	>
						189	*Information announcements on board*	$x_{12,48,189}$	>
			49	Way-finding information	$I_{12,49}$	190	*Information about vehicle routes clearly indicated (Signboards & Instructions)*	$x_{12,49,190}$	>
						191	*Signposting of different facilities and services*	$x_{12,49,191}$	>
						192	*Signposting for transfers between transport modes*	$x_{12,49,192}$	>
						193	*Information and assistance provided by staff*	$x_{12,49,193}$	>
			50	Overall efficiency	$I_{12,50}$	194	*Service efficiency*	$x_{12,50,194}$	>
						195	*Passengers/km*	$x_{12,50,195}$	>
						196	*Annual number of passengers*	$x_{12,50,196}$	>

N	Evaluation categories	C_N	i	Indicators	$I_{N,i}$	n	Variables	$x_{N,i,n}$	D
						197	*Annual number of trips*	$x_{12,50,197}$	>
						198	*Occupancy rate*	$x_{12,50,198}$	>

6.4 Chapter 6: Conclusion

The tension between convenience (measurability) and comprehensiveness when selecting indicators is common in sustainability research (Litman, 2016). Although a comprehensive and representative list is compiled, for indicators to be more reliable they need to be clear and measurable as well. Therefore, a smaller set of indicators is typically considered important to ensure high quality and to provide a standardised way for sampling that is feasible. An indicator is considered feasible if it requires data that is obtainable at reasonable cost and effort (Umhlaba Development Services, 2011) and complies with the principles described Table 3-1 (Litman, 2016). In the case of this research, reducing the list of indicators would mean sacrificing its comprehensiveness. The 198 variables that were identified to make up the indicators are still considered measurable at this stage although requiring an extensive amount of work. The validation process followed in Chapter 7 now proceeds to elucidate the issue of measurability vs comprehensiveness.

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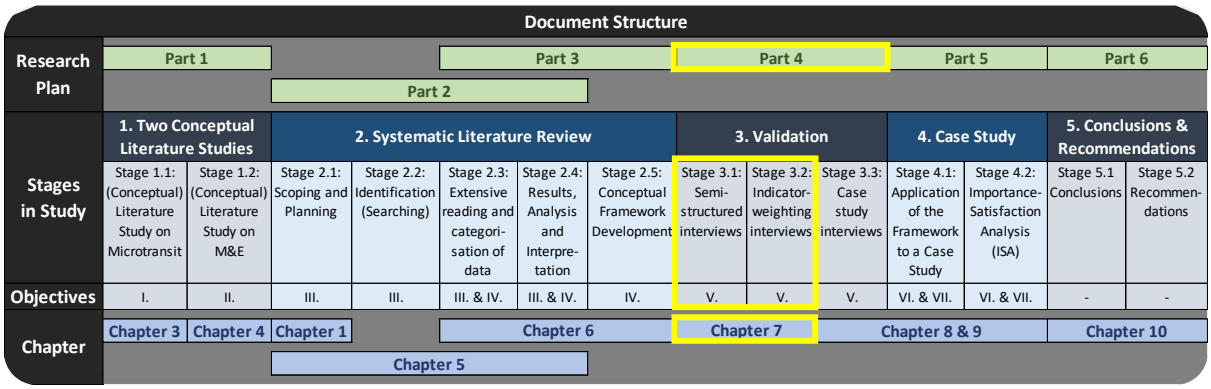
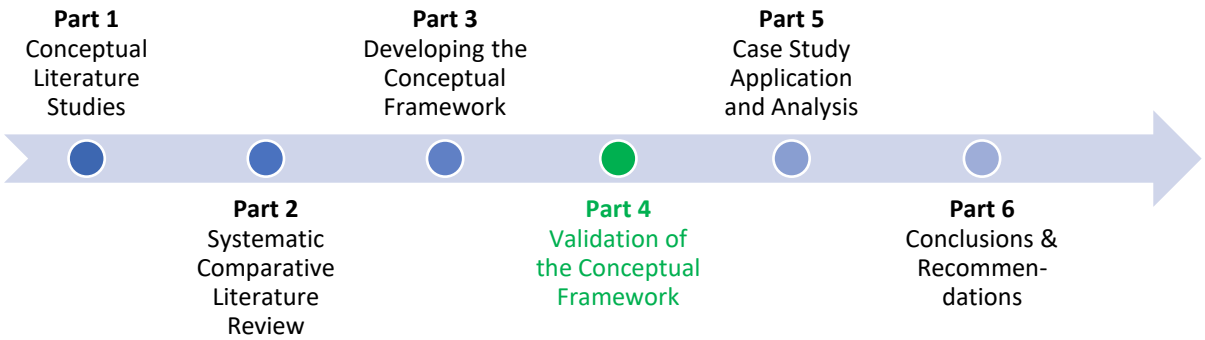
Chapter 7 Validation of the Microtransit M&E Conceptual Framework



Following conclusion of the SLR, this chapter proceeds with the validation of the developed framework. Through completion of this chapter, the initial subjective conceptual framework will be validated as a more objective enhanced conceptual framework. To achieve this, the validation methodology is provided in Section 7.1. Semi-structured and indicator-weighting interviews are described and conducted in Sections 7.2 and 7.3 respectively along with statistical analyses of the results. Section 7.4 then concludes with the enhanced weighted conceptual framework.

Chapter key outcomes	Development of the conceptual framework validation methodology
	Conduct and analyse semi-structured interview to finalise indicator set
	Elucidation on techniques and methods employed to weigh indicators
	Conduct and analyse indicator-weighting interviews
	Update and present the final enhanced conceptual framework



This chapter commences with Part 4 (Validation of the Conceptual Framework) of this research study as illustrated above. To finalise the developed conceptual framework, validation is required of the initial subjective conceptual framework. The validation process is especially important when 'developing an instrument to measure the construct in the context of the concepts being studied' (Polit and Beck, 2006). The remainder of this chapter is dedicated towards a comprehensive process of framework validation.

7.1 Conceptual framework validation methodology

Methodological triangulation is a technique employed for validation of and ensuring credibility of results (O'Donoghue and Punch, 2003; Angkananon, Wald and Gilbert, 2013). It involves studying a phenomenon through more than one kind of method and has been found beneficial for confirmation of findings, increased comprehensiveness and validity, and enhanced understandings of the phenomenon considered (Bekhet and Zauszniewski, 2012).

Methodological triangulation was used in this study based on theory from existing transport frameworks, semi-structured expert interviews and questionnaires, and 'real world' application to a case study. The complete methodology for validation of the initial subjective conceptual framework towards the weighted finalised M&E framework is illustrated in Figure 7-1.

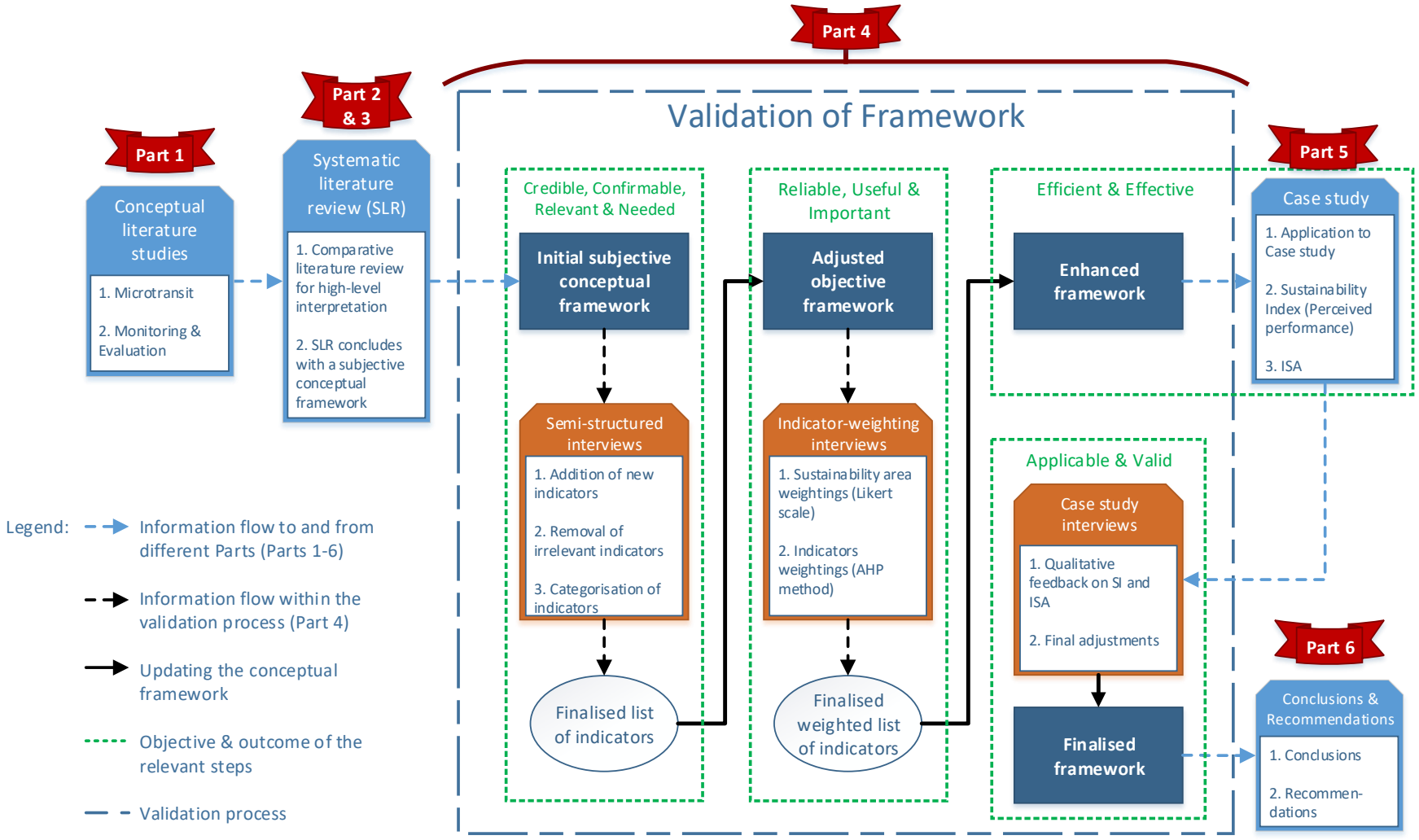


Figure 7-1 Methodology for the validation of the M&E conceptual framework

7.2 Stage 3.1 – Semi-structured interview

Expert review through a semi-structured interview is the process of asking the opinions, suggestions, feedback or comments from experts and has an interpretive orientation (Angkananon, Wald and Gilbert, 2013).

From the methodology suggested in Figure 7-1, the plan for conducting the semi-structured interview towards establishing that the initial subjective conceptual framework is credible, confirmable, relevant, and needed towards finalising the list of indicators is illustrated in Figure 7-2. While the adjusted enhanced framework is refered to as an objective framework, it is recognised that nothing can be purely objective. Objectivism integrates both subjectivity as well as objectivity since objective knowledge would always require some form of active, sophisticated subjective reasoning (perception / synthetic reasoning / analytical reasoning / logical deduction etc). These subjective processes can thus enhance objective comprehension. The focus was thus to aim to be *as objective as possible*, and must be kept in mind when the researcher refers to the framework as "objective".

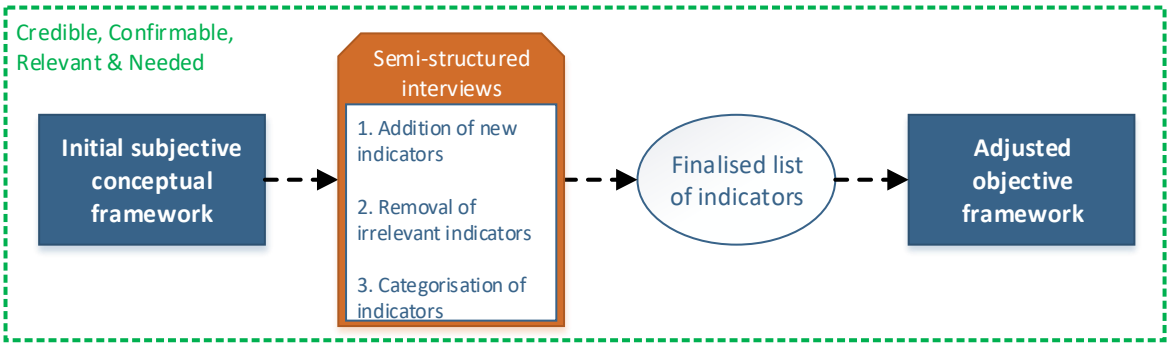


Figure 7-2 Method for the semi-structured interviews towards an adjusted more objective framework

The semi-structured interview was held with an expert in the field of microtransit - owning and managing his own microtransit business start-up. The interviewee has a degree in Environmental Management.

When viewing the initial subjective conceptual framework, the interviewee expressed his interest to the framework referring to it as "super sharp". Later in the interview the interviewee commented on the framework stating that "…this is valuable stuff…these are the questions that I have to ask myself".

Although the interviewee was instructed to consider the indicators on a systems level, the interviewee was inclined to look at the importance of the indicators from a business perspective to determine if they are important to consider in order for the business to be sustainable. This is clearly also very important since the ultimate aim is for the whole system to be sustainable, which will not be possible if it is not even sustainable on a business level. The interviewee's perspective gave a refreshing look at the M&E framework, but was also considered with caution since, although some indicators might not seem important for a business to thrive, they are still critical to consider for sustainability considerations on a system level.

All modifications that were suggested for each evaluation category (Area of Sustainability) during the interview are detailed in Table 7-1 with some additional comments added as well. All

indicators/variables that were deemed relevant with no modifications required were not included in Table 7-1, rather only the changes that were suggested.

Table 7-1 Semi-structured interview summary

N	*Evaluation categories (AoS)*	*Modifications*	*Comments*
1	**Pollution**	<u>Air pollution</u> Air pollution should be measured according to US EPA criteria: • Particle Pollution (particulate matter – PM_{10}, $PM_{2.5}$) • Ground-level ozone (O_3) • Carbon monoxide (CO) • Sulphur oxides (SO_x – use SO_2 as main indicator for SO_x family) • Nitrogen oxides (NO_x) • Lead (Pb) <u>Water Pollution</u> Vehicle fluid losses and oil spills should not be measured per capita, rather the total sum. Use US EPA criteria for water pollution. <u>Waste Pollution</u> ~~*Lead acid*~~ *batteries in municipal solid waste streams* – Modified (All batteries must be considered – EVs typically use lithium-ion batteries) *Transportation Solid Waste per capita (tonne)* – Irrelevant (remove)	<u>Air pollution</u> Compare microtransit with other vehicles that are also classified by US EPA as a L2 vehicle via US EPA criteria. Air pollution is "massively important" <u>Water Pollution</u> 'Impervious' surface area is not seen as important to consider for the company. However, on a systems level this remains an important consideration as runoff water from these surfaces significantly contributes to water pollution. <u>Noise Pollution</u> "Super important… Noise pollution is according to every city we've approached one of the number one complaints they get… especially microtransit where in the rest of the world tuk-tuks are used"
2	**Transport resource consumption (renewable & non-renewable)**	<u>Energy Consumption</u> Well-to-wheel energy efficiency is determined for EVs: *Overall energy efficiency (Well-to-wheel)* – Modified <u>Vehicle fuel consumption</u> *Litres fossil fuel consumed per km* – Modified *Litres non-fossil fuel consumed per km* – Modified	<u>Vehicle fuel consumption</u> 'Fuel efficiency' seems irrelevant for microtransit vehicles that are EVs. If a microtransit vehicle is an EV, then the 'Vehicle fuel consumption' indicator should automatically have a good index rating since no fuel is consumed. This indicator is thus relevant to consider when comparing transport modes.
3	**Ecological & Geographical damage/impacts**	<u>GHG emissions</u> Refer to US EPA criteria CO_2 emission should not be measured per capita – rather total CO_2 emissions	<u>Ecological system</u> "Very difficult to measure" Although difficult to measure, it is still important to consider. A microtransit should not have a negative impact on the ecological system. <u>GHG emissions</u> "Super important"

N	*Evaluation categories (AoS)*	*Modifications*	*Comments*
4	**Initiatives for environmental protection**	No changes	Technological maturity is more important than investments and studies of environmental impacts.
5	**(Customer) Service Quality (Level of Service)**	<u>Convenience</u> *Bathroom facilities in vehicle* - not important to consider for microtransit since it typically uses first-and-last mile transport. It can be removed. *Existence of differential services such as water, newspaper, blanket etc.* – Modified	<u>Comfort</u> "Massively important" <u>Convenience</u> Payment is very important *Existence of differential services such as water, newspaper, blanket etc.* – considered irrelevant by interviewee. This will not be removed since it can contribute towards convenience and should still be considered. <u>Reliability</u> "One of the most important things that transport systems expect from us" <u>Driver attitude & appearance</u> "Hugely important" <u>General Customer Satisfaction</u> "Massively important"
6	**Accessibility & Availability**	<u>Social Equity & Inclusion</u> Add '*Accessibility to senior citizens*' as a variable <u>Availability</u> *Network coverage (km of network related to population ~~or area~~)* – this should be a density question; however, it is difficult to determine *Length of reserved PT routes related to area or population* – irrelevant (remove) *Percentage of customers having direct journeys* – irrelevant (remove)	<u>Social Equity & Inclusion</u> Accessibility to women is not incorporated sufficiently and equally in our current transport systems e.g. women using a walker/pram; In some Muslim countries women may not drive Accessibility to children is a "very delicate matter"; "huge legislative issues". Regulations makes it nearly impossible to transport children. <u>Availability</u> "Massively important" "Network coverage is a difficult one to answer… either you map it out in routes, or you map it out in a suburb or area…this is grey"
7	**Safety & Security**	<u>Accidents & Prevention</u> *Use of crash helmets (%*) – Irrelevant (remove) suggested (refer to comments)	<u>Accidents & Prevention</u> 'Use of crash helmets and use of seatbelts are determined by law and should not be considered at ground level'. However, on a systems level this

N	Evaluation categories (AoS)	Modifications	Comments
		Passenger's perception of & satisfaction with safety level *Feeling secure in transfer & waiting areas* – Irrelevant (remove) *Number of incidents of property damage and lost property* – Modified	might still be important to consider to prevent accidents and injuries. Passenger's perception of & satisfaction with safety level This is amongst the most important to consider. The interviewee indicated that microtransit services have no specific waiting areas which means they cannot be measured and are irrelevant For insurance purposes, driver's level of capability is important to measure.
8	**Government & Community Involvement**	Government Interoperability *Government ~~performance~~ co-operation* – Modified *Government financial suppor*t – Irrelevant (remove) (This is already considered under Governmental costs (financial feasibility)	Government Interoperability "Historically, governments don't really support first-and-last-mile systems". For a private company evaluating its sustainability performance, whether government provides financial support will not affect its sustainability. However, government co-operation and legislative concerns will influence its sustainability.
9	**Mobility (Travel & Transfer)**	Speed *Average speed of using NMT service before getting to stop/pick-up/drop-off point* – Irrelevant (remove) Modal split/Transit integration *Adequacy of NMT services near transit system* – Irrelevant (remove) General mobility *Number of trips per vehicle per day* – Modified Overall ease of making transfers	Modal split/Transit integration "Important when doing reporting to the city" General mobility Contribution to a reduction in congestion "is probably one of the most important (factors to consider for general mobility)"
10	**Financial Perspective**	Governmental costs (Financial feasibility) If the microtransit company is a private company and not supported by government, then this indicator along with all its variables is not important to consider since it will not affect its sustainability. In such a case, these are irrelevant and can be removed. Since sustainability needs to be considered on a systems level, these will still be included since, for the system to work, it must still be financially feasible from	Governmental costs (Financial feasibility) "We don't measure this… but the system does" Costs to (private) company (Financial feasibility) Especially for EVs operating and maintenance costs are very important: "EVs are very cheap to operate… we operate now at 9c per kilometre"

N	Evaluation categories (AoS)	Modifications	Comments
		a governmental perspective (who has to provide the road network) Costs to (private) company (Financial feasibility) *Total infrastructure costs* – Irrelevant (remove)	"We cannot yet determine maintenance" – since it is still a start-up and have not been fully deployed
11	**Socio-economic**	Land development – seen as irrelevant by interviewee (refer to comments) As a private microtransit company, the impacts on land development seem to be very low to none. On a systems level is must still be considered whether the microtransit system contributes positively to land development, or have a negative impact on it.	Socio-economic development "Area property values we don't really have an influence on" Social development "Career opportunities and creation of jobs is huge" Land development "We can't have any impact on land development" "On a systems level, is it still important to consider?" "Yes, I think so - Absolutely"
12	**(Economic) Productivity of the system**	Way-finding information -This is digital/tech-driven nowadays. *Information about vehicle routes clearly indicated (Digitally or signboards & instructions)* – Modified Overall efficiency (impressions) – Modified	Demand "Demand for freight transport is currently a big thing for us" Way-finding information "Sign-posting…most municipals want to move away from sign-posting since transport is becoming digital" Other variables under this indicator is irrelevant if way-finding information is completely digital/tech-driven. For first-and-last-mile transport, signposting is not necessary.

It is noteworthy that although some alterations were suggested by the interviewee, all of these were on the variable level. No changes were suggested to any of the indicators or the evaluation categories (Areas of sustainability). This was seen as a positive sign that on a higher level, all possible factors were considered comprehensively and categorised sufficiently.

While some of the variables were suggested to be irrelevant, it was clear that the interviewee considered them from his perspective for the company to be "successful" and sustainable from a profitability and business perspective. On a bigger scale and from a systems approach, it is still believed that several of the variables should still be considered.

Considering that barely any changes were suggested to the indicators or areas of sustainability, it was decided to continue with the indicator-weighting interviews. The comprehensive set of indicators was identified from several relevant studies obtained through an extensive SLR, and confirmed by a rare

expert in the field of microtransit since the concept is still new. The indicator-weighting interviews will confirm the reliability, usefulness, and importance of this list by ranking the indicators. If certain indicators are identified as particularly unimportant to consider, their relative importance towards achieving overall sustainability will be ranked as such by the respondents.

7.3 Stage 3.2 – Indicator-weighting interviews

From the methodology suggested in Figure 7-1, the next step in developing the conceptual framework is weighing the areas of sustainability (AoS), indicators, and variables through indicator-weighting interviews as illustrated in Figure 7-3 towards completing the enhanced framework. Various methods are suggested and used in literature (Miranda and Rodrigues da Silva, 2012; Tsamboulas, Verma and Moraiti, 2013; Zheng *et al.*, 2013; Yang, Lee and Chen, 2016). In this research three weighting methods were considered and used towards different purposes: Analytical Hierarchy Process (AHP), Likert scale rankings, and equally weighted average (EWA). The AHP and Likert scale methods were used in the indicator-weighting interviews and discussed further in Sections 7.4.1 and 7.4.2. EWA is discussed in Section 7.4.3.

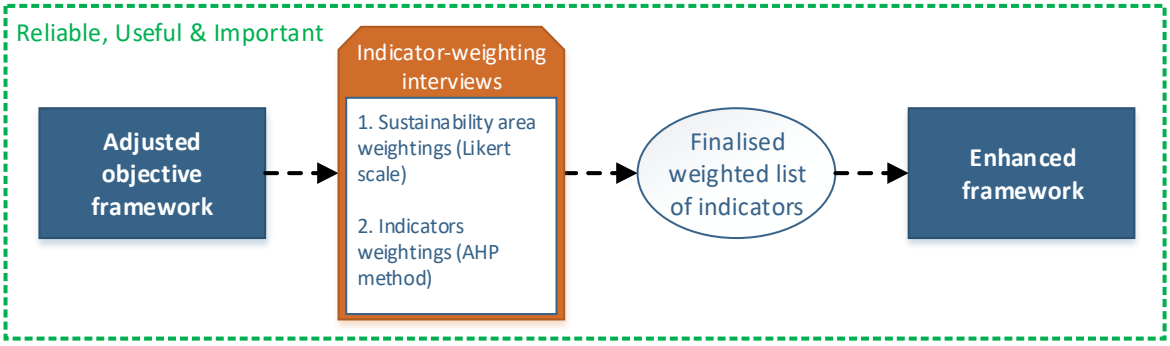


Figure 7-3 Method for indicator-weighting interviews towards a weighted and enhanced framework

Indicators often overlap regarding the respective impacts they could have on the three pillars of sustainability (spheres/domains): social, economic, and environmental as was illustrated earlier in Figure 3-1. Indicators could have both direct and indirect impacts on each of these domains. Not only does each indicator proportionally contribute differently to each domain, their relative importance for achieving overall microtransit system sustainability also differs and has to be determined. Weighting the components of the framework (AoS, indicators, and variables) is a complex process where literature addresses the weighting thereof in different ways. A study evaluating 40 different composite indices concluded that the majority of cases (40%) used the equally weighted average (EWA) approach (Singh *et al.*, 2009). The Analytical Hierarchy Process (AHP) was also identified as a method that is commonly used (Singh *et al.*, 2007).

One approach for assigning weights is to equally weigh the three spheres of sustainability through EWA and then identify appropriate indicators for each sphere. This seems hardly realistic since indicators often overlap and can contribute proportionally differently to each domain. Since this research study follows a bottom-up approach, key performance indicators were firstly identified regarding microtransit system sustainability. After establishing the main set of 50 indicators they were categorised into twelve AoS. These AoS could then be weighted according to their relative importance to social, economic, and environmental sustainability respectively. Instead of thus equally weighting the three spheres and determining indicators from there, the most important indicators and their AoS

for achieving microtransit sustainability were identified primarily, which could then individually be weighted according to their respective importance to each domain. This would prevent limitations being set on important AoS or overemphasis being placed on less important AoS since the three domains do not have to be weighted equally. Rather, it could indicate which of the three domains is more important to consider for a sustainable microtransit system keeping in mind that transport sustainability does not merely mean to sustain the transport system, but also the broader impacts it could have (Zheng *et al.*, 2013).

In the case of this research it is clear that the EWA approach would not accurately weight the AoS or indicators since their importance for achieving overall sustainability differs considerably as well as their relative importance to each of the three domains. The Likert scale and AHP methods will be utilised for weighting the AoS and indicators in the following sections.

7.3.1 Weighting: Likert scale method

The Likert scale (often used interchangeably with 'rating scale'), named after its inventor Rensis Likert, is a psychometric scale that is commonly used in research that involves scaling responses in questionnaires (Likert, 1932). In this approach participants typically specify their level of agreement or disagreement on a symmetric scale ranging from mildly positive to strongly positive with the same relative negative range (Carifio and Perla, 2007). The Likert scale thus captures the degree/intensity of the respondent's perception for a given item. The symmetric scale is typically a 5- or 7-point scale which means it has a 'neutral' or 'moderate' midpoint option. These attitudes, opinions, or perceptions on any given 'Likert-type scale response anchor' can thus easily be determined. Although the agree/disagree scale is a commonly used response anchor, scaling can also be based on various other response anchors as perceived by the respondent: quality, frequency, intensity, likeliness, approval, awareness, performance, satisfaction, importance etc. (Vagias, 2006). In the case of this research, the relative weights of all indicators and AoS had to be determined. To do this the *importance* of every indicator and AoS relative to the others were considered as response anchor.

Of the identified 12 areas of sustainability, four areas contribute mostly to economic development, four areas to social developments, and four areas to environmental development. These areas do however overlap and in most cases contribute to all three pillars of sustainability to some degree. For this reason, the areas of sustainability will be weighted by experts according to their relative importance to each pillar of sustainability. Using weighted averages, the relative weights of every AoS was determined as described later in this section. The Likert-scale method was not however used for weighting the 50 indicators; instead the AHP method was used for reasons explained in the following section. The 7-point *importance* Likert scale is described in Table 7-2.

Table 7-2 Importance Likert scale (7-point)

Rating	*Interpretation*
N/A	Not applicable
1	Not at all important
2	Slightly important
3	Somewhat important
4	Moderately important (Neutral)
5	Quite important
6	Very important
7	Extremely important

For every survey, S, a Likert scale rating, r, will be obtained for all three domains (*soc, env, eco*) of every AoS, N regarding the relative importance of every AoS to each domain:

$$r_{S,N,soc} = social\ rating\ between\ 1\ and\ 7\ (or\ 0\ for\ N/A)$$
$$r_{S,N,env} = environmental\ rating\ between\ 1\ and\ 7\ (or\ 0\ for\ N/A)$$
$$r_{S,N,eco} = economic\ rating\ between\ 1\ and\ 7\ (or\ 0\ for\ N/A)$$

where 'S' is survery number ranging from 1 to 7
and 'N' is AoS ranging from 1 to 12
These ratings are summed to obtain a total for every AoS, N, per survey, S:

$$r_{S,N,total} = r_{S,N,soc} + r_{S,N,env} + r_{S,N,eco}$$

These ratings are used to determine weights, W, for all three domains of every AoS, N, per survey, S:

$$W_{S,N,soc} = r_{S,N,soc} \,/\, r_{S,N,total}$$
$$W_{S,N,env} = r_{S,N,env} \,/\, r_{S,N,total}$$
$$W_{S,N,eco} = r_{S,N,eco} \,/\, r_{S,N,total}$$

The overall proportional weights that each AoS, N, contribute to the three domains respectively are determined by taking the average from all surveys:

$$W_{N,soc} = \frac{\sum_S (W_{S,N,soc})}{S}$$
$$W_{N,env} = \frac{\sum_S (W_{S,N,env})}{S}$$
$$W_{N,eco} = \frac{\sum_S (W_{S,N,eco})}{S}$$

The sum of the three domain ratings for every AoS, N, per survey, S, can be divided by the sum of all ratings obtained for all AoS in order to determine the relative weightings, $W_{1,S,N}$, of each AoS per survey:

$$W_{1,S,N} = \frac{r_{S,N,total}}{\sum_N (r_{S,N,total})}$$

The above calculations used the Likert scale ratings assigned to the three domains of sustainability in order to determine weightings for every AoS. This is one way to determine weightings for every AoS. Another approach could be to obtain Likert scale ratings, r, directly for every AoS regarding its importance for overall sustainability. This will enable the interviewee to assign ratings, r, according to which AoS he/she believes is more important for overall sustainability relative to the others:

$$r_{S,N,sust} = rating\ between\ 1\ and\ 7\ (or\ 0\ for\ N/A)$$

These ratings could then be divided by their sum in order to determine weightings for every AoS per survey (weighted average):

$$W_{2,S,N} = \frac{r_{S,N,sust}}{\sum_N (r_{S,N,sust})}$$

Both approaches for establishing weightings for each AoS were used. This required the interviewees to provide Likert scale ratings for every AoS regarding their importance to social, economic, and environmental sustainability respectively, as well as regarding the AoS's importance for overall sustainability. These two AoS weights were expected to be similar to each other to some degree. However, a combination of these two weights would ensure comprehensively weighted ratings to be applied to each AoS. For every survey, the weights for each of the 12 AoS are determined by taking the average of these two approaches' findings:

$$W_{S,N} = \frac{W_{1,S,N} + W_{2,S,N}}{2}$$

The final weights assigned to each AoS are determined by taking the average across all surveys:

$$W_N = \frac{\sum_S (W_{S,N})}{S}$$

With this approach, the interviewee can review whether he is satisfied with each of the AoS's relative weights determined with the different Likert scale ratings. The interviewees thus have more control over assigning weightings directly and adjusting their ratings accordingly compared to the AHP method discussed in the following section.

A completed example of the Likert-scale ranking part of the survey (hereafter referred to as Survey A) for the twelve AoS is included in Appendix D3 Table D-1, requiring a total of 48 ratings.

7.3.2 Weighting: AHP method

The Analytic Hierarchy Process (AHP), also known as expert panel weighting, was first introduced by Saaty in 1980 (Saaty, 1980). It is a structured technique that can be used to analyse complex decisions by reducing them to a series of pairwise comparisons and synthesising the results. Criteria weights are determined through expert judgements by considering each criterion's relative importance (Singh *et al.*, 2007). Through pairwise comparison, each element is compared to every other element in the set forcing a 'trade-off' approach between criteria towards determining relative weightings. After weightings have been determined for every criterion, the consistency of the decision maker's judgements is determined to reduce bias throughout the decision-making process (Saaty, 1980).

A key advantage of the AHP method is its characteristic ability to handle intangibles present in any process of decision-making (Javanbarg *et al.*, 2012). Since the tool is guided by experts' judgements it is considered a tool that can easily translate quantitative or qualitative evaluations of the expert respondent into multi-criteria rankings. The expert's knowledge is obtained through simple pairwise comparisons without the need for extensive qualitative information gathering and analysis (Saaty, 1980). The pairwise comparisons do however mean that every criterion is compared to all other criteria in the set. The number of comparisons, m, needed increases exponentially with the number of criteria, n, as determined with the equation below:

$$m = \frac{n(n-1)}{2}$$

This would require an unrealistic number of comparisons for large criteria sets making the expert's evaluation task unreasonable. The exponential increase in comparisons is illustrated in Figure 7-4.

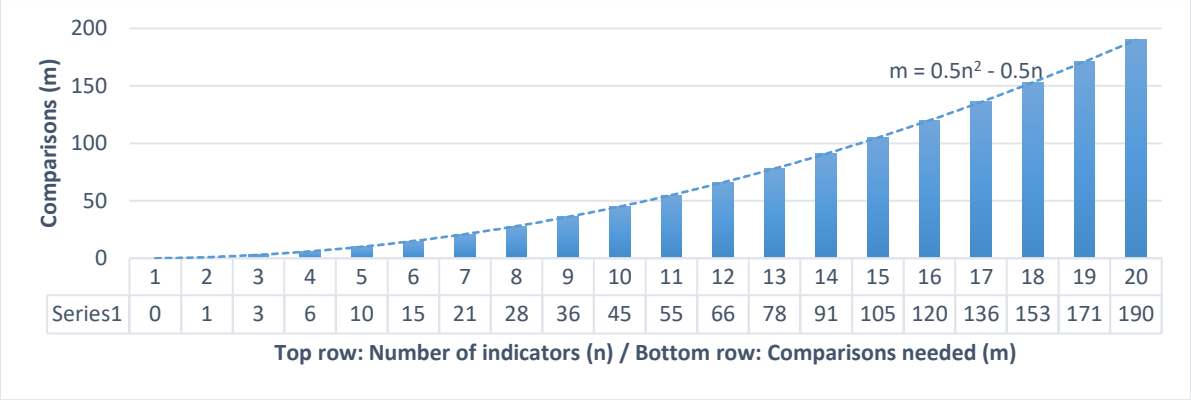


Figure 7-4 Exponential increase in number of comparisons needed per number of criteria/indicators

In the case of this research study we have 50 indicators requiring weightings, meaning 1225 comparisons would be needed. Consider Figure 7-5 as an illustrative example with a set of 15 indicators. This set would require 105 comparisons which is still too large.

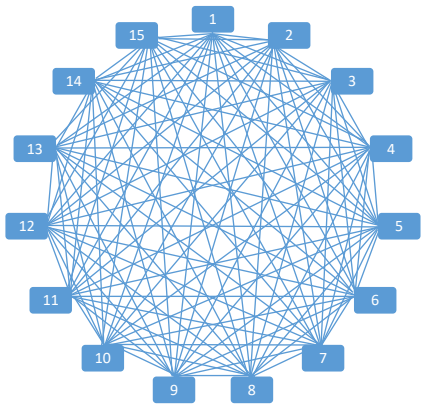


Figure 7-5 Direct pairwise comparison of 15 indicators

Referring to Figure 7-6, it would therefore be more ideal to divide the 15 indicators into smaller categories for example: 5, 4, 3, and 3 that will require 10, 6, 3, and 3 comparisons respectively as well as comparing the 4 smaller categories to each other needing another 6 comparisons. A total of 28 ratings is thus needed for the smaller categories compared to the 105 ratings needed when comparing all 15 indicators directly to one another.

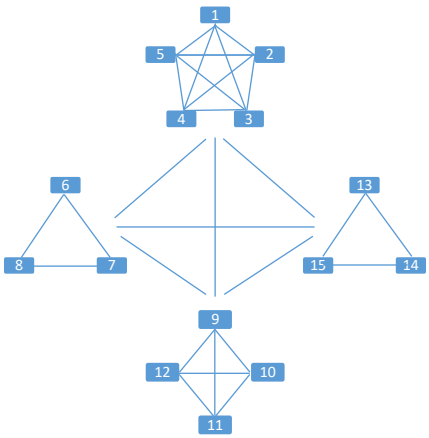


Figure 7-6 Pairwise comparison of 15 indicators divided into 4 smaller categories

The comparative approach of the AHP method is thus only useful and practical with smaller sets of criteria/indicators (say < 10) within a category since each indicator has to be compared relative to all other indicators in that category. Considering the above example, the number of categories can thus also increase substantially when all indicators are split into smaller groups. The categories should thus rather be compared with another method (Likert-scale) than the AHP method since pairwise comparison becomes exponentially more impractical for larger sets. In the case of this research, the 50 indicators were categorised into 12 AoS. Due to too many comparisons required by the AHP method and the Likert-scale's ability to assign weights more directly, the 12 AoS were weighted using a Likert-scale. It would thus be more feasible for experts to assign direct importance ratings to the AoS based on their relative importance to environmental, social, and economic sustainability respectively as well as the overall sustainability. Table 7-3 summarises the number of comparisons needed per AoS for this research using the AHP method.

Table 7-3 Number of comparisons needed per AoS

N	*AoS/Evaluation category*	*Number of indicators (n)*	*Comparisons needed (m)*
1	Pollution	5	10
2	Transport resource consumption (renewable & nonrenewable)	3	3
3	Ecological & Geographical damage/impacts	3	3
4	Initiatives for environmental protection	3	3
5	(Customer) Service Quality (Level of Service)	6	15
6	Accessibility & Availability	4	6
7	Safety & Security	6	15
8	Government & Community Involvement	2	1
9	Mobility (Travel & Transfer)	5	10
10	Financial Perspective	4	6
11	Socio-economic	3	3
12	(Economic) Productivity of the system	6	15
	Total	**50**	**90**

The AHP method for determining the relative weights for the indicators in each AoS is determined by implementing the following steps:

i. Computing the vector of criteria weights:

A pairwise comparison n x n matrix, $\boldsymbol{A}$, is created with its entries, a_{ij}, representing the relative importance of the i^{th} criterion to the j^{th} criterion (a_{ij} denotes the entry in the i^{th} row and the j^{th} column). For $a_{ij} > 1$ the i^{th} criterion is more important than the j^{th} criterion and vice versa for $a_{ij} < 1$. For $a_{ij} = 1$, the criteria are equally important. The following constraint is true for a_{ij} and a_{ji}:

$$a_{ij} \cdot a_{ji} = 1$$

The numerical scale in Table 7-4 illustrates the degree of importance for two criteria relative to each other for i equally or more important than j. Although the interpretations are based on odd numbers (1, 3, 5, 7, and 9) intermediate values not corresponding to a specific interpretation can also be provided.

Table 7-4 Relative importance ratings for AHP

Value of a_{ij}	*Interpretation*
1	Equally important

2	
3	Moderately more important
4	
5	Strongly more important
6	
7	Very Strongly more important
8	
9	Extremely important

By making the sum of the entries in each column from matrix $\boldsymbol{A}$ equal to 1, the normalised pairwise comparison matrix, $\boldsymbol{A}_{norm}$, is derived. Each entry, $\overline{a}_{ij}$, in $\boldsymbol{A}_{norm}$ is determined with the equation:

$$\overline{a}_{ij} = \frac{a_{ij}}{\sum_{l=1}^{n} a_{lj}}$$

Taking the average of all entries per row from $\boldsymbol{A}_{norm}$, the n-dimensional criteria weight vector, $\boldsymbol{w}$, can be determined with each criterion's weight:

$$w_i = \frac{\sum_{l=1}^{n} \overline{a}_{il}}{n}$$

ii. Checking the consistency

To check the consistency of the expert judgement ratings a consistency index, CI, is determined for n criteria:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

To determine λ_{max}, we first need to sum each column in $\boldsymbol{A}$ to obtain entries for vector $\boldsymbol{s}$ (s_1, s_2...s_i):

$$s_i = \sum_{l=1}^{n} a_{lj}$$

The scalar value for λ_{max} is then determined by applying the dot product between vectors $\boldsymbol{s}$ and $\boldsymbol{w}$:

$$\lambda_{max} = \boldsymbol{s} \cdot \boldsymbol{w}$$

With λ_{max} known, the consistency index value of CI can be determined. If the expert respondent is perfectly consistent a value of $CI = 0$ will always be obtained. Since there will always be some inconsistencies, Saaty (1980) recommends that small values of inconsistencies may be tolerated for CR < 0.1 and can be considered reliable where:

$$CR = \frac{CI}{RI} < 0.1$$

The random index (RI) values are the consistency index values when the entries of $\boldsymbol{A}$ are entirely random. For small problems where the number of criteria, n, are < 10, the RI values are presented in Table 7-5.

Table 7-5 Random Index (RI) values for small problems (n < 10)

n	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Following this approach of determining weights and checking their consistencies were done for each set of indicators of every AoS in this research project. Using *Microsoft Excel* during the indicator-weighting interviews for answering the AHP survey enabled the researcher to determine and provide CR values for each AoS immediately after it has been entered. The experts thus had to adjust their importance ratings if $CR > 0.1$ until they obtained a CR value below 0.1 for every AoS to ensure consistency.

A completed example of the AHP weighting part of the survey (hereafter referred to as Survey B) for the 50 indicators is included in Appendix D3 Table D-2.

7.3.3 Weighting: EWA Method

After establishing methods for ranking the AoS and indicator components, the variables remain to be weighted. Neither the Likert scale method nor the AHP method would be realistic to assign weightings during interviews since 188 variables would need to be weighted. Referring to Figure 7-4 it is clear that the AHP method would be unrealistic since the exponential increase in comparisons needed per number of variables would mean that 188 variables require 17 578 comparisons. If the Likert scale method is used this would still require 188 ratings in the interview after 48 Likert-scale ratings have already been given to the AoS and 90 pairwise comparison ratings have been given to the indicators. Assigning weightings to each of the variables would not be possible due to the increase in length of the surveys it will cause and the time-consuming interview process compared to what can realistically be expected from expert interviewees while still obtaining accurate results. Interviewees might start rushing through the survey if it is too extensive, risking the quality of the results.

Establishing accurate weightings for the AoS and the indicators is considered more critical than that of the variables. These two components make up the skeleton that accurately indicates what factors are most important for achieving overall sustainability. Due to this reason and the fact that the majority of research studies concerning composite indices use the equally weighted average (EWA) approach (Singh *et al.*, 2009) where variables for determining a certain indicator are merely given equal weights, the variables for each indicator in this study will be weighted according to the EWA approach.

Even though it is believed that variables are not necessarily equally important for determining indicator values, weighting each one is considered a trivial task especially since the variables can easily change. The variables are not set in stone, rather the AoS and indicators are designed to represent the concrete conceptual framework to which variables can be added, removed, or modified so that it can be used as a management tool. It is believed that the most effective variables for determining each indicator require additional research and would be clarified once the conceptual framework has been applied on several fully deployed microtransit systems. The EWA method thus simplifies the addition or removal of variables since they can easily be re-weighted without requiring expert interviews.

7.3.4 Interview results and analysis

While the AHP can be applied to large groups of respondents it is typically applied to smaller groups of respondents considered experts in the field being researched. Several studies reported findings from the AHP research that were based on small groups of experts: five respondents (Peterson, Silsbee

and Schmoldt, 1994), five participants (Al-Harbi, 2001), seven participants (Armaocost *et al.*, 1994), seven experts (Munira and Santoso, 2017), and 18 participants (Mawapanga and Debertin, 1996).

Due to the AHP process in this study being quite long and extensive compared to other studies, the shortage of experts regarding microtransit systems, the availability of possible experts, and the fact that only a small number of experts are commonly used in research for the AHP method, a final set of seven expert participants was interviewed in this study as summarised in Table 7-6 anonymously. These experts consist of academics from SU and individuals from industry including from companies *Mellowcabs*, and *GoMetro (Pty) Ltd* and its subsidiary *flx rides*.

The researcher had numerous unsuccessful attempts at arranging interviews with Western Cape government officials from the Ministry of Transport and Public Works. After multiple attempts and due to difficulty in arranging interviews as well as time constraints, no government official was included in the final set of experts interviewed.

Table 7-6 Expert participants (anonymous) in indicator-weighting interviews

#	*Field of Profession*	*Title/Position*	*Highest Qualification*
1	Academic (Professor)	Specialist in ITS and smart mobility; Entrepreneur in ITS	PH.D.
2	Academic (Professor)	Specialist in transport	PH.D.
3	Academic (Lecturer)	Specialist in ITS and smart mobility	M.ENG (Transportation)
4	Intelligent Transport, Energy, Cities	Senior executive, Commercial	LLB.
5	Intelligent Transport	Entrepreneur in microtransit	B.SC (Environmental Management)
6	Intelligent Transport	Technical expert in microtransit	B.ENG (Mechanical)
7	Intelligent Transport	Technical expert in microtransit	M.Sc. Electrical Eng.

Ideally there should be broad consensus among the identified experts on the relative importance weightings of the AoS and indicators. Following completion of all indicator-weighting interviews and surveys, the results for the AoS and indicators weights were obtained as per Table 7-7 and Table 7-8 respectively. The tables also include the average weights, standard deviation and coefficient of variance (CV) for each element. Also, to determine how each element's weight for every survey compares with the average weight from all surveys, the absolute value of a weighting's fractional distance from the average is determined as a percentage with the following equation:

$$Absolute\ distance\ from\ mean\ (as\ \%) = \left|1 - \frac{W_N}{W_{N,avg}}\right| \text{ x } 100\%$$

This enabled the researcher to easily identify outlier weightings that differ significantly across elements. The average of all indicators' fractional distance showed that S6 ('Survey 6') had the most inconsistencies compared to the other surveys with an average fractional distance percentage of 39% as illustrated in Figure 7-7 below. Thus its results also negatively affect the mean and as such also the other surveys' fractional distances from the mean.

When conducting the interviews, the researcher did however discover that one of the participant's basic understanding and knowledge of the concepts of microtransit and sustainability was inadequate for him/her to be considered as an expert, and considered removing this participant from this research study. Following completion of the expert surveys and interviews, the researcher then expected this participant's results (S6) to deliver the least accurate results since this participant was clearly uninformed on the subjects of microtransit and sustainability out of all experts. After analysing the results, this was then confirmed with the inconsistencies observed and thus further supported the argument for excluding this participant's results from this research, as this participant could not be considered an expert.

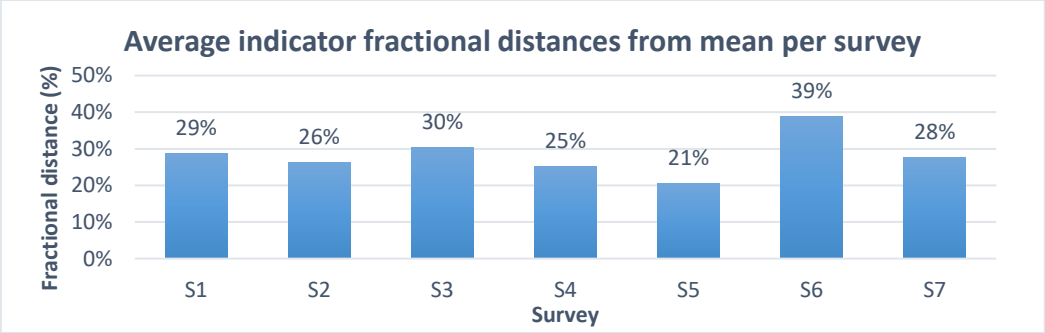


Figure 7-7 Average indicator fractional distances from mean per survey

Table 7-7 Expert survey results on AoS

		Final Weights (W_N)							All surveys analysis			Absolute % distance from mean: $\|1 - (W_N/W_{N,avg})\|$								Without Survey 6		
N	*Evaluation categories (AoS)*	S1	S2	S3	S4	S5	S6	S7	$W_{N,avg}$	StDev	CV	S1	S2	S3	S4	S5	S6	S7	Avg	$W_{N,avg}$	StDev	CV
1	Pollution	0.10	0.10	0.10	0.10	0.08	0.09	0.09	0.094	0.007	7%	6%	2%	4%	6%	11%	0%	8%	6%	**0.094**	0.007	8%
2	Transport resource consumption	0.10	0.12	0.10	0.08	0.10	0.08	0.05	0.090	0.021	23%	12%	29%	10%	7%	12%	13%	42%	14%	**0.091**	0.022	24%
3	Ecological & Geographical damage/impacts	0.10	0.08	0.08	0.07	0.05	0.09	0.05	0.074	0.019	26%	35%	4%	6%	10%	32%	27%	30%	18%	**0.071**	0.019	27%
4	Initiatives for environmental protection	0.10	0.08	0.08	0.03	0.03	0.08	0.03	0.062	0.028	45%	61%	24%	26%	46%	46%	26%	44%	41%	**0.059**	0.029	49%
5	(Customer) Service Quality (Level of Service)	0.07	0.08	0.10	0.10	0.08	0.11	0.12	0.094	0.018	19%	24%	18%	4%	6%	12%	16%	28%	13%	**0.092**	0.018	20%
6	Accessibility & Availability	0.07	0.10	0.12	0.12	0.12	0.09	0.10	0.102	0.017	17%	30%	6%	15%	14%	14%	8%	1%	16%	**0.104**	0.018	17%
7	Safety & Security	0.07	0.08	0.06	0.07	0.08	0.06	0.12	0.077	0.021	27%	7%	0%	24%	14%	8%	19%	56%	11%	**0.080**	0.022	27%
8	Government & Community Involvement	0.07	0.04	0.04	0.07	0.07	0.05	0.03	0.052	0.016	30%	37%	26%	25%	28%	28%	10%	34%	29%	**0.053**	0.017	32%
9	Mobility (Travel & Transfer)	0.09	0.12	0.10	0.12	0.10	0.11	0.10	0.104	0.011	10%	18%	11%	6%	12%	4%	5%	1%	10%	**0.103**	0.012	11%
10	Financial Perspective	0.09	0.10	0.08	0.12	0.08	0.08	0.12	0.094	0.018	19%	9%	2%	17%	24%	11%	17%	28%	13%	**0.097**	0.018	19%
11	Socio-economic	0.07	0.06	0.06	0.03	0.08	0.08	0.07	0.065	0.017	26%	11%	11%	9%	48%	29%	21%	7%	22%	**0.062**	0.017	27%
12	(Economic) Productivity of the system	0.07	0.08	0.10	0.10	0.12	0.08	0.10	0.092	0.017	18%	22%	16%	6%	9%	27%	15%	12%	16%	**0.094**	0.017	18%
									AVG:	0.017	22%	23%	12%	13%	19%	20%	15%	24%	17%	**AVG:**	0.018	23%

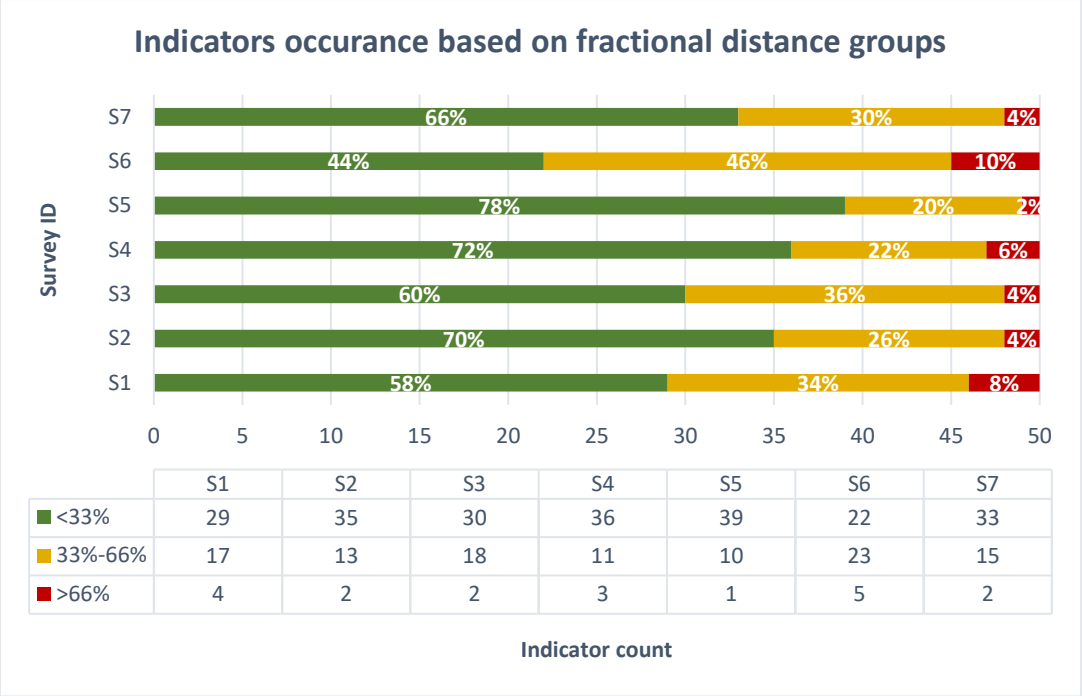
Table 7-8 Expert survey results on indicators

		Final Weights (W_{Ni})							All surveys analysis			Absolute % distance from mean: $\|1 - (W_N/W_{N,avg})\|$								Without Survey 6		
i	*Indicators*	S1	S2	S3	S4	S5	S6	S7	$W_{N,I,avg}$	StDev	CV	S1	S2	S3	S4	S5	S6	S7	Avg	$W_{N,I,avg}$	StDev	CV
1	Air Pollution	0.19	0.39	0.39	0.26	0.23	0.52	0.42	0.34	0.119	35%	46%	14%	14%	23%	33%	52%	21%	26%	**0.31**	0.098	31%
2	Waste Pollution/Production	0.29	0.18	0.16	0.26	0.23	0.18	0.16	0.21	0.051	25%	38%	12%	25%	26%	8%	12%	23%	22%	**0.21**	0.055	26%
3	Water Pollution	0.38	0.11	0.09	0.28	0.43	0.19	0.26	0.25	0.129	52%	54%	58%	63%	13%	72%	23%	5%	52%	**0.26**	0.139	54%
4	Noise Pollution	0.07	0.27	0.26	0.11	0.07	0.06	0.10	0.13	0.089	67%	48%	100%	92%	15%	48%	54%	26%	60%	**0.15**	0.091	63%
5	Light Pollution	0.07	0.05	0.10	0.08	0.05	0.04	0.06	0.06	0.021	33%	8%	19%	60%	18%	29%	35%	3%	27%	**0.07**	0.020	30%
6	Energy Consumption	0.44	0.43	0.59	0.40	0.30	0.14	0.30	0.37	0.143	39%	20%	16%	59%	8%	20%	63%	20%	24%	**0.41**	0.109	27%
7	Infrastructure & Vehicle Materials Consumption	0.11	0.14	0.16	0.20	0.16	0.24	0.16	0.17	0.041	24%	34%	15%	6%	19%	3%	42%	3%	15%	**0.16**	0.029	19%
8	Vehicle fuel consumption	0.44	0.43	0.25	0.40	0.54	0.62	0.54	0.46	0.121	26%	4%	7%	45%	13%	17%	35%	17%	17%	**0.43**	0.106	25%
9	Ecological system	0.43	0.44	0.24	0.26	0.49	0.68	0.16	0.39	0.178	46%	11%	15%	38%	33%	27%	76%	58%	25%	**0.34**	0.133	39%
10	Climate change/GHG emissions	0.43	0.44	0.62	0.41	0.31	0.20	0.54	0.42	0.139	33%	1%	5%	47%	3%	26%	52%	27%	17%	**0.46**	0.108	24%

		Final Weights (W_{Ni})							*All surveys analysis*			*Absolute % distance from mean: $\|1 - (W_N/W_{N,avg})\|$*								*Without Survey 6*		
i	***Indicators***	S1	S2	S3	S4	S5	S6	S7	$W_{N,I,avg}$	StDev	CV	S1	S2	S3	S4	S5	S6	S7	Avg	$W_{N,I,avg}$	StDev	CV
11	Land-use	0.14	0.11	0.14	0.33	0.20	0.12	0.30	0.19	0.088	46%	25%	42%	28%	72%	4%	38%	56%	34%	**0.20**	0.090	45%
12	Studies of environmental impacts	0.54	0.14	0.25	0.20	0.16	0.65	0.25	0.31	0.199	63%	73%	54%	20%	37%	48%	107%	20%	47%	**0.26**	0.147	57%
13	Investments dedicated to environmental protection	0.11	0.43	0.50	0.31	0.54	0.23	0.50	0.37	0.161	43%	71%	15%	34%	17%	44%	39%	34%	36%	**0.40**	0.162	41%
14	Technological maturity of transport system	0.35	0.43	0.25	0.49	0.30	0.12	0.25	0.31	0.123	39%	11%	37%	20%	57%	5%	61%	20%	26%	**0.34**	0.098	29%
15	Comfort	0.12	0.09	0.32	0.14	0.08	0.16	0.17	0.15	0.081	53%	24%	43%	110%	11%	46%	5%	9%	47%	**0.15**	0.089	59%
16	Convenience	0.12	0.24	0.20	0.20	0.29	0.24	0.14	0.20	0.058	29%	40%	17%	3%	3%	41%	18%	31%	21%	**0.20**	0.061	31%
17	Reliability	0.43	0.27	0.11	0.32	0.20	0.39	0.30	0.29	0.112	38%	50%	7%	63%	12%	31%	36%	4%	32%	**0.27**	0.112	41%
18	Driver attitude & appearance	0.06	0.08	0.11	0.09	0.10	0.05	0.21	0.10	0.053	53%	37%	23%	11%	11%	3%	52%	110%	17%	**0.11**	0.052	48%
19	Image/Attractiveness/Aesthetics	0.08	0.15	0.09	0.09	0.11	0.05	0.09	0.09	0.031	33%	13%	61%	4%	3%	14%	48%	7%	19%	**0.10**	0.026	25%
20	General Customer Satisfaction	0.19	0.18	0.18	0.17	0.22	0.11	0.10	0.16	0.044	27%	14%	10%	9%	2%	37%	33%	40%	14%	**0.17**	0.041	24%
21	Customer accessibility to transport system	0.30	0.34	0.41	0.25	0.27	0.23	0.26	0.30	0.063	21%	2%	16%	38%	16%	7%	23%	11%	16%	**0.31**	0.060	20%
22	Transport system accessibility to other locations	0.17	0.16	0.22	0.42	0.20	0.23	0.18	0.22	0.090	40%	24%	30%	4%	88%	11%	2%	21%	31%	**0.22**	0.099	44%
23	Social Equity & Inclusion	0.10	0.12	0.11	0.14	0.14	0.42	0.14	0.17	0.114	68%	42%	26%	34%	18%	16%	153%	16%	27%	**0.12**	0.018	14%
24	Availability	0.43	0.38	0.27	0.20	0.39	0.12	0.42	0.31	0.120	38%	37%	20%	15%	38%	24%	61%	34%	27%	**0.35**	0.094	27%
25	Accidents & Prevention	0.18	0.20	0.31	0.16	0.25	0.17	0.32	0.23	0.068	30%	20%	13%	38%	29%	11%	27%	40%	22%	**0.24**	0.068	28%
26	Crime	0.25	0.15	0.08	0.11	0.09	0.12	0.13	0.13	0.057	44%	89%	15%	40%	18%	34%	9%	3%	39%	**0.13**	0.062	47%
27	Emergency situation control	0.08	0.24	0.22	0.09	0.16	0.11	0.08	0.14	0.069	49%	41%	73%	59%	36%	13%	25%	42%	44%	**0.15**	0.073	50%
28	Passenger's perception & satisfaction with safety	0.23	0.15	0.10	0.11	0.23	0.33	0.17	0.19	0.081	43%	24%	22%	48%	41%	23%	74%	11%	32%	**0.16**	0.058	35%
29	Driver's level of capability	0.11	0.16	0.17	0.30	0.11	0.22	0.22	0.19	0.067	36%	38%	12%	9%	60%	41%	20%	20%	32%	**0.18**	0.071	40%
30	Vehicle & Road condition	0.14	0.10	0.12	0.24	0.16	0.06	0.09	0.13	0.057	44%	10%	23%	8%	81%	25%	52%	33%	30%	**0.14**	0.054	38%
31	Government Interoperability	0.75	0.75	0.75	0.75	0.67	0.67	0.33	0.67	0.152	23%	13%	13%	13%	13%	0%	0%	50%	10%	**0.67**	0.167	25%
32	Community Involvement	0.25	0.25	0.25	0.25	0.33	0.33	0.67	0.33	0.152	46%	25%	25%	25%	25%	0%	0%	100%	20%	**0.33**	0.167	50%
33	Time	0.34	0.16	0.39	0.20	0.37	0.19	0.36	0.29	0.097	34%	17%	44%	36%	31%	28%	32%	26%	31%	**0.30**	0.097	32%
34	Speed	0.13	0.11	0.11	0.17	0.10	0.09	0.18	0.13	0.034	27%	1%	15%	11%	33%	24%	26%	41%	17%	**0.13**	0.034	26%
35	Distance	0.26	0.16	0.08	0.15	0.13	0.07	0.24	0.16	0.072	46%	67%	4%	49%	1%	17%	55%	52%	28%	**0.17**	0.067	40%
36	Modal split/Transit integration	0.17	0.32	0.24	0.19	0.20	0.29	0.10	0.22	0.076	35%	21%	49%	13%	12%	6%	33%	56%	20%	**0.20**	0.076	37%
37	General mobility	0.11	0.25	0.17	0.29	0.20	0.35	0.13	0.21	0.088	41%	50%	15%	19%	34%	4%	65%	40%	25%	**0.19**	0.069	36%
38	Affordability to customer	0.47	0.28	0.55	0.36	0.33	0.47	0.48	0.42	0.098	23%	13%	33%	30%	15%	22%	12%	15%	23%	**0.41**	0.105	25%

		Final Weights (W_{Ni})							*All surveys analysis*			*Absolute % distance from mean: $\|1 - (W_N/W_{N,avg})\|$*								*Without Survey 6*		
i	***Indicators***	S1	S2	S3	S4	S5	S6	S7	$W_{N,I,avg}$	StDev	CV	S1	S2	S3	S4	S5	S6	S7	Avg	$W_{N,I,avg}$	StDev	CV
39	**Costs to (private) company (Financial feasibility)**	0.25	0.24	0.21	0.19	0.20	0.22	0.23	0.22	0.020	9%	12%	8%	3%	12%	9%	1%	5%	9%	**0.22**	0.021	10%
40	**Governmental costs (Financial feasibility)**	0.18	0.12	0.14	0.13	0.14	0.10	0.12	0.13	0.027	20%	37%	10%	8%	6%	7%	26%	12%	14%	**0.14**	0.024	17%
41	**Financial security**	0.10	0.36	0.09	0.32	0.33	0.21	0.17	0.23	0.113	50%	57%	60%	58%	43%	45%	6%	26%	53%	**0.23**	0.123	54%
42	**Socio-economic development**	0.61	0.49	0.62	0.50	0.49	0.56	0.31	0.51	0.104	20%	19%	4%	22%	2%	4%	9%	39%	10%	**0.50**	0.112	22%
43	**Social development**	0.27	0.31	0.24	0.25	0.31	0.32	0.49	0.31	0.084	27%	13%	1%	24%	20%	1%	2%	56%	12%	**0.31**	0.092	30%
44	**Land development**	0.12	0.20	0.14	0.25	0.20	0.12	0.20	0.17	0.049	28%	31%	13%	21%	43%	13%	30%	13%	24%	**0.18**	0.047	26%
45	**Demand**	0.30	0.21	0.35	0.35	0.22	0.14	0.29	0.26	0.078	30%	14%	21%	31%	32%	18%	47%	10%	23%	**0.29**	0.061	21%
46	**Capacity**	0.20	0.21	0.15	0.16	0.23	0.09	0.21	0.18	0.048	27%	9%	19%	17%	11%	29%	48%	19%	17%	**0.19**	0.033	17%
47	**Maintenance**	0.11	0.15	0.10	0.11	0.11	0.06	0.10	0.10	0.028	27%	3%	45%	8%	4%	7%	45%	7%	14%	**0.11**	0.021	18%
48	**Information systems (ICT)/Travel information**	0.15	0.09	0.09	0.19	0.14	0.25	0.17	0.15	0.058	38%	5%	42%	43%	25%	9%	64%	11%	25%	**0.14**	0.043	31%
49	**Way-finding information**	0.14	0.07	0.08	0.07	0.08	0.17	0.10	0.10	0.039	39%	37%	30%	21%	34%	18%	69%	4%	28%	**0.09**	0.026	29%
50	**Overall efficiency (impressions)**	0.11	0.27	0.24	0.12	0.22	0.29	0.13	0.20	0.074	37%	44%	36%	23%	37%	10%	45%	33%	30%	**0.18**	0.068	38%
									AVG:	0.085	37%	29%	26%	30%	25%	21%	39%	28%	26%	**AVG:**	0.078	33%

Counting the number of indicators that have a fractional distance percentage of less than 33%, between 33% and 66%, and more than 66% respectively, delivers the numbers and proportions as illustrated in Figure 7-8. This graph and its table clearly shows that S6 delivered the least consistent results compared to the other surveys with 56% of its indicator weights having a fractional distance of more than 33%. Mainly due to the fact that this expert seemed least informed out of all experts on the subjects of microtransit and sustainability, further supported by the inconsistencies observed in this participant's results, it was decided to remove the results of S6 from consideration. As seen in Table 7-8, this reduced the average standard deviation across all indicators and improved the coefficient of variance value as well.



	S1	S2	S3	S4	S5	S6	S7
<33%	29	35	30	36	39	22	33
33%-66%	17	13	18	11	10	23	15
>66%	4	2	2	3	1	5	2

Figure 7-8 Indicators occurrence based on fractional distance groups

Removing the results of S6 from consideration improved the overall standard deviations and coefficient of variance values as seen in Table 7-8. This is also illustrated in Table 7-9 with the occurrence of CV of less than 33%, between 33% and 66%, and more than 66% respectively, for all surveys and in the case where S6 is not considered.

Table 7-9 Indicator occurence based on CV groups

CV (%)	*Occurrence (# of indicators)*	
	All surveys	*Without Survey 6*
<33%	21	29
33%-66%	27	21
>66%	2	0

After the weightings have been assigned to the 12 AoS via the Likert scale, noticeable differences were observed between the values of $W_{1,S,N}$ and $W_{2,S,N}$. While the idea was to assign a final weighting to each AoS based on the average of $W_{1,S,N}$ and $W_{2,S,N}$, it was decided that it would not make sense to use $W_{1,S,N}$ towards this purpose. $W_{1,S,N}$ was useful in determining relative weightings between the three sustainability domains. However, it became clear that using the sum of the ratings for each domain as a method for determining an AoS's contribution to overall sustainability did not accurately represent the participant's view of that particular AoS's overall importance, which is reflected directly by $W_{2,S,N}$. Thus, it was decided that the second part of Survey A provided a more representative and direct reflection of the interviewees' views on determining the priority and relative weightings of each AoS. The final weightings assigned to each of the twelve AoS were thus based on $W_{2,S,N}$ and are the weights used in Table 7-7. Besides two outliers manually identified in Figure 7-9, we observe a general trend with some AoS being identified as more important and thus having higher weightings than others. Although we observe fluctuations among the weights as assigned by the different surveys, this would be expected since values are based on value-judgement ratings and not observable hard data.

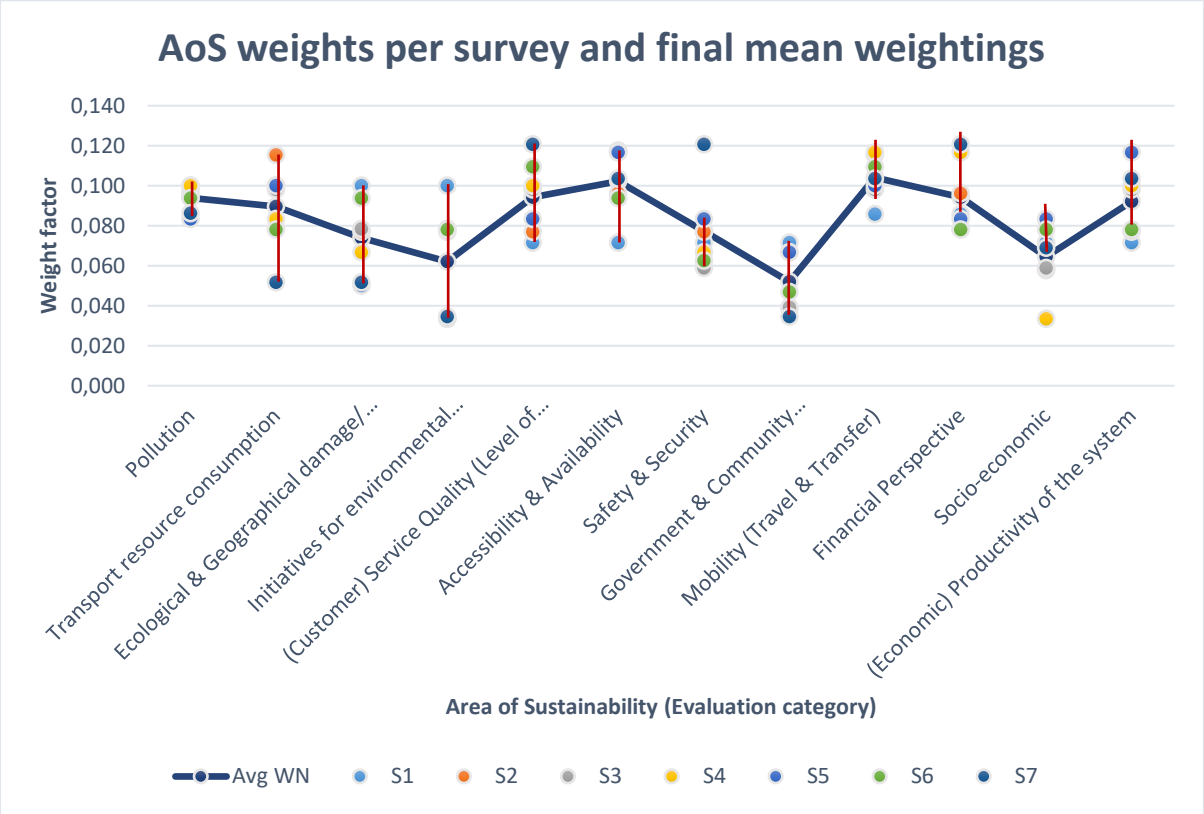


Figure 7-9 AoS weights per survey and final mean weightings

The results from the first part of Survey A pertaining to the three domains of sustainability and the AoS's contribution to each of these spheres are presented in Table 7-10.

Table 7-10 Expert survey results on AoS domains

		I. Environmental									
N	***Evaluation categories (AoS)***	S1	S2	S3	S4	S5	S6	S7	Avg	StDev	CV
1	**Pollution**	0.39	0.41	0.55	0.64	0.47	~~0.54~~	0.44	0.48	0.09	18%
2	**Transport resource consumption**	0.39	0.40	0.45	0.55	0.35	~~0.35~~	0.40	0.42	0.07	16%
3	**Ecological & Geographical damage/impacts**	0.41	0.47	0.44	0.46	0.58	~~0.44~~	0.41	0.46	0.06	13%
4	**Initiatives for environmental protection**	0.41	0.40	0.42	0.63	0.50	~~0.38~~	0.47	0.47	0.09	18%
5	**(Customer) Service Quality (Level of Service)**	0.21	0.00	0.00	0.00	0.08	~~0.13~~	0.15	0.07	0.09	117%
6	**Accessibility & Availability**	0.27	0.00	0.11	0.11	0.17	~~0.08~~	0.09	0.12	0.08	66%
7	**Safety & Security**	0.27	0.00	0.00	0.00	0.27	~~0.29~~	0.08	0.10	0.14	136%
8	**Government & Community Involvement**	0.23	0.00	0.17	0.00	0.17	~~0.09~~	0.28	0.14	0.11	77%
9	**Mobility (Travel & Transfer)**	0.31	0.29	0.18	0.09	0.15	~~0.00~~	0.21	0.21	0.11	53%
10	**Financial Perspective**	0.25	0.23	0.00	0.00	0.17	~~0.00~~	0.15	0.13	0.11	84%
11	**Socio-economic**	0.27	0.31	0.18	0.10	0.13	~~0.18~~	0.24	0.20	0.08	37%
12	**(Economic) Productivity of the system**	0.27	0.21	0.13	0.00	0.08	~~0.20~~	0.23	0.15	0.10	63%
								Avg:	**0.25**	0.09	58%

		II. Social									
N	***Evaluation categories (AoS)***	S1	S2	S3	S4	S5	S6	S7	Avg	StDev	CV
1	**Pollution**	0.33	0.29	0.36	0.27	0.33	~~0.31~~	0.31	0.32	0.03	9%
2	**Transport resource consumption**	0.28	0.27	0.27	0.09	0.29	~~0.29~~	0.27	0.24	0.07	29%
3	**Ecological & Geographical damage/impacts**	0.29	0.27	0.44	0.23	0.25	~~0.38~~	0.29	0.30	0.08	26%
4	**Initiatives for environmental protection**	0.29	0.33	0.33	0.38	0.29	~~0.44~~	0.20	0.30	0.07	25%

5	(Customer) Service Quality (Level of Service)	0.43	0.67	0.60	0.70	0.46	~~0.47~~	0.46	0.55	0.11	20%
6	Accessibility & Availability	0.40	0.60	0.56	0.78	0.42	~~0.50~~	0.55	0.55	0.13	23%
7	Safety & Security	0.40	0.55	0.67	0.86	0.55	~~0.50~~	0.54	0.59	0.15	25%
8	Government & Community Involvement	0.38	0.56	0.50	0.86	0.50	~~0.55~~	0.33	0.52	0.17	32%
9	Mobility (Travel & Transfer)	0.38	0.41	0.36	0.27	0.38	~~0.55~~	0.43	0.37	0.08	22%
10	Financial Perspective	0.31	0.38	0.25	0.22	0.25	~~0.30~~	0.38	0.30	0.07	22%
11	Socio-economic	0.40	0.31	0.36	0.30	0.44	~~0.41~~	0.41	0.37	0.05	15%
12	(Economic) Productivity of the system	0.33	0.43	0.25	0.30	0.38	~~0.33~~	0.38	0.35	0.06	17%
								Avg:	**0.40**	0.09	22%

		III. Economic									
N	***Evaluation categories (AoS)***	S1	S2	S3	S4	S5	S6	S7	Avg	StDev	CV
1	Pollution	0.28	0.29	0.09	0.09	0.20	~~0.15~~	0.25	0.20	0.08	42%
2	Transport resource consumption	0.33	0.33	0.27	0.36	0.35	~~0.35~~	0.33	0.33	0.03	9%
3	Ecological & Geographical damage/impacts	0.29	0.27	0.11	0.31	0.17	~~0.19~~	0.29	0.24	0.08	32%
4	Initiatives for environmental protection	0.29	0.27	0.25	0.00	0.21	~~0.19~~	0.33	0.23	0.11	48%
5	(Customer) Service Quality (Level of Service)	0.36	0.33	0.40	0.30	0.46	~~0.40~~	0.38	0.37	0.05	14%
6	Accessibility & Availability	0.33	0.40	0.33	0.11	0.42	~~0.42~~	0.36	0.33	0.11	33%
7	Safety & Security	0.33	0.45	0.33	0.14	0.18	~~0.21~~	0.38	0.31	0.11	38%
8	Government & Community Involvement	0.38	0.44	0.33	0.14	0.33	~~0.36~~	0.39	0.34	0.10	28%
9	Mobility (Travel & Transfer)	0.31	0.29	0.45	0.64	0.46	~~0.45~~	0.36	0.42	0.12	28%
10	Financial Perspective	0.44	0.38	0.75	0.78	0.58	~~0.70~~	0.46	0.57	0.16	28%
11	Socio-economic	0.33	0.38	0.45	0.60	0.44	~~0.41~~	0.35	0.43	0.09	21%
12	(Economic) Productivity of the system	0.40	0.36	0.63	0.70	0.54	~~0.47~~	0.38	0.50	0.13	26%
								Avg:	**0.35**	0.10	29%

In Table 7-10, while the average standard deviation values appear to be acceptable for each domain (9%, 9% and 10% respectively), the average CV value for the environmental sphere is particularly high. This indicates some disagreement among experts on the priority of certain AoS for environmental development. Areas of sustainability *(Customer) Service Quality (Level of Service),* and *Safety & Security* especially showed large CV values since about half of the participants indicated that these AoS are not applicable (0%) to environmental development, while others indicated that these AoS do to some extent contribute, although little.

A summary of the final average weights for each AoS to each domain is provided in Table 7-11. The domain weightings are multiplied with the AoS weights to determine the total priority of each domain towards overall sustainability. This table also illustrates how the first four AoS (1-4) are mainly focused on environmental development, the second four AoS (5-8) are mainly focused on social development, and the last four (AoS 9-12) are mainly focused on economic development to some degree.

Table 7-11 Summary of expert survey results on AoS domains

		$W_{N,dom}$			$W_{N,dom}$ (%)				W_N x $W_{N,dom}$ (%)		
N	***Evaluation categories (AoS)***	**I.**	**II.**	**III.**	**I.**	**II.**	**III.**	W_N	**I.**	**II.**	**III.**
1	Pollution	0.481	0.318	0.201	48%	32%	20%	0.094	5%	3%	2%
2	Transport resource consumption	0.424	0.245	0.332	42%	24%	33%	0.091	4%	2%	3%
3	Ecological & Geographical damage/impacts	0.463	0.297	0.240	46%	30%	24%	0.071	3%	2%	2%
4	Initiatives for environmental protection	0.470	0.304	0.226	47%	30%	23%	0.059	3%	2%	1%
5	(Customer) Service Quality (Level of Service)	0.074	0.553	0.373	7%	55%	37%	0.092	1%	5%	3%
6	Accessibility & Availability	0.124	0.549	0.326	12%	55%	33%	0.104	1%	6%	3%
7	Safety & Security	0.103	0.592	0.305	10%	59%	31%	0.080	1%	5%	2%
8	Government & Community Involvement	0.140	0.522	0.338	14%	52%	34%	0.053	1%	3%	2%

9	**Mobility (Travel & Transfer)**	0.208	0.373	0.419	21%	37%	42%	0.103	2%	4%	4%
10	**Financial Perspective**	0.134	0.301	0.566	13%	30%	57%	0.097	1%	3%	5%
11	**Socio-economic**	0.203	0.370	0.427	20%	37%	43%	0.062	1%	2%	3%
12	**(Economic) Productivity of the system**	0.152	0.347	0.501	15%	35%	50%	0.094	1%	3%	5%
	Total average	0.25	0.40	0.35	25%	40%	35%	**Σ**	**24%**	**40%**	**36%**
					These total weights are for when each AoS weights equally (1/12 = 8.33%)				These total weights take into account the relative weights (W_N)of each AoS		

Using Table 7-11, we can rank the importance of the 12 AoS based on their relative priority weights. This is illustrated in Figure 7-10 along with the proportion that each of these weights contributes towards each of the three sustainability domains.

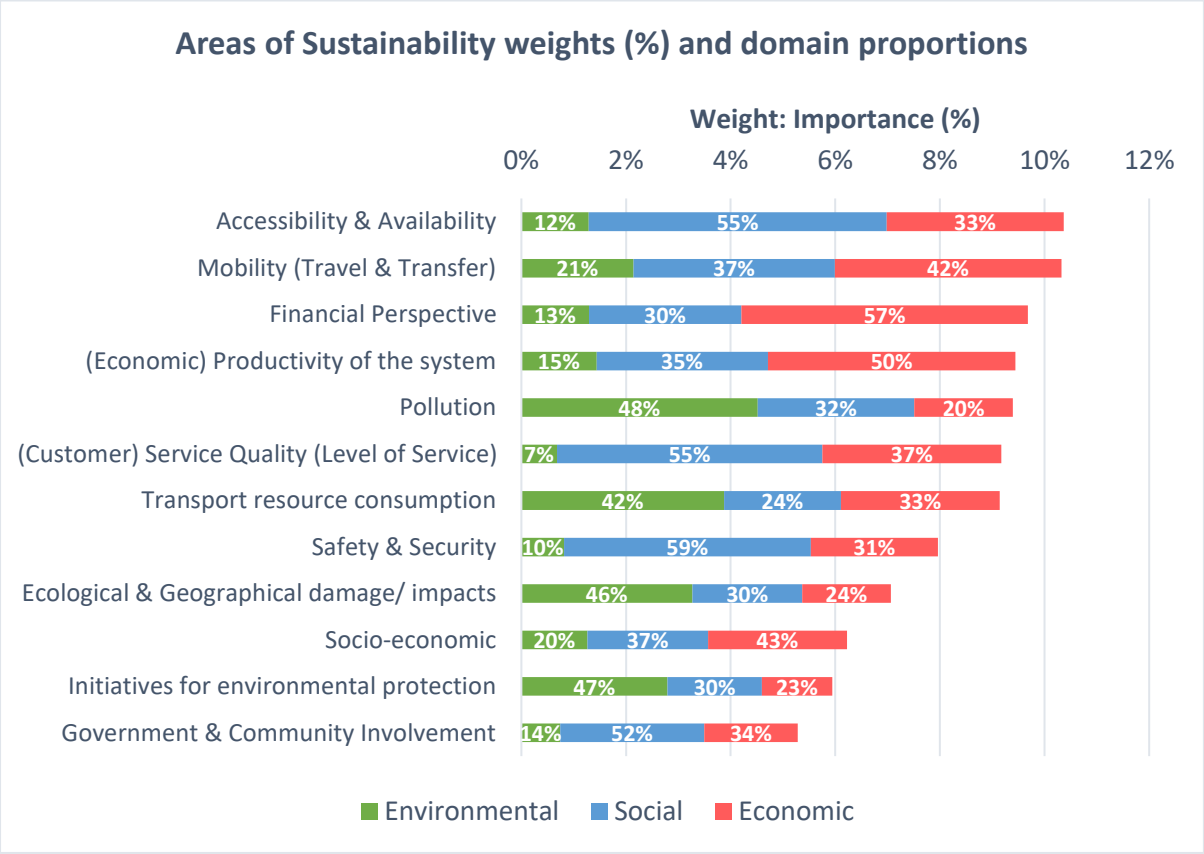


Figure 7-10 Areas of Sustainability weights (%) and domain proportions

From a domain perspective, Figure 7-11 illustrates the priority of each of the three sustainability domains as well as the AoS proportions comprising each domain.

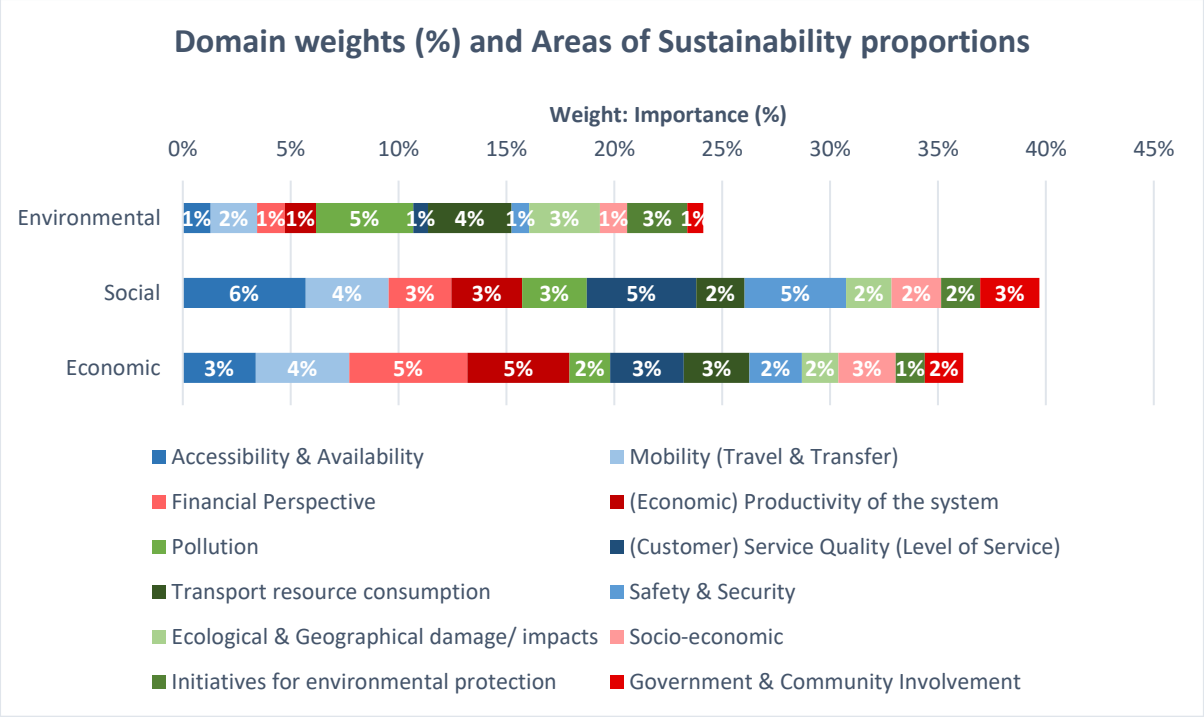


Figure 7-11 Domain weights (%) and Areas of Sustainability proportions

7.4 Enhanced and weighted conceptual framework

The SLR method developed for this research study (incorporating the CFA) enabled a comprehensive approach in working from data towards concepts, categories, and ultimately the development of a new theory (as illustrated in Figure 7-12) for a novel transport system that to date has not been fully deployed. No framework of its kind to date existed prior to the one developed in this research. Although similar transport evaluation frameworks exist for other transport modes, none had a focus on the novel concept of microtransit systems which focuses on 'first-and-last-mile' technology-enabled transport in an era of shared mobility, IoT, and a focus on ICT.

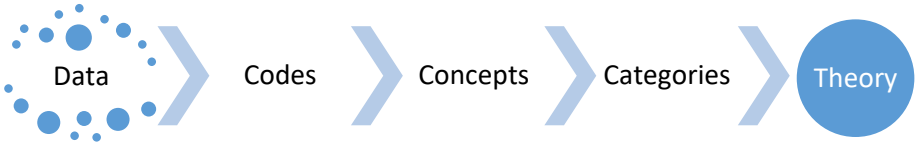


Figure 7-12 Overview of GTM process

Although the framework was developed for monitoring and evaluating the sustainability of microtransit systems specifically, following completion thereof it is suggested that due to the comprehensiveness of the framework and its modern stance, it could be considered generic to similar transport modes to microtransit and also be applied to these modes to determine how their sustainability performance would compare e.g. smart mobility services (ITS), shuttle services, bike transport, minibus taxis etc. The finalised weighted M&E framework for microtransit systems, enhanced and validated through expert interviews, is illustrated in Table 7-12. Possible units for measurement were also included for each variable.

Table 7-12 Enhanced and weighted conceptual framework

N	Evaluation categories	W_N	C_N	$W_{N,env}$	$W_{N,soc}$	$W_{N,eco}$	i	Indicators	$W_{N,i}$	$I_{N,i}$	n	Variables	Unit	$w_{N,i,n}$	$x_{N,i,n}$	D
1	**Pollution**	**0.094**	C_1	**0.48**	**0.32**	**0.20**	1	Air Pollution	0.31	$I_{1,1}$	1	*Particle pollution (particulate matter – PM_{10}, $PM_{2.5}$)*	*µg/m³*	*0.14*	$x_{1,1,1}$	<
											2	*Ground-level ozone (O_3)*	*ppm*	*0.14*	$x_{1,1,2}$	<
											3	*Carbon monoxide (CO)*	*ppm*	*0.14*	$x_{1,1,3}$	<
											4	*Sulphur oxides (SO_x – use SO_2 as main indicator for SO_x family)*	*ppm/ppb*	*0.14*	$x_{1,1,4}$	<
											5	*Nitrogen oxides (NO_x– use NO_2 as main indicator for NO_x family)*	*ppb*	*0.14*	$x_{1,1,5}$	<
											6	*Lead emissions (Pb)*	*µg/m³*	*0.14*	$x_{1,1,6}$	<
											7	*Volatile organic compounds (VOCs)*	*mg/m³*	*0.14*	$x_{1,1,7}$	<
							2	Waste Pollution/ Production	0.21	$I_{1,2}$	8	*Number of vehicles scrapped annually*	*Vehicles (#)*	*0.25*	$x_{1,2,8}$	<
											9	*Batteries in municipal solid waste streams*	*Batteries (#)*	*0.25*	$x_{1,2,9}$	<
											10	*Hazardous materials incidents*	*Incidents (#)*	*0.25*	$x_{1,2,10}$	<
											11	*Percentage (%) recyclable/re-useable materials of vehicle*	*%*	*0.25*	$x_{1,2,11}$	<
							3	Water Pollution	0.26	$I_{1,3}$	12	*Vehicle pollutants (exhaust, dirt, oil, deicing chemicals) deposited on surface areas*	*n/a*	*0.2*	$x_{1,3,12}$	<
											13	*Hardened "impervious" surface area (e.g. highways & parking lots): increases storm water runoff & lower groundwater recharge rates*	*Area (km²)*	*0.2*	$x_{1,3,13}$	<
											14	*Oil spills and fluid loss incidents*	*Incidents (#)*	*0.2*	$x_{1,3,14}$	<
											15	*Underground storage tank (petroleum) leaks*	*Incidents (#)*	*0.2*	$x_{1,3,15}$	<
											16	*Management of used oil, leaks and storm water*	*yes/no*	*0.2*	$x_{1,3,16}$	>
							4	Noise Pollution	0.15	$I_{1,4}$	17	*Level of noise from urban transport (Decibels)*	*Db*	*0.5*	$x_{1,4,17}$	<
											18	*% Population exposed to transport related noise > 55 dB*	*%*	*0.5*	$x_{1,4,18}$	<
							5	Light Pollution	0.07	$I_{1,5}$	19	*Lumen (lm)*	*lm*	*1*	$x_{1,5,19}$	<
2	**Transport resource consumption (renewable & non-renewable)**	**0.091**	C_2	**0.42**	**0.25**	**0.33**	6	Energy Consumption	0.41	$I_{2,6}$	20	*Transport system energy use per capita*	*kWh/a*	*0.33*	$x_{2,6,20}$	<
											21	*Overall energy efficiency (Well-to-wheel for EVs)*	*%*	*0.33*	$x_{2,6,21}$	>
											22	*How clean/green is the energy/fuels used?*	*Company survey (likert scale)*	*0.33*	$x_{2,6,22}$	>
							7	Infrastructure & Vehicle Materials Consumption	0.16	$I_{2,7}$	23	*Tonnes of materials used for vehicles & infrastructure*	*kg/tonnes*	*1*	$x_{2,7,23}$	<
							8	Vehicle fuel consumption	0.43	$I_{2,8}$	24	*Litres fossil fuel consumed per km ($x_{2,8,24}$ = 1 if no fossil fuel is consumed)*	*litre/km*	*0.33*	$x_{2,8,24}$	<
											25	*Litres non-fossil fuel consumed per km ($x_{2,8,25}$ = 1 if no non-fossil fuel is consumed)*	*litre/km*	*0.33*	$x_{2,8,25}$	<
											26	*Fuel efficiency ($x_{2,8,26}$ = 1 if no fuel is consumed)*	*%*	*0.33*	$x_{2,8,26}$	>
3	**Ecological & Geographical damage/impacts**	**0.071**	C_3	**0.46**	**0.30**	**0.24**	9	Ecological system	0.34	$I_{3,9}$	27	*Loss of wetlands/agricultural lands/deforestation*	*Area (km²)*	*0.25*	$x_{3,9,27}$	<
											28	*Number of wild life/animal collisions*	*Incidents (#)*	*0.25*	$x_{3,9,28}$	<
											29	*Fragmentation of ecosystems and habitats*	*opinion (rating)*	*0.25*	$x_{3,9,29}$	<
											30	*Vibration caused by transport system*	*hertz*	*0.25*	$x_{3,9,30}$	<
							10		0.46	$I_{3,10}$	31	*Carbon dioxide (CO_2) emissions*	*ppm*	*0.25*	$x_{3,10,31}$	<

N	Evaluation categories	W_N	C_N	$W_{N,env}$	$W_{N,soc}$	$W_{N,eco}$	i	Indicators	$W_{N,i}$	$I_{N,i}$	n	Variables	Unit	$w_{N,i,n}$	$x_{N,i,n}$	D
								Climate change/GHG emissions			32	*Methane (CH_4) emissions*	*ppm*	*0.25*	$x_{3,10,32}$	<
											33	*Nitrous oxide (N_2O) emissions*	*ppm*	*0.25*	$x_{3,10,33}$	<
											34	*Hydrofluorocarbon (HFC) emissions*	*µg/m³*	*0.25*	$x_{3,10,34}$	<
							11	Land-use	0.20	$I_{3,11}$	35	*Land consumption (km²) for transport infrastructure (roads, parking)*	*Area (km²)*	*0.5*	$x_{3,11,35}$	<
											36	*Land area lost due to erosion caused (km²)*	*Area (km²)*	*0.5*	$x_{3,11,36}$	<
4	**Initiatives for environmental protection**	**0.059**	C_4	**0.47**	**0.30**	**0.23**	12	Studies of environmental impacts	0.26	$I_{4,12}$	37	*Number of studies on environmental impacts*	*Studies (#)*	*1*	$x_{4,12,37}$	>
							13	Investments dedicated to environmental protection	0.40	$I_{4,13}$	38	*Total sum of investments*	*currency (Rand)*	*1*	$x_{4,13,38}$	>
							14	Technological maturity of transport system	0.34	$I_{4,14}$	39	*How technologically advanced & mature is the system?*	*Technological readiness level (TRL) rating*	*1*	$x_{4,14,39}$	>
5	**(Customer) Service Quality (Level of Service)**	**0.092**	C_5	**0.08**	**0.55**	**0.37**	15	Comfort	0.15	$I_{5,15}$	40	*Occupancy rate/availability of seating (Crowding)*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,40}$	>
											41	*Space in vehicle (per individual)*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,41}$	>
											42	*Cleanliness of vehicle*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,42}$	>
											43	*Temperature inside vehicle (shelter, ventilation, aircon)*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,43}$	>
											44	*Quaking level*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,44}$	<
											45	*Noise level*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,45}$	<
											46	*Overall riding comfort*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,46}$	>
											47	*Comfort due to presence of information screens*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,47}$	>
											48	*Comfort while waiting at bus/vehicle stops (including cleanliness)*	*Customer survey (likert scale)*	*0.11*	$x_{5,15,48}$	>
							16	Convenience	0.20	$I_{5,16}$	49	*Electronic fare payment option*	*Customer survey (likert scale)*	*0.17*	$x_{5,16,49}$	>
											50	*Number & variety of shops, cafés and restaurants near stops*	*Customer survey (likert scale)*	*0.17*	$x_{5,16,50}$	>
											51	*Availability of Wi-Fi & cellphone signals*	*Customer survey (likert scale)*	*0.17*	$x_{5,16,51}$	>
											52	*Availability of cellphone charging facilities*	*Customer survey (likert scale)*	*0.17*	$x_{5,16,52}$	>
											53	*Existence of differential services such as water, newspaper, blanket etc.*	*Customer survey (likert scale)*	*0.17*	$x_{5,16,53}$	>
											54	*Convenience of the vehicle schedules*	*Customer survey (likert scale)*	*0.17*	$x_{5,16,54}$	>
							17	Reliability	0.27	$I_{5,17}$	55	*Punctuality (measured with average of delay times)*	*minutes*	*0.25*	$x_{5,17,55}$	<
											56	*Uncertainty*	*Customer survey (likert scale)*	*0.25*	$x_{5,17,56}$	<
											57	*Variability in travel time*	*minutes*	*0.25*	$x_{5,17,57}$	<
											58	*Cancellations*	*Incidents (#)*	*0.25*	$x_{5,17,58}$	<
							18	Driver attitude & appearance	0.11	$I_{5,18}$	59	*Awareness*	*Customer survey (likert scale)*	*0.2*	$x_{5,18,59}$	>
											60	*Courtesy and helpfulness of staff/driver*	*Customer survey (likert scale)*	*0.2*	$x_{5,18,60}$	>
											61	*Law-abidingness*	*Customer survey (likert scale)*	*0.2*	$x_{5,18,61}$	>

N	Evaluation categories	W_N	C_N	$W_{N,env}$	$W_{N,soc}$	$W_{N,eco}$	i	Indicators	$W_{N,i}$	$I_{N,i}$	n	Variables	Unit	$w_{N,i,n}$	$x_{N,i,n}$	D
											62	*Complaint handling and effective complaint resolution*	*Customer survey (likert scale)*	*0.2*	$x_{5,18,62}$	>
											63	*Driver appearance*	*Customer survey (likert scale)*	*0.2*	$x_{5,18,63}$	>
							19	Image/ Attractiveness/ Aesthetics	0.10	$I_{5,19}$	64	*Customer perception of vehicle appearance/aesthetics*	*Customer survey (likert scale)*	*0.33*	$x_{5,19,64}$	>
											65	*Customer perception of waiting areas/vehicle stops aesthetics*	*Customer survey (likert scale)*	*0.33*	$x_{5,19,65}$	>
											66	*Preservation of heritage rating*	*Customer survey (likert scale)*	*0.33*	$x_{5,19,66}$	>
							20	General Customer Satisfaction	0.17	$I_{5,20}$	67	*Overall Satisfaction with the service*	*Customer survey (likert scale)*	*0.2*	$x_{5,20,67}$	>
											68	*I feel that taking public transit is consistent with my lifestyle*	*Customer survey (likert scale)*	*0.2*	$x_{5,20,68}$	>
											69	*How likely are you to recommend this service to others?*	*Customer survey (likert scale)*	*0.2*	$x_{5,20,69}$	>
											70	*How likely are you to use this service again?*	*Customer survey (likert scale)*	*0.2*	$x_{5,20,70}$	>
											71	*Percentage of complaints from all passengers*	*%*	*0.2*	$x_{5,20,71}$	>
6	**Accessibility & Availability**	**0.104**	C_6	**0.12**	**0.55**	**0.33**	21	Customer accessibility to transport system	0.31	$I_{6,21}$	72	*NMT facilities to transport system (Quality of surrounding walking and cycling conditions)*	*Customer survey (likert scale)*	*0.25*	$x_{6,21,72}$	>
											73	*Accessibility to terminals/vehicle stops from work/home*	*Customer survey (likert scale)*	*0.25*	$x_{6,21,73}$	>
											74	*Easiness to get on/off the vehicle*	*Customer survey (likert scale)*	*0.25*	$x_{6,21,74}$	>
											75	*Numbers of stations/stops*	*Customer survey (likert scale)*	*0.25*	$x_{6,21,75}$	>
							22	Transport system accessibility to other locations	0.22	$I_{6,22}$	76	*Accessibility to public buildings*	*Customer survey (likert scale)*	*0.33*	$x_{6,22,76}$	>
											77	*Accessibility to essential services*	*Customer survey (likert scale)*	*0.33*	$x_{6,22,77}$	>
											78	*Accessibility to open spaces*	*Customer survey (likert scale)*	*0.33*	$x_{6,22,78}$	>
							23	Social Equity & Inclusion	0.12	$I_{6,23}$	79	*Accessibility to women*	*Customer survey (likert scale)*	*0.2*	$x_{6,23,79}$	>
											80	*Accessibility to users with special needs (disabilities)*	*Customer survey (likert scale)*	*0.2*	$x_{6,23,80}$	>
											81	*Accessibility to those with low income*	*Customer survey (likert scale)*	*0.2*	$x_{6,23,81}$	>
											82	*Accessibility to children*	*Customer survey (likert scale)*	*0.2*	$x_{6,23,82}$	
											83	*Accessibility to senior citizens*	*Customer survey (likert scale)*	*0.2*	$x_{6,23,83}$	>
							24	Availability	0.35	$I_{6,24}$	84	*Availability during peak hours*	*Customer survey (likert scale)*	*0.2*	$x_{6,24,84}$	>
											85	*Number of vehicles in operation at any given time*	*Vehicles (#)*	*0.2*	$x_{6,24,85}$	>
											86	*Frequency of vehicles (service)*	*Customer survey (likert scale)*	*0.2*	$x_{6,24,86}$	>
											87	*Operating hours*	*Customer survey (likert scale)*	*0.2*	$x_{6,24,87}$	>
											88	*Network coverage (km of network related to population)*	*km per capita*	*0.2*	$x_{6,24,88}$	>
7	**Safety & Security**	**0.080**	C_7	**0.10**	**0.59**	**0.31**	25	Accidents & Prevention	0.24	$I_{7,25}$	89	*Number of (traffic & pedestrians) accidents (per km)*	*Incidents (#)/km*	*0.17*	$x_{7,25,89}$	<
											90	*Number of fatalities and injuries (per km)*	*Incidents (#)/km*	*0.17*	$x_{7,25,90}$	<
											91	*Passengers' use of seatbelts (%)*	*%*	*0.17*	$x_{7,25,91}$	>
											92	*Passengers' use of crash helmets (%)*	*%*	*0.17*	$x_{7,25,92}$	>
											93	*Testing the crashworthiness of vehicles and rating*	*rating*	*0.17*	$x_{7,25,93}$	>
											94	*Sufficient vehicle lighting & use of reflective devices*	*rating*	*0.17*	$x_{7,25,94}$	>
							26	Crime	0.13	$I_{7,26}$	95	*Incidences of stolen items reported by commuters*	*Incidents (#)*	*0.25*	$x_{7,26,95}$	<
											96	*Incidences of commuters being attacked by armed robbers*	*Incidents (#)*	*0.25*	$x_{7,26,96}$	<
											97	*Number of stolen vehicles*	*Vehicles (#)*	*0.25*	$x_{7,26,97}$	<
											98	*Effective Police/Security patrol teams near service*	*Customer survey (likert scale)*	*0.25*	$x_{7,26,98}$	>
							27		0.15	$I_{7,27}$	99	*Response time to emergency*	*minutes*	*0.33*	$x_{7,27,99}$	<

N	Evaluation categories	W_N	C_N	$W_{N,env}$	$W_{N,soc}$	$W_{N,eco}$	i	Indicators	$W_{N,i}$	$I_{N,i}$	n	Variables	Unit	$w_{N,i,n}$	$x_{N,i,n}$	D
								Emergency situation control			100	*Availability of & accessibility to firefighting appliances*	*Customer survey (likert scale)*	*0.33*	$x_{7,27,100}$	>
											101	*Information to improve your sense of security during emergency situations*	*Customer survey (likert scale)*	*0.33*	$x_{7,27,101}$	>
							28	Passenger's perception of & satisfaction with safety level	0.16	$I_{7,28}$	102	*Safety getting on and off transport*	*Customer survey (likert scale)*	*0.2*	$x_{7,28,102}$	>
											103	*Safety on board*	*Customer survey (likert scale)*	*0.2*	$x_{7,28,103}$	>
											104	*Number of incidents of property damage and lost property (per total number of passengers)*	*Incidents (#)/Σ(passengers)*	*0.2*	$x_{7,28,104}$	<
											105	*Incidence of overloading*	*Incidents (#)/Σ(trips)*	*0.2*	$x_{7,28,105}$	<
											106	*Customer's perception of overall safety*	*Customer survey (likert scale)*	*0.2*	$x_{7,28,106}$	>
							29	Driver's level of capability	0.18	$I_{7,29}$	107	*Frequency of driver assessment*	*assessments (#)/year*	*0.17*	$x_{7,29,107}$	>
											108	*Drivers level of training: Percentage (%) of trained/certified/ experienced drivers*	*%*	*0.17*	$x_{7,29,108}$	>
											109	*Incidence of exceeding speed limit*	*Incidents (#)*	*0.17*	$x_{7,29,109}$	<
											110	*Incidence of driving under the influence of alcohol/drugs*	*Incidents (#)*	*0.17*	$x_{7,29,110}$	<
											111	*Incidence of red light running (traffic lights)*	*Incidents (#)*	*0.17*	$x_{7,29,111}$	<
											112	*Incidence of not stopping or yielding in junctions/pedestrian crossings/red lights*	*Incidents (#)*	*0.17*	$x_{7,29,112}$	<
							30	Vehicle & Road condition	0.14	$I_{7,30}$	113	*Frequency of potholes (%)*	*Incidents (#)/km*	*0.25*	$x_{7,30,113}$	<
											114	*Overall road quality (Satisfaction with road system condition)*	*Driver survey (likert scale)*	*0.25*	$x_{7,30,114}$	>
											115	*Mechanically deficient vehicles still in use (%)*	*%*	*0.25*	$x_{7,30,115}$	<
											116	*Old vehicles still in use (average age of vehicles)*	*years*	*0.25*	$x_{7,30,116}$	<
8	**Government & Community Involvement**	**0.053**	C_8	**0.14**	**0.52**	**0.34**	31	Government Interoperability	0.67	$I_{8,31}$	117	*Government co-operation*	*Company survey (likert scale)*	*0.5*	$x_{8,31,117}$	>
											118	*Degree to which system comply with legislation (Contracts and limitations)*	*Company survey (likert scale)*	*0.5*	$x_{8,31,118}$	>
							32	Community Involvement	0.33	$I_{8,32}$	119	*Public participation in decision-taking (degree to which public influence decisions)*	*PP survey (likert scale)*	*0.5*	$x_{8,32,119}$	>
											120	*Public response to transit system*	*PP survey (likert scale)*	*0.5*	$x_{8,32,120}$	>
9	**Mobility (Travel & Transfer)**	**0.103**	C_9	**0.21**	**0.37**	**0.42**	33	Time	0.30	$I_{9,33}$	121	*Average time making use of NMT before using the transport service*	*minutes*	*0.14*	$x_{9,33,121}$	<
											122	*Average waiting time at stop/pick-up/drop-off point*	*minutes*	*0.14*	$x_{9,33,122}$	<
											123	*Average time taken to board vehicle*	*minutes*	*0.14*	$x_{9,33,123}$	<
											124	*Average commuting/In-vehicle travel time*	*minutes*	*0.14*	$x_{9,33,124}$	<
											125	*Average parking search time*	*minutes*	*0.14*	$x_{9,33,125}$	<
											126	*Delays due to congestion/Dwell time*	*minutes*	*0.14*	$x_{9,33,126}$	<
											127	*Total average travel time to points of interest (per day)*	*minutes*	*0.14*	$x_{9,33,127}$	<
							34	Speed	0.13	$I_{9,34}$	128	*Average speed of using NMT service before getting to stop/pick-up/drop-off point*	*km/h*	*0.33*	$x_{9,34,128}$	>
											129	*Average commuting/In-vehicle speed*	*km/h*	*0.33*	$x_{9,34,129}$	>
											130	*Total average transfer speed to points of interest*	*km/h*	*0.33*	$x_{9,34,130}$	>
							35	Distance	0.17	$I_{9,35}$	131	*Average commuting distance*	*km*	*0.33*	$x_{9,35,131}$	<

N	Evaluation categories	W_N	C_N	$W_{N,env}$	$W_{N,soc}$	$W_{N,eco}$	i	Indicators	$W_{N,i}$	$I_{N,i}$	n	Variables	Unit	$w_{N,i,n}$	$x_{N,i,n}$	D
											132	*Total average transfer distance*	*km*	*0.33*	$x_{9,35,132}$	<
											133	*Proximity of the stops in km*	*km*	*0.33*	$x_{9,35,133}$	<
							36	Modal split/ Transit integration	0.21	$I_{9,36}$	134	*Level of contributing to modal split & transit integration via "First & Last mile" transport*	*PP survey (likert scale)*	*0.5*	$x_{9,36,134}$	>
											135	*Adequate intermodal terminals*	*PP survey (likert scale)*	*0.5*	$x_{9,36,135}$	>
							37	General mobility	0.19	$I_{9,37}$	136	*Number of trips per vehicle per day*	*trips/vehicle (per day)*	*0.33*	$x_{9,37,136}$	>
											137	*Mobility of inhabitants*	*trips/inhabitant (per day)*	*0.33*	$x_{9,37,137}$	>
											138	*Contribution to a reduction in congestion (motorised traffic)*	*PP survey (likert scale)*	*0.33*	$x_{9,37,138}$	>
10	**Financial Perspective (Costs)**	**0.097**	C_{10}	**0.13**	**0.30**	**0.57**	38	Affordability to customer	0.41	$I_{10,38}$	139	*Commute cost/Fare of a ticket*	*currency (Rand)*	*0.25*	$x_{10,38,139}$	<
											140	*Total travel cost (affordability of monthly travel expense)*	*currency (Rand)*	*0.25*	$x_{10,38,140}$	<
											141	*The amount paid in relation to the service offered*	*PP survey (likert scale)*	*0.25*	$x_{10,38,141}$	<
											142	*Discounts and free rides*	*PP survey (likert scale)*	*0.25*	$x_{10,38,142}$	>
							39	Costs to (private) company (Financial feasibility)	0.22	$I_{10,39}$	143	*Total operating & maintenance costs*	*currency (Rand)*	*0.33*	$x_{10,39,143}$	<
											144	*Total environmental costs*	*currency (Rand)*	*0.33*	$x_{10,39,144}$	<
											145	*Total public service costs*	*currency (Rand)*	*0.33*	$x_{10,39,145}$	<
							40	Governmental costs (Financial feasibility)	0.14	$I_{10,40}$	146	*Public cost for transport service*	*currency (Rand)*	*0.25*	$x_{10,40,146}$	<
											147	*Public transport investment expenditure in % of GDP*	*%*	*0.25*	$x_{10,40,147}$	<
											148	*Road network expenditure in % of GDP*	*%*	*0.25*	$x_{10,40,148}$	<
											149	*Resources efficiency (efficient use of government resource in city transport planning)*	*PP survey (likert scale)*	*0.25*	$x_{10,40,149}$	>
							41	Financial security	0.23	$I_{10,41}$	150	*Fare revenue*	*currency (Rand)*	*0.33*	$x_{10,41,150}$	>
											151	*Degree to which the transport system is economically self-sufficient*	*Company survey (likert scale)*	*0.33*	$x_{10,41,151}$	>
											152	*Overall profitability*	*Company survey (likert scale)*	*0.33*	$x_{10,41,152}$	>
11	**Socio-economic**	**0.062**	C_{11}	**0.20**	**0.37**	**0.43**	42	Socio-economic development	0.51	$I_{11,42}$	153	*Socio-economic growth*	*PP survey (likert scale)*	*0.17*	$x_{11,42,153}$	>
											154	*Wider economic impacts (positive)*	*PP survey (likert scale)*	*0.17*	$x_{11,42,154}$	>
											155	*Area property values*	*PP survey (likert scale)*	*0.17*	$x_{11,42,155}$	>
											156	*Regional access to markets*	*PP survey (likert scale)*	*0.17*	$x_{11,42,156}$	>
											157	*Ease of reaching economically important assets*	*PP survey (likert scale)*	*0.17*	$x_{11,42,157}$	>
											158	*Support for local industries*	*PP survey (likert scale)*	*0.17*	$x_{11,42,158}$	>
							43	Social development	0.31	$I_{11,43}$	159	*Promotion of career opportunities/creation of jobs*	*PP survey (likert scale)*	*0.33*	$x_{11,43,159}$	>
											160	*Promotion of local tourism*	*PP survey (likert scale)*	*0.33*	$x_{11,43,160}$	>
											161	*Promotion of land-use*	*PP survey (likert scale)*	*0.33*	$x_{11,43,161}$	>
							44	Land development	0.18	$I_{11,44}$	162	*Green space preservation*	*PP survey (likert scale)*	*0.33*	$x_{11,44,162}$	>
											163	*Land development patterns (Sprawled vs. compact development)*	*PP survey (likert scale)*	*0.33*	$x_{11,44,163}$	>
											164	*Regeneration*	*PP survey (likert scale)*	*0.33*	$x_{11,44,164}$	>
12		**0.094**	C_{12}	**0.15**	**0.35**	**0.50**	45	Demand	0.29	$I_{12,45}$	165	*Passengers demand*	*PP survey (likert scale)*	*0.5*	$x_{12,45,165}$	>
											166	*Demand for freight transport*	*PP survey (likert scale)*	*0.5*	$x_{12,45,166}$	>

N	Evaluation categories	W_N	C_N	$W_{N,env}$	$W_{N,soc}$	$W_{N,eco}$	i	Indicators	$W_{N,i}$	$I_{N,i}$	n	Variables	Unit	$w_{N,i,n}$	$x_{N,i,n}$	D
	(Economic) Productivity of the system						46	Capacity	0.19	$I_{12,46}$	167	*Seat capacity (space per person)*	*Customer survey (likert scale)*	*0.25*	$x_{12,46,167}$	>
											168	*Seating/Passenger capacity per vehicle*	*passenger seats (#)*	*0.25*	$x_{12,46,168}$	>
											169	*Network capacity of vehicles, terminals & stops*	*Company survey (likert scale)*	*0.25*	$x_{12,46,169}$	>
											170	*Storage area in vehicle capacity*	*Customer survey (likert scale)*	*0.25*	$x_{12,46,170}$	>
							47	Maintenance	0.11	$I_{12,47}$	171	*Maintenance of vehicles*	*Company survey (likert scale)*	*0.33*	$x_{12,47,171}$	>
											172	*Vehicle failure*	*Company survey (likert scale)*	*0.33*	$x_{12,47,172}$	<
											173	*Ratio of non-working vehicles at any given time*	*Company survey (likert scale)*	*0.33*	$x_{12,47,173}$	<
							48	Information systems (ICT)/ Travel information	0.14	$I_{12,48}$	174	*Availability & Accessibility of real time travel information*	*Customer survey (likert scale)*	*0.17*	$x_{12,48,174}$	>
											175	*Availability & Accessibility of travel information before your trip (e.g. timetable of service)*	*Customer survey (likert scale)*	*0.17*	$x_{12,48,175}$	>
											176	*Accuracy and reliability of travel information displays*	*Customer survey (likert scale)*	*0.17*	$x_{12,48,176}$	>
											177	*Ease of ticket purchasing*	*Customer survey (likert scale)*	*0.17*	$x_{12,48,177}$	>
											178	*Quality of information systems*	*Customer survey (likert scale)*	*0.17*	$x_{12,48,178}$	>
											179	*Information announcements on board*	*Customer survey (likert scale)*	*0.17*	$x_{12,48,179}$	>
							49	Way-finding information	0.09	$I_{12,49}$	180	*Information about vehicle routes clearly indicated (Digitally or signboards & instructions)*	*Customer survey (likert scale)*	*0.25*	$x_{12,49,180}$	>
											181	*Signposting of different facilities and services*	*Customer survey (likert scale)*	*0.25*	$x_{12,49,181}$	>
											182	*Signposting for transfers between transport modes*	*Customer survey (likert scale)*	*0.25*	$x_{12,49,182}$	>
											183	*Information and assistance provided by staff*	*Customer survey (likert scale)*	*0.25*	$x_{12,49,183}$	>
							50	Overall efficiency (impressions)	0.18	$I_{12,50}$	184	*Service efficiency*	*Customer survey (likert scale)*	*0.2*	$x_{12,50,184}$	>
											185	*Passengers/km*	*Company survey (likert scale)*	*0.2*	$x_{12,50,185}$	>
											186	*Annual number of passengers*	*Company survey (likert scale)*	*0.2*	$x_{12,50,186}$	>
											187	*Annual number of trips*	*Company survey (likert scale)*	*0.2*	$x_{12,50,187}$	>
											188	*Occupancy rate*	*Company survey (likert scale)*	*0.2*	$x_{12,50,188}$	>

It should be noted that although the enhanced weighted framework includes suggested variables for determining the respective indicators, the focus of this research was to develop a conceptual framework where the main concepts were identified for microtransit systems' sustainability. The variables are an extensive list that is not set in stone. These variables have various units of measurement, making it difficult to normalise and determine a sustainability index at this stage.

For each of the 50 indicators, several ways in which their performance can be measured, and much disagreement on what variables to use towards this purpose (explained with example below) exist. Several variables that are considered important for evaluating the microtransit system's sustainability are often difficult or nearly impossible to measure. Although a comprehensive approach towards indicator identification was followed in this research study based on guidelines as stipulated earlier in Table 3-1, it is argued that additional extensive research is necessary on each of the 50 indicators to develop adequate ways of determining their performance index-values with appropriate variables that are easily obtainable with little effort and cost-effectively.

This is a process that requires a vast amount of research from multiple disciplinarians that could result in even more variables than the 188 (reduced from 198 from the initial framework) identified in this research, already considered a too large number for simple and efficient M&E of the system. What makes it even more complicated is that while every AoS has been weighted according to its importance to sustainable development, and every indicator has been weighted according to their respective contributions to each of the AoS, every variable would also have to be weighted according to its contributions to every indicator. Although EWA is used in numerous composite indices (40% of indices according to a study by Singh et al. (2009)), it is argued that even though the twelve AoS and the indicators have been weighted, this does not mean that variables can simply be weighted equally. Although the process might be simplified, accuracy would be sacrificed.

Consider the following example: The relative contribution of *Pollution* as an AoS has been identified through Likert scale weightings, and the relative contribution of the indicator *Air pollution* through AHP weightings. The variables (criteria) making up *Air pollution* as identified in this study are:

- *Particle pollution (particulate matter – PM_{10}, $PM_{2.5}$)*
- *Ground-level ozone (O_3)*
- *Carbon monoxide (CO)*
- *Sulphur oxides (SO_x – use SO_2 as main indicator for SO_x family)*
- *Nitrogen oxides (NO_x– use NO_2 as main indicator for NO_x family)*
- *Lead emissions (Pb)*
- *Volatile organic compounds (VOCs)*

It is highly probable that each of the above-mentioned variables does not have an equal effect on air quality, and should thus not be weighted as such. In addition to the fact that variables should also be weighted (which would make the framework significantly more complex), we observe that several agencies and researchers also disagree on the variables that should be considered. Referring to Table 7-13, it is clear how determining an air quality index (AQI) differs for different locations and according to different institutions based on the variables they consider (CDMX, no date; Government of Canada, 2008; COMEAP, 2011; US EPA, 2011; Hsu, 2012; van den Elshout, 2012; Lakshmi, 2014). Researchers from some of the relevant articles also suggest various combinations of variables to use.

Table 7-13 Pollutants considered by different locations for air quality index determination

Location	*SO_2*	*NO_2*	*CO*	*O_3*	*VOC*	*$PM_{2.5}$*	*PM_{10}*	*Pb*	*NH_3*
Canada (AQHI)		x		x		x			
Hong Kong (AQHI)	x	x		x		x	x		
China (AQI)	x	x	x	x		x	x		
India (AQI)	x	x	x	x		x	x	x	x
Mexico (IMECA)	x	x	x	x		x	x		
South Korea (CAI)	x	x	x	x			x	x	
United Kingdom (DAQI)	x	x		x		x	x		
Europe (CAQI)	?	x	?	x		?	x		
United States (AQI)	x	x	x	x		x	x	x	
Relevant Article ID (citation)	*SO_2*	*NO_2*	*CO*	*O_3*	*VOC*	*$PM_{2.5}$*	*PM_{10}*	*Pb*	*NH_3*
28 (Onatere, Nwagboso and Georgakis, 2014)	x	x	x		x		x		
49 (Miranda and Rodrigues da Silva, 2012)			x						
57 (Macário, 2010)	x	x	x		x		x		
67 (Mihyeon Jeon and Amekudzi, 2005)	x	x	x		x			x	
a2 (Litman, 2016)	x	x	x		x	x	x		

This example demonstrates the complexity of identifying appropriate variables for determining only one of the 50 identified indicators. Doing this for every indicator becomes a very lengthy process since:

- researchers disagree on which variables are important to be used, thus requiring further in-depth research on every indicator;
- some important variables are often difficult to measure;
- the sustainability indicators require multi-disciplinary considerations for variable identification;
- the comprehensiveness of the list of indicators exponentially increases the number of variables;
- variables also need to be weighted (increases interview durations to an impractically long and time-consuming process); and
- the units of the variables will differ and require normalisation.

It is clear that variable identification is an extensive process and can easily become a bottomless pit. Determining the most effective combination of variables for each indicator can easily become a research study on its own for every indicator. Although it has been attempted in this study and 188 variables were identified, this list can easily change through time and should thus frequently be re-evaluated and re-thought and adjusted after the framework has been applied to microtransit systems once they have been fully deployed. The value of the conceptual framework lies in its areas of sustainability and indicators where its concepts were identified, categorised, and integrated through an extensive and comprehensive SLR and then weighted and validated through expert interviews and questionnaires. Figure 7-13 illustrates the simplified version of the radial 'mind-map-like' diagram that only includes the 12 areas of sustainability and 50 indicators of the conceptual framework.

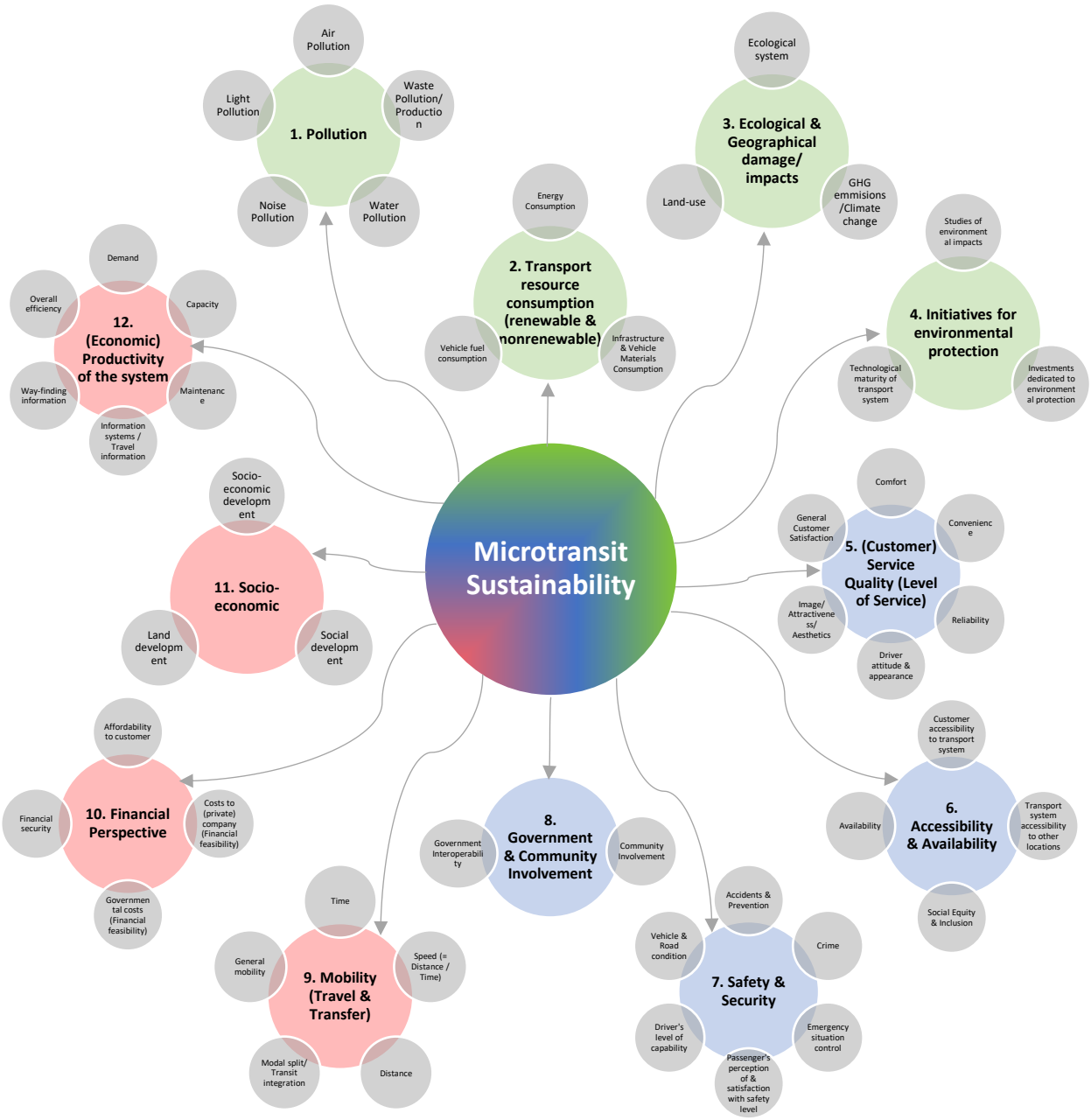


Figure 7-13 Simplified radial 'mind-map-like' diagram for the conceptual framework

7.5 Chapter 7: Conclusion

The SLR method developed for this research study (incorporating the CFA) enabled a comprehensive approach in working from data towards concepts, categories, and ultimately the development of a new theory through constructing a novel conceptual weighted framework for microtransit systems. No framework of its kind to date existed prior to the one developed in this research. Although similar transport evaluation frameworks exist for other transport modes, none had a focus on the novel concept of microtransit systems which focuses on 'first-and-last-mile' technology-enabled transport in an era of shared mobility, IoT, and a focus on ICT.

The novel conceptual weighted framework was determined comprehensively and is considered fixed. It provides a fixed foundation where variables can easily be modified, removed, or added. This can be done as deemed necessary by future research on microtransit systems or by the policy-makers, decision-makers and private companies utilising the framework in its current form.

In the following chapter, the conceptual framework is applied as a management tool to a case study towards finalising the conceptual framework and the validation thereof.

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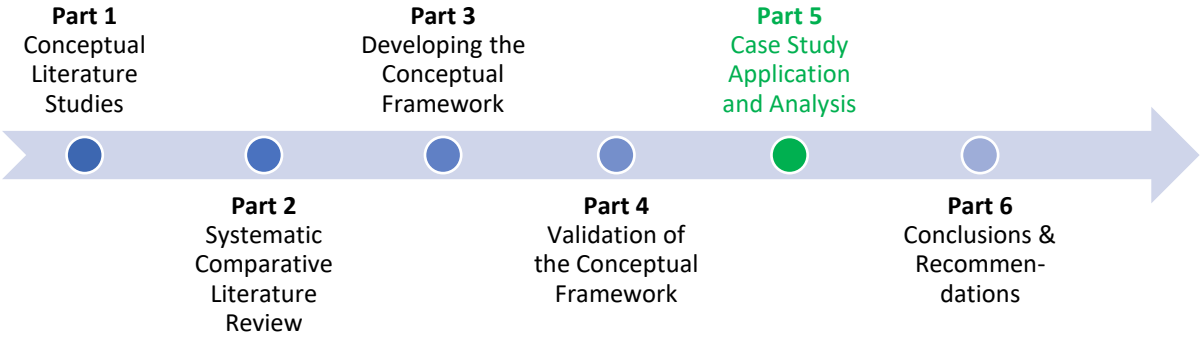
Chapter 8 Case Study Application: Mellowcabs

Document Structure														
Research Plan	Part 1		Part 2		Part 3			Part 4			Part 5			Part 6
Stages in Study	1. Two Conceptual Literature Studies		2. Systematic Literature Review					3. Validation			4. Case Study			5. Conclusions & Recommendations
	Stage 1.1: (Conceptual) Literature Study on Microtransit	Stage 1.2: (Conceptual) Literature Study on M&E	Stage 2.1: Scoping and Planning	Stage 2.2: Identification (Searching)	Stage 2.3: Extensive reading and categori-sation of data	Stage 2.4: Results, Analysis and Interpre-tation	Stage 2.5: Conceptual Framework Development	Stage 3.1: Semi-structured interviews	Stage 3.2: Indicator-weighting interviews	Stage 3.3: Case study interviews	Stage 4.1: Application of the Framework to a Case Study	Stage 4.2: Importance-Satisfaction Analysis (ISA)	Stage 5.1 Conclusions	Stage 5.2 Recommen-dations
Objectives	I.	II.	III.	III.	III. & IV.	III. & IV.	IV.	V.	V.	V.	VI. & VII.	VI. & VII.	-	-
Chapter	Chapter 3	Chapter 4	Chapter 1	Chapter 5	Chapter 6			Chapter 7		Chapter 8 & 9			Chapter 10	

Following conclusion of the SLR and establishing the validated enhanced weighted conceptual framework, this chapter proceeds with applying the enhanced framework as a management tool to a case study towards finalising the conceptual framework and its validation. The *Mellowcabs* initiative is introduced in Section 8.1.1 and will be considered for the case study. In Sections 8.1.2 and 8.1.3, the process for determining the sustainability index (SI) is explained and then determined. Importance-satisfaction analysis (ISA) is then conducted in Section 8.2. The chapter concludes with Section 8.3 which provides a discussion on the final case study interview held to finalise the validation of the framework.

Chapter key outcomes	Introduction to *Mellowcabs* for case study application
	Consideration of performance measurement vs satisfaction (perceived performance) measurement
	Determination of sustainability index (SI) values
	Conduct and analyse importance satisfaction analysis (ISA)
	Retrieve feedback from case study interviews and make final adjustments
	Finalise the enhanced conceptual M&E framework for microtransit systems



8.1 Stage 4.1 – Application of the Framework to a Case Study

From the validation methodology suggested in Figure 7-1, the plan for the case study application part is illustrated in Figure 8-1 towards establishing that the enhanced conceptual framework is efficient, effective, applicable, and valid towards the final M&E framework for microtransit systems.

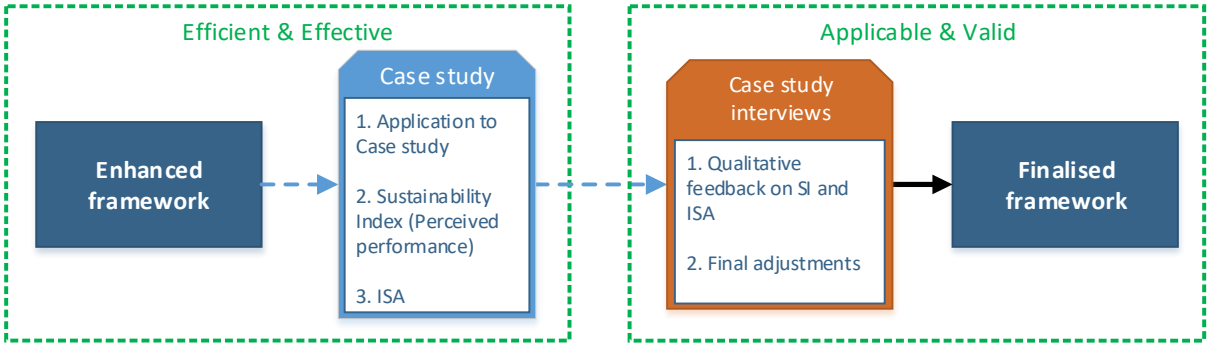


Figure 8-1 Method for case study application towards the finalised M&E framework

8.1.1 Introduction to the Mellowcabs initiative: A Case Study

To illustrate its potential as a management tool, the enhanced weighted conceptual framework is applied to the microtransit company *Mellowcabs* as a case study.

Mellowcabs, founded early in 2012, manufactures and operates electrically powered three-wheeled mini-cabs to provide on-demand, low-cost, flexible and eco-friendly transport services for people (2 passengers at most) and freight (passenger section is replaced with a cargo section) in densely populated urban environments like cities within a 3-4 km radius (Grace, 2015; Peters, 2016). More or less 65% of trips in urban environments are less than four kilometers, and as such, *Mellowcabs* aims to stake a claim in this market (Carstens, 2013). The aim is not to compete with existing modes of transport, but rather to complement existing networks through modal integration by bridging the gap between public transport and private vehicle use (Peters, 2016).

As a technology-enabled service, it connects its vehicles with commuters via a mobile app, which can also be used for making payments. It is also equipped with on-board tablet computers which can provide an interactive experience to commuters (Peters, 2016; Tsele, 2017). Social media platforms are also available on these tablet computers and can be used to connect with customers (Tsele, 2017). By bringing the web's advertising model into the real world (Carstens, 2013), the alternative mode of transport also serves as a mobile billboard with great advertising capabilities due to its maximized exterior advertising space (Peters, 2016). Geo-location software would enable specific advertisements to appear on the tablet as the vehicle approaches certain locations e.g. a restaurant running a lunch special (Carstens, 2013). It has a powerful multiple income sources model through diversification of its revenue streams: advertising, commuter fares, and leasing vehicles for on-demand cargo delivery (Tsele, 2017). Commuters will be able to pay cash or via the app (Grace, 2015).

The vehicles are designed and manufactured in South Africa (Carstens, 2013; Peters, 2016). The service aims at creating jobs through incentivising its drivers towards becoming driver-operators. This is done by providing them with a vehicle of their own after two years of successful operation, and *Mellowcabs* paying a lease fee for the use of their vehicles (Carstens, 2013).

The safety of passengers are ensured through regular vehicle movement reports, narcotic and alcohol testing of drivers, feedback from commuters via on-board tablets, liability insurance for its drivers, the public, and its passengers, and ensuring drivers have valid motorcycle (code A) licenses (Carstens, 2013).

Mellowcabs aims to provide convenient and affordable first-and-last-mile transport in a sustainable manner (Carstens, 2013). The mini-cab, illustrated in Figure 8-2, has a solar panel on its roof generating up to 35% of the vehicle's power. Lithium-ion batteries (200 Ah) are used in the vehicle. The range of a single Mellowcab is estimated to be up to 110 km per day. It is able to reach a top speed of 65 km/h but can be programmed to maintain a speed within a certain range. Other facts regarding the vehicle are indicated in the figure below.

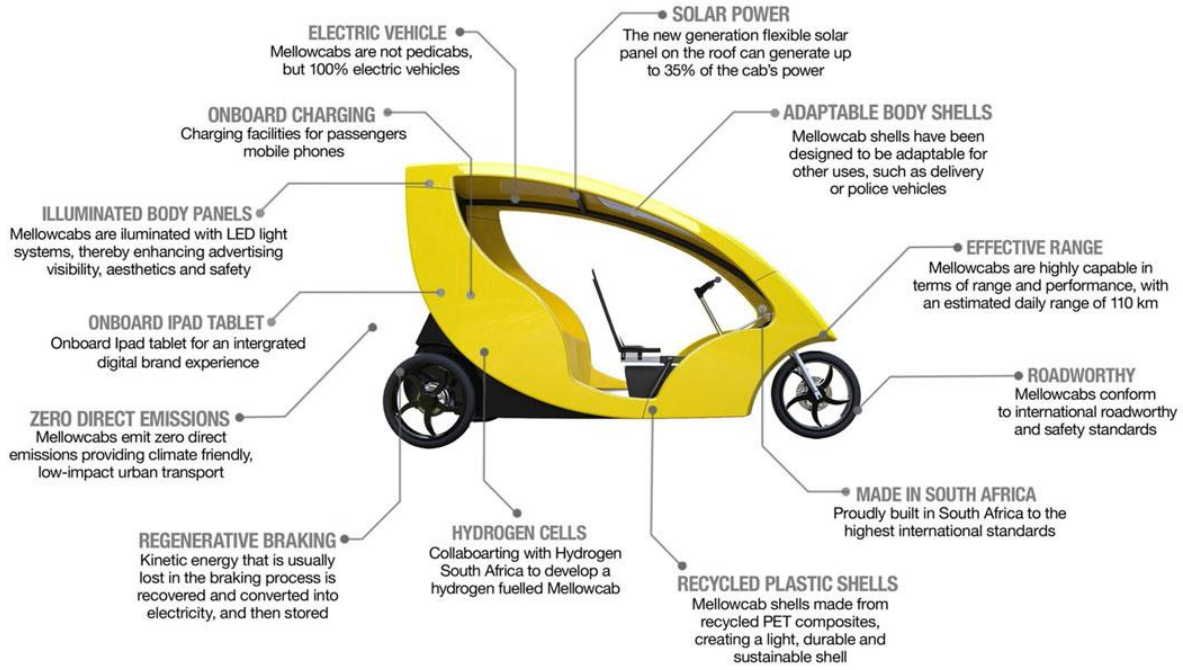


Figure 8-2 The Mellowcabs microtransit vehicle and interesting facts (Mellowcabs, 2017)

8.1.2 Performance vs Satisfaction measurement

Following the discussion on variable identification at the end of Chapter 7, this section proceeds with considering performance measurement of each variable against determining levels of satisfaction (perceived performance).

Instead of identifying and determining the performance of every variable quantitatively followed by a normalisation process which requires minimum and maximum values for each variable, the conceptual framework can also be considered on its indicator level. This would mean determining values for 50 indicators which will be more feasible for companies or policy-makers since the process will be realistic in the effort, time, and costs required for its evaluation. As indicated previously, a smaller set of indicators is typically considered important to ensure high quality. Considering 50 indicators instead of 180+ variables would thus increase feasibility and ensure higher quality for every indicator.

Instead of performance values, satisfaction levels could be determined which instantly means the process is normalised. Satisfaction can be viewed as 'perceived performance'. Considering satisfaction instead of performance values would mean sacrificing accuracy since the values will not be based on factual real-world figures but rather satisfaction ratings. However, it would make the evaluation process feasible for evaluators meaning continuous monitoring would be possible. Especially considering that microtransit systems have not yet been fully deployed, much required data will not yet be available. Satisfaction ratings would at this stage enable determining values for all indicators in a normalised way and enable the determination of a sustainability index (SI) based on satisfaction ratings, and allow the application of importance-satisfaction analysis (ISA) as a management tool for sustainability evaluation even before real-world performance data is available.

Due to these reasons, a third survey (the first two surveys of which were conducted toward indicator identification and indicator weightings) was completed by three individuals from *Mellowcabs*, where they were requested to provide satisfaction ratings to each of the 50 indicators based on a 10-point *satisfaction* (perceived performance) Likert-scale. The 10-point *satisfaction* Likert-scale can be divided into seven categories according to Freitas (2013) based on levels of satisfaction, as shown in Table 8-1 where $I_{N,i}$ is the indicator (satisfaction) rating.

Table 8-1 Indicator rating threshold categories and descriptions (Freitas, 2013)

Category	Value thresholds	Description
A	$9 \leq I_{N,i} \leq 10$	Extremely satisfied
B	$8 \leq I_{N,i} < 9$	Very satisfied
C	$7 \leq I_{N,i} < 8$	Satisfied
D	$5 \leq I_{N,i} < 7$	Nor satisfied, nor dissatisfied
E	$4 \leq I_{N,i} < 5$	Dissatisfied
F	$3 \leq I_{N,i} < 4$	Very dissatisfied
G	$0 \leq I_{N,i} < 3$	Extremely dissatisfied

A completed example of the satisfaction rating survey (hereafter referred to as Survey C) for the 50 indicators is included in Appendix D3 Table D-3. Interviewees were required to make a value-judgement on each indicator based on his/her knowledge and opinion of *Mellowcabs*'s performance. Table 8-2 presents and analyses the results: including the average (Avg), standard deviation (StDev) and coefficient of variance (CV) for each indicator.

Table 8-2 Indicator satisfaction ratings and analysis

				Satisfaction (perceived performance) & Analysis					
N	***Evaluation categories (AoS)***	***i***	***Indicators***	***S1***	***S2***	***S3***	***Avg***	***StDev***	***CV***
1	**Pollution**	1	Air Pollution	9	9	9	**9.0**	**0.0**	**0%**
		2	Waste Pollution/Production	9	10	7	**8.7**	**1.5**	**18%**
		3	Water Pollution	10	10	9	**9.7**	**0.6**	**6%**
		4	Noise Pollution	10	10	8	**9.3**	**1.2**	**12%**
		5	Light Pollution	7	9	8	**8.0**	**1.0**	**13%**
2	**Transport resource consumption (renewable & non-renewable)**	6	Energy Consumption	8	9	9	**8.7**	**0.6**	**7%**
		7	Infrastructure & Vehicle Materials Consumption	6	8	6	**6.7**	**1.2**	**17%**
		8	Vehicle fuel consumption	9	10	8	**9.0**	**1.0**	**11%**
3	**Ecological & Geographical damage/impacts**	9	Ecological system	8	9	8	**8.3**	**0.6**	**7%**
		10	Climate change/GHG emissions	9	10	8	**9.0**	**1.0**	**11%**
		11	Land-use	8	9	7	**8.0**	**1.0**	**13%**

				Satisfaction (perceived performance) & Analysis					
N	Evaluation categories (AoS)	i	Indicators	S1	S2	S3	Avg	StDev	CV
4	Initiatives for environmental protection	12	Studies of environmental impacts	8	6	4	6.0	2.0	33%
		13	Investments dedicated to environmental protection	8	5	8	7.0	1.7	25%
		14	Technological maturity of transport system	8	6	7	7.0	1.0	14%
5	(Customer) Service Quality (Level of Service)	15	Comfort	6	8	6	6.7	1.2	17%
		16	Convenience	7	9	8	8.0	1.0	13%
		17	Reliability	7	8	4	6.3	2.1	33%
		18	Driver attitude & appearance	6	7	6	6.3	0.6	9%
		19	Image/Attractiveness/Aesthetics	7	10	9	8.7	1.5	18%
		20	General Customer Satisfaction	7	9	8	8.0	1.0	13%
6	Accessibility & Availability	21	Customer accessibility to transport system	6	7	6	6.3	0.6	9%
		22	Transport system accessibility to other locations	5	6	7	6.0	1.0	17%
		23	Social Equity & Inclusion	5	7	5	5.7	1.2	20%
		24	Availability	5	7	5	5.7	1.2	20%
7	Safety & Security	25	Accidents & Prevention	5	7	6	6.0	1.0	17%
		26	Crime	5	8	6	6.3	1.5	24%
		27	Emergency situation control	6	7	6	6.3	0.6	9%
		28	Passenger's perception of & satisfaction with safety level	5	8	7	6.7	1.5	23%
		29	Driver's level of capability	5	8	6	6.3	1.5	24%
		30	Vehicle & Road condition	7	6	6	6.3	0.6	9%
8	Government & Community Involvement	31	Government Interoperability	7	7	7	7.0	0.0	0%
		32	Community Involvement	5	9	5	6.3	2.3	36%
9	Mobility (Travel & Transfer)	33	Time	5	9	7	7.0	2.0	29%
		34	Speed	7	7	4	6.0	1.7	29%
		35	Distance	7	9	4	6.7	2.5	38%
		36	Modal split/Transit integration	8	9	8	8.3	0.6	7%
		37	General mobility	7	9	8	8.0	1.0	13%
10	Financial Perspective (Costs)	38	Affordability to customer	9	8	7	8.0	1.0	13%
		39	Costs to (private) company (Financial feasibility)	7	9	8	8.0	1.0	13%
		40	Governmental costs (Financial feasibility)	7	8	8	7.7	0.6	8%
		41	Financial security	8	8	7	7.7	0.6	8%
11	Socio-economic	42	Socio-economic development	6	4	6	5.3	1.2	22%
		43	Social development	6	4	6	5.3	1.2	22%
		44	Land development	5	4	6	5.0	1.0	20%
12	(Economic) Productivity of the system	45	Demand	8	10	7	8.3	1.5	18%
		46	Capacity	5	9	5	6.3	2.3	36%
		47	Maintenance	8	9	9	8.7	0.6	7%
		48	Information systems (ICT)/Travel information	6	7	9	7.3	1.5	21%
		49	Way-finding information	6	7	6	6.3	0.6	9%
		50	Overall efficiency (impressions)	8	10	8	8.7	1.2	13%
							Overall average:	1.1	16%

Although only three available individuals from *Mellowcabs* were identified as acceptable candidates for making value-judgements based on their level of satisfaction (perceived performance) with each indicator, the analyses of the satisfaction ratings in Table 8-2 delivered adequate and useful results. The overall average standard deviation for all indicators is 1.1 and the coefficient of variance only 16%. This indicates that the three participants were consistent enough in their value judgements. Some indicator ratings that were inconsistent and had higher variance coefficients include: Studies of environmental impacts (33%), Reliability (33%), Community Involvement (36%), Distance (38%), and Capacity (36%).

Although satisfaction ratings are considered less accurate than factual figures that are based on real hard data, it will still give an indication of which indicators are performing better or worse than others, and can be compared to their importance with ISA. Its usefulness increases through continuous

monitoring, where changes in the satisfaction ratings can be observed to indicate whether the implemented actions had the desired effects and impacts. If in the future, performance values will be determined, a normalisation process would be required for adding the variables together in order to calculate a composite index. This can be done with linear scaling transformation (LST). This process is however not applicable to this study since value-judgement satisfaction ratings have the same unit and are thus already normalised. As such, a normalisation process will not be considered.

8.1.3 Determining the Sustainability Index (SI)

The conceptual framework developed in this study is constructed to deliver a single final value expressing the sustainability performance of the microtransit system under consideration, and is called the sustainability index (SI).

Since weighting and approaches to aggregation have a significant impact on the overall composite indicator, choosing the correct approach to aggregation is important to consider. Although most studies use the EWA method for aggregating elements into a composite index, it was previously established and explained that this would not be sufficient.

In this study, various options were considered for weighting the variables, indicators, and AoS towards establishing their importance relative to one another, as was discussed in Sections 7.3.1-7.3.3. It was decided that the approach to aggregation in this study would be to use these relative importance weightings for aggregating all elements into a composite index i.e. through a (nested) weighted sum approach.

Some argue that challenges exist regarding multi-criteria sustainability appraisal: double counting of indicators might arise due to correlations between indicators measuring some aspect of the same underlying principle. While the response in literature would sometimes be to test indicators for statistical correlation, it is believed that this risk is mitigated through the value-judgements that was made by expert-based/participatory weighting used in this study as well as the trade-of approach that the AHP used on each of the 50 indicators identified in this study. It must also be noted that there will always to some extent be some correlation between different measures of the same aggregate (OECD and JRC, 2008).

A concern when using additive aggregations such as the EWA is the full compensability they imply: some indicators performing poorly can be compensated by other sufficiently higher performing indicators i.e. through trade-offs (OECD and JRC, 2008). While it is possible to implement a “penalty system” for when one indicator performs notably worse than others and adjusting the composite indicator accordingly, it was decided to exclude this from this study since it is believed that the expert-based/participatory weighting used in this study is sufficient for establishing weights for the diverse range of indicators toward aggregation and the AHP allowed for lower compensability compared to that of EWA. Also, since it is believed that detailed and important information might get lost through this type of aggregation through compensation, this study accommodates for this by using ISA to compare all indicators to each other and provide an overview analysis. While determining a SI might be useful to some extent for the company under consideration, analysing the data through ISA is considered to be of more value and a significant contributing factor of this study.

Regardless of what aggregation approach is used, all indicator weights are essentially value judgements. While some researchers choose to determine weightings based on statistical methods others might choose to implement a reward/penalty system to elements that are considered more important based on expert opinion. According to the OECD/JRC Handbook, the absence of an "objective" approach for determining weighting and aggregation methods does not necessarily lead to rejection of the validity of composite indicators as long as the entire process is transparent (OECD and JRC, 2008).

The final sustainability index (SI) can thus be determined by aggregation through a (nested) weighted sum approach, which is the summation of all component parts of the framework based on relative weightings as follows:

$$SI = \sum_N W_N C_N$$

where W_N = AoS weight
and C_N = AoS (performance or satisfaction) rating

$$C_N = \sum_i W_{N,i} I_{N,i}$$

where $W_{N,i}$ = indicator weight
and $I_{N,i}$ = indicator (performance or satisfaction) rating

$$I_{N,i} = \sum_n w_{N,i,n} x_{N,i,n}$$

where $w_{N,i,n}$ = variable weight
and $x_{N,i,n}$ = variable (performance or satisfaction) rating

Following the above-mentioned method and using the satisfaction ratings in Table 8-2 for determining a sustainability index value for the *Mellowcabs* company delivered a final value of $SI = 7.35$. Since this value is based on indicator satisfaction ratings and not performance ratings, it cannot be used to compare *Mellowcabs* to other microtransit companies towards assessing its relative sustainability performance. Instead, this value only has meaning to the company itself as it provides a perceived standard from which it can aim to further improve this rating (by identifying and improving high-priority indicators). At this stage, the meaning of the SI is limited to the company's perception and satisfaction through value-judgement.

A sustainability index can also be determined for each of the three sustainability domains. This can be done with the following equation (also refer to Table 7-11):

$$SI_{dom} = \sum_N \left(\frac{W_N \cdot W_{N,dom}}{\sum_N (W_N \cdot W_{N,dom})} \right) C_N$$

Using this equation, the sustainability indices for each domain were obtained as follows: $SI_{env} = 7.76$; $SI_{soc} = 7.14$; and $SI_{eco} = 7.30$. Based on the satisfaction (perceived performance) value-judgements of three individuals from *Mellowcabs*, it can be assumed that the company performs best with regard to environmental development, and struggles the most with social development at this stage,

although all ratings were between 7 and 8 and thus fall into the C-category of 'Satisfied' as based on Table 8-1. These indices are however only indicative of the company's view, and can only be used by the company as benchmarks for future improvements.

8.2 Stage 4.2 – Importance-Satisfaction Analysis (ISA)

Ideally, the importance-performance analysis (IPA) technique originally suggested by Martilla & James (1977) would be preferred for analysing microtransit companies through utilising the management tool (Martilla and James, 1977). As described in Section 8.1.2, determining performance through variable determination is however not feasible at this stage.

The only option at this stage is to perform ISA which is similar to IPA, but based on the perceived performance (satisfaction ratings) from the microtransit company's employees and management team, and the expert importance ratings. For this research, this approach towards conducting the case study and identifying the most critical criteria is followed.

The next step for analysing data obtained from the conceptual framework suggested in this research could be to conduct ISA where satisfaction ratings are obtained from commuters and drivers once the microtransit system has been fully deployed and used regularly by customers. This would give the company an indication on the perceived performance of the company's sustainability from a customer's perspective and a more objective 'outside' view.

The ideal would be to conduct IPA since this approach would be based on hard data obtained from the system and inserted as variables into the conceptual framework. A final set of appropriate and measurable variables would however have to be identified, weighted, and the units normalised. Once the variable set has been finalised, performance ratings can be determined based on minimum and maximum values enabling normalisation of units. Minimum and maximum values will become available as soon as a few microtransit companies have been deployed and necessary data becomes available. Since IPA would be based on hard data for performance measurement, results will be more accurate and comparable between different microtransit systems. Relative indicator performance ratings as well as sustainable index (SI) values would also carry more meaning and be comparable between different microtransit systems.

However, for this research ISA was conducted based on individuals' satisfaction ratings from *Mellowcabs* as discussed in Section 8.1.2. These values are plotted against the importance ratings for each indicator which is computed by multiplying the indicators weights with their respective AoS weights as follows:

$$W_i = W_N \cdot W_{N,i}$$

The relative importance of each indicator is then determined by comparing all indicators to the indicator with the largest weighting and thus having maximum importance (made 100%). The same was done to determine the relative importance for all indicators for each domain. These results are presented in Table 8-3.

Table 8-3 Importance fractions and relative importance values of indicators

i	*Indicators*	W_i	*Relative %*	*Env (relative)*	*Soc (relative)*	*Eco (relative)*
38	Affordability to customer	3.99%	100.0%	32%	61%	100%
8	Vehicle fuel consumption	3.97%	99.4%	100%	49%	58%
6	Energy Consumption	3.74%	93.8%	94%	47%	55%
24	Availability	3.58%	89.7%	27%	100%	52%
31	Government Interoperability	3.52%	88.3%	29%	93%	53%
10	Climate change/GHG emissions	3.25%	81.4%	90%	49%	35%
21	Customer accessibility to transport system	3.19%	79.9%	24%	89%	46%
42	Socio-economic development	3.14%	78.7%	38%	59%	59%
33	Time	3.12%	78.1%	39%	59%	58%
1	Air Pollution	2.94%	73.8%	84%	48%	26%
45	Demand	2.69%	67.6%	24%	48%	60%
17	Reliability	2.51%	62.8%	11%	70%	41%
3	Water Pollution	2.43%	60.9%	70%	39%	22%
9	Ecological system	2.39%	59.8%	66%	36%	25%
13	Investments dedicated to environmental protection	2.37%	59.3%	66%	37%	24%
22	Transport system accessibility to other locations	2.31%	57.9%	17%	64%	33%
41	Financial security	2.22%	55.7%	18%	34%	56%
39	Costs to (private) company (Financial feasibility)	2.14%	53.5%	17%	33%	54%
36	Modal split/Transit integration	2.12%	53.0%	26%	40%	39%
14	Technological maturity of transport system	2.04%	51.2%	57%	32%	20%
2	Waste Pollution/Production	2.01%	50.4%	58%	33%	18%
37	General mobility	1.97%	49.3%	24%	37%	37%
43	Social development	1.95%	48.8%	23%	37%	37%
25	Accidents & Prevention	1.90%	47.6%	12%	57%	26%
46	Capacity	1.82%	45.7%	17%	32%	40%
16	Convenience	1.79%	45.0%	8%	50%	30%
32	Community Involvement	1.76%	44.1%	15%	47%	26%
35	Distance	1.75%	43.9%	22%	33%	33%
50	Overall efficiency (impressions)	1.72%	43.1%	16%	30%	38%
20	General Customer Satisfaction	1.57%	39.4%	7%	44%	26%
12	Studies of environmental impacts	1.53%	38.4%	43%	24%	15%
7	Infrastructure & Vehicle Materials Consumption	1.43%	35.9%	36%	18%	21%
11	Land-use	1.43%	35.8%	39%	22%	15%
29	Driver's level of capability	1.43%	35.8%	9%	43%	19%
15	Comfort	1.39%	34.7%	6%	39%	23%
34	Speed	1.37%	34.4%	17%	26%	26%
4	Noise Pollution	1.37%	34.4%	39%	22%	12%
40	Governmental costs (Financial feasibility)	1.34%	33.5%	11%	20%	34%
28	Passenger's perception of & satisfaction with safety level	1.30%	32.7%	8%	39%	18%
48	Information systems (ICT)/Travel information	1.30%	32.6%	12%	23%	29%
23	Social Equity & Inclusion	1.29%	32.4%	10%	36%	19%
27	Emergency situation control	1.17%	29.3%	7%	35%	16%
44	Land development	1.14%	28.6%	14%	21%	22%
30	Vehicle & Road condition	1.12%	28.1%	7%	34%	15%
47	Maintenance	1.06%	26.6%	10%	19%	24%
26	Crime	1.05%	26.2%	6%	32%	14%
18	Driver attitude & appearance	0.99%	24.7%	4%	28%	16%
19	Image/Attractiveness/Aesthetics	0.93%	23.3%	4%	26%	15%
49	Way-finding information	0.84%	21.1%	8%	15%	19%
5	Light Pollution	0.64%	16.1%	18%	10%	6%

Using the values from Table 8-2 and Table 8-3, these results can be plotted against each other to determine the ISA-graph as seen in Figure 8-3. The data in the ISA-graph is divided into four quadrants based on the relative average importance and average satisfaction ratings of the 50 indicators; the cross-point thus is $[(W_{N,i})_{relative\ avg};\ (I_{N,i})_{avg}]$. This approach is consistent with the suggested approach in the seminal work of Martilla and James (1977) where they argue: "the value of this

approach is in identifying relative than absolute levels of importance and performance" (Martilla and James, 1977).

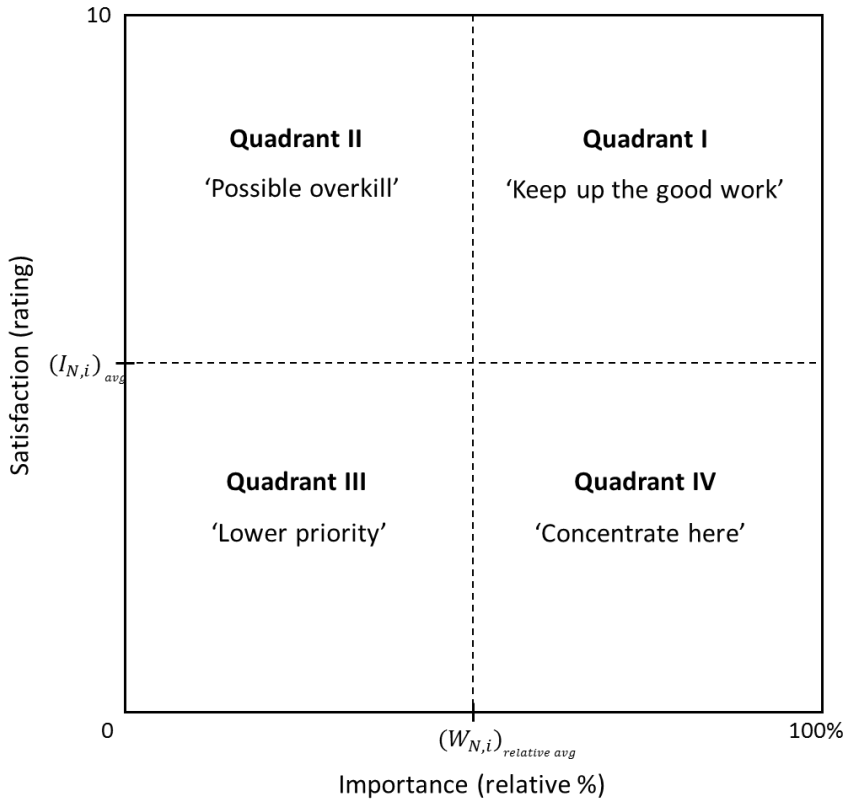


Figure 8-3 Importance-Satisfaction Analysis (ISA) theoretical graph

The four quadrants in Figure 8-3 are described briefly in Table 8-4.

Table 8-4 Description of each ISA quadrant

Quadrant	Description
I 'Keep up the good work'	The area where the elements are considered important and perceived performance (degree of satisfaction) is high. For these elements, current strategic action plans are maintained.
II 'Possible overkill'	The area where the elements are considered not so important and perceived performance (degree of satisfaction) is high. Efforts towards the elements in this quadrant can be reduced.
III 'Lower priority'	The area where the elements are considered not so important and perceived performance (degree of satisfaction) is high. These elements are not considered for implementation of improved strategic action plans.
IV 'Concentrate here'	The area where the elements are considered important and perceived performance (degree of satisfaction) is low. For maximised results, improved strategic action plans should be applied to the elements in this quadrant.

8.2.1 Using importance ratings for performance/satisfaction aim

Considering the 50 indicators through categorising them into only four quadrants does not provide sufficient analysis. The researcher suggests determining an 'aim-diagonal' instead of merely determining the gap between indicators' importance and their satisfaction ratings. The 'aim-diagonal' is determined with four nodes by using the relative average importance and satisfaction ratings as per Table 8-5.

Table 8-5 "Aim-diagonal" nodes for the ISA graph

Node	*Importance (**X**)*	*Satisfaction (**Y**)*
Node 1	0	0
Node 2	$(W_{N,i})_{relative\ avg}$	$(I_{N,i})_{relative\ avg}$
Node 3 *(for slope > 1)* **OR** *(for slope < 1)*	$\left(\frac{(W_{N,i})_{relative\ avg}}{(I_{N,i})_{relative\ avg}}\right)$ x 10 100%	10 $\left(\frac{(I_{N,i})_{relative\ avg}}{(W_{N,i})_{relative\ avg}}\right)$ x 100%
Node 4	100%	10

As seen in this table, the 'aim-diagonal' is based on current indicator average importance and satisfaction ratings (50%; 7.24) instead of merely considering the gap between importance and satisfaction ratings in which case the diagonal would go through the cross-point at node 2 of (50%; 5.0). This means that the 'aim-diagonal' is adjusted as the satisfaction ratings change to ensure that the 'aim-diagonal' always goes through the cross-point of the four quadrants. As the satisfaction ratings increase, the average would also increase and thus the four quadrants as well as the 'aim-diagonal' are adjusted accordingly.

Although the 'Concentrate here' quadrant displays which indicators are considered a priority since they were identified as important but are not performing satisfactorily, it is still necessary to identify which indicators are the highest priority and which ones to focus on first. Although simple to understand, merely classifying the 50 indicators into four groups is not sufficient for providing enough guidance. An approach for distinguishing more clearly between the 50 indicators is suggested by inserting the diagonal line with points as in Table 8-5 to the ISA graph to measure the indicators' (vertical) distance from this diagonal. The diagonal is based on the current importance and satisfaction rating averages and assumes low satisfaction ratings are acceptable for low importance ratings, while high satisfaction ratings are required for high importance ratings.

This diagonal line can be used as a guide (aim) to determine the indicators' vertical distances from the line. It can thus be determined to what extent some of the indicators are 'overperforming' and 'underperforming' considering their relative importance and perceived performance ratings. Using the diagonal line together with the four quadrants should clarify which indicators must be addressed and prioritised. The following section applies this idea to the ISA graph and conducts analysis on case study results.

8.2.2 Final ISA results and analysis

Using the relative importance and satisfaction results from Table 8-2 and Table 8-3 and following the approach for plotting the "aim-diagonal" as per Table 8-5, the final ISA-graph is determined and

illustrated in Figure 8-4. The same approach was followed and ISA-graphs could also be determined for each domain specifically based on the relative importance values of each indicator for that domain. The environmental, social, and economic ISA-graphs are depicted in Figure 8-5, Figure 8-6, and Figure 8-7 respectively.

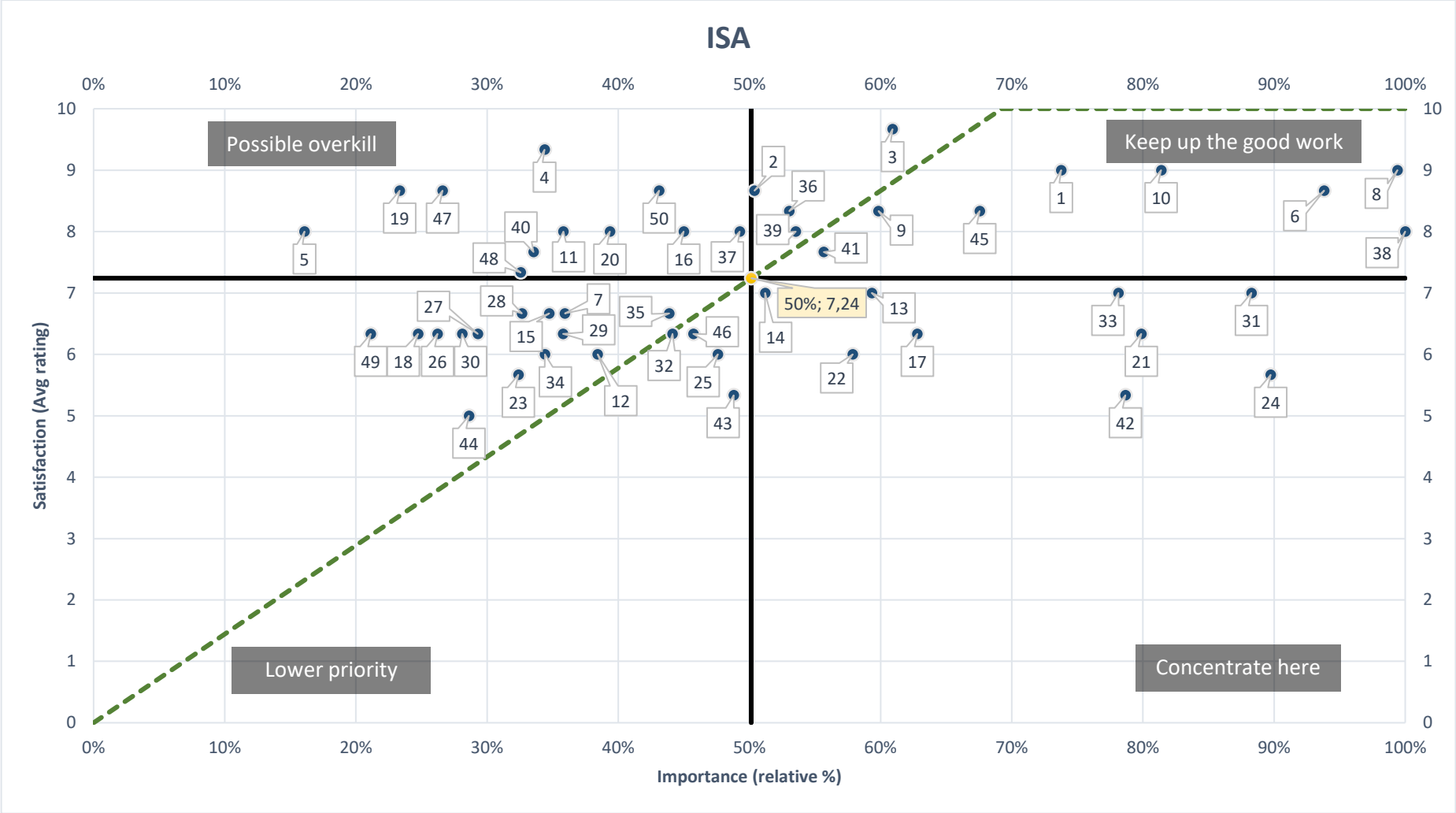


Figure 8-4 Importance-satisfaction analysis (ISA) diagram (Mellowcabs)

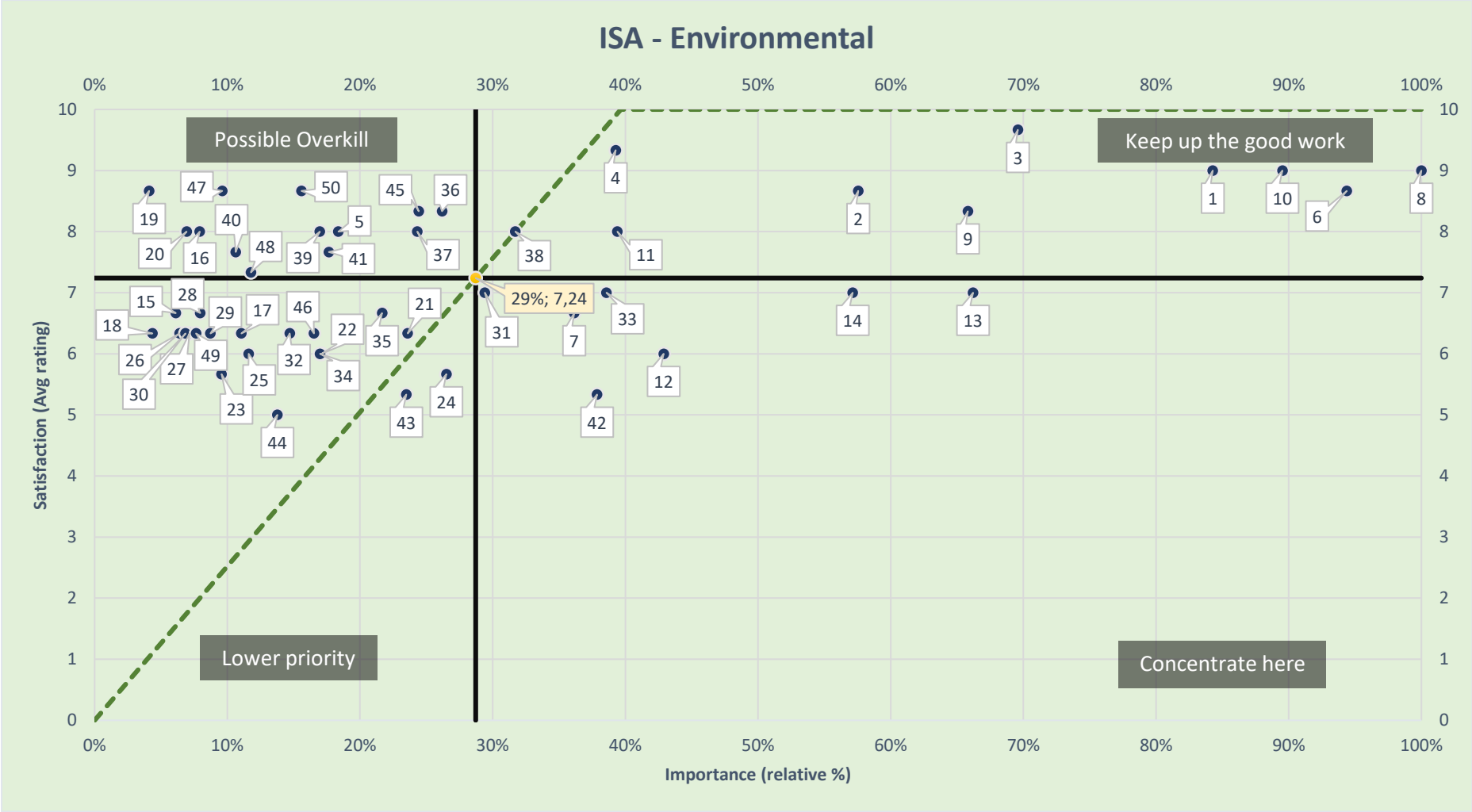


Figure 8-5 Importance-satisfaction analysis (ISA) diagram: Environmental (Mellowcabs)

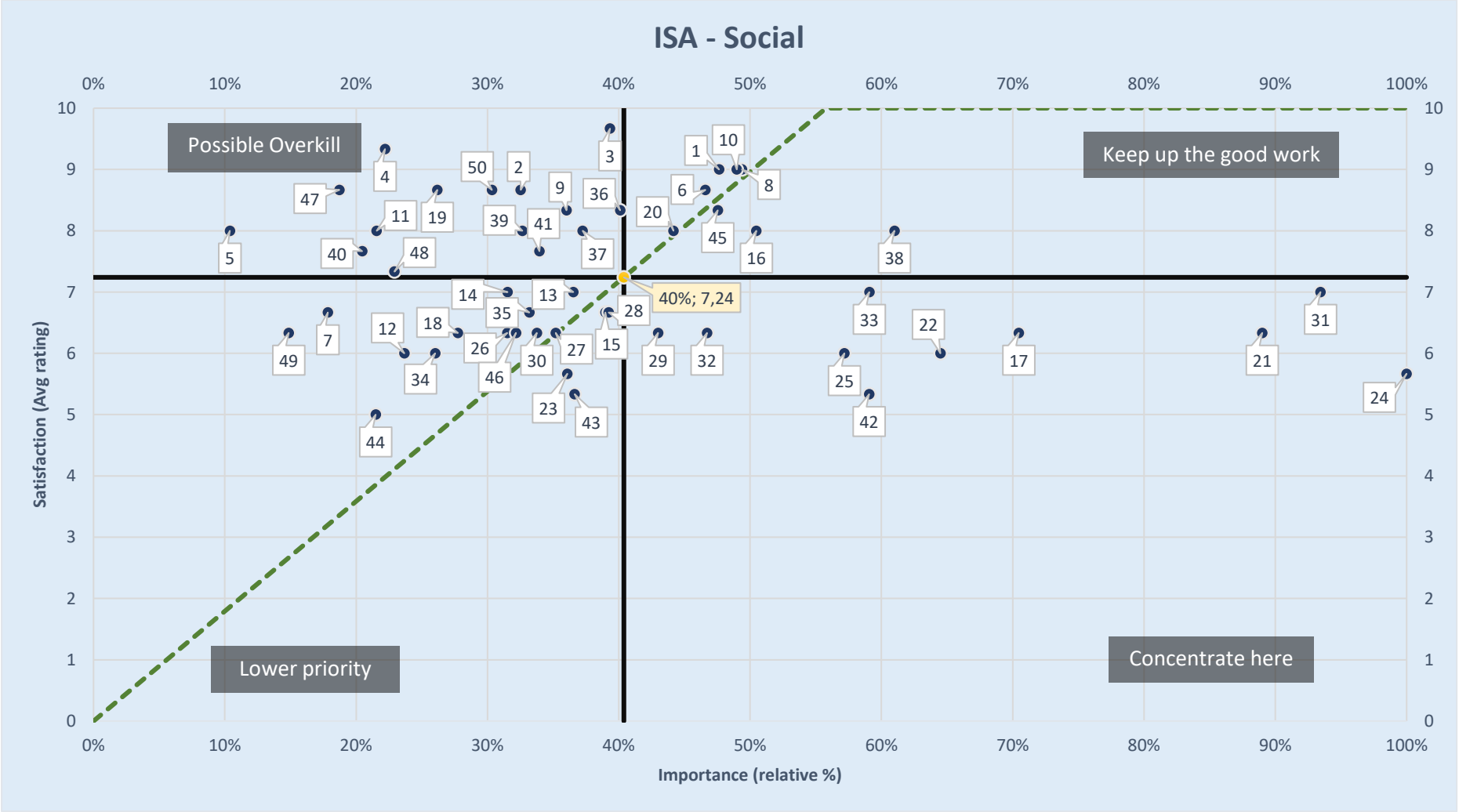


Figure 8-6 Importance-satisfaction analysis (ISA) diagram: Social (Mellowcabs)

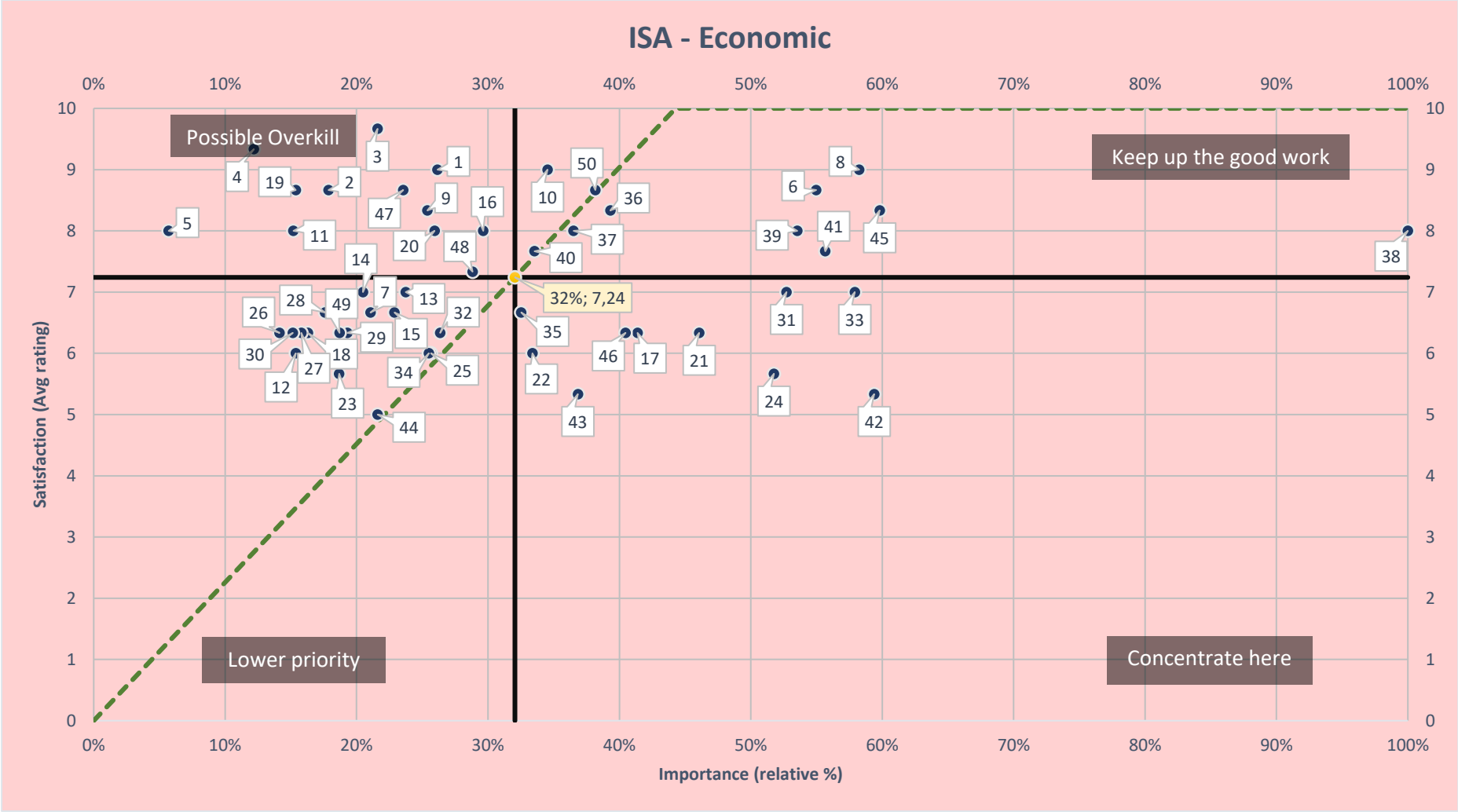


Figure 8-7 Importance-satisfaction analysis (ISA) diagram: Economic (Mellowcabs)

The results from Figure 8-4 are presented table-format in Table 8-6. This table includes the vertical distances between each indicator and the "aim-diagonal" as illustrated in the 'Difference' column. The 'Direction' column indicates whether the indicator needs to be improved (>) since it is underperforming and by how much, or whether it is overperforming (and by how much), and resources dedicated to this indicator can be reduced (<).

Table 8-6 Summary of ISA results (Mellowcabs)

i	*Indicators*	$W_{N,i}$	*Quadrant*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
42	Socio-economic development	0.5	Concentrate here	79%	5.3	10.0	4.7	>
24	Availability	0.35	Concentrate here	90%	5.7	10.0	4.3	>
21	Customer accessibility to transport system	0.31	Concentrate here	80%	6.3	10.0	3.7	>
31	Government Interoperability	0.67	Concentrate here	88%	7.0	10.0	3.0	>
33	Time	0.3	Concentrate here	78%	7.0	10.0	3.0	>
17	Reliability	0.27	Concentrate here	63%	6.3	9.1	2.7	>
22	Transport system accessibility to other locations	0.22	Concentrate here	58%	6.0	8.4	2.4	>
38	Affordability to customer	0.41	Keep up the good work	100%	8.0	10.0	2.0	>
43	Social development	0.31	Lower Priority	49%	5.3	7.0	1.7	>
13	Investments dedicated to environmental protection	0.4	Concentrate here	59%	7.0	8.6	1.6	>
45	Demand	0.29	Keep up the good work	68%	8.3	9.8	1.4	>
6	Energy Consumption	0.41	Keep up the good work	94%	8.7	10.0	1.3	>
1	Air Pollution	0.31	Keep up the good work	74%	9.0	10.0	1.0	>
8	Vehicle fuel consumption	0.43	Keep up the good work	99%	9.0	10.0	1.0	>
10	Climate change / GHG emissions	0.46	Keep up the good work	81%	9.0	10.0	1.0	>
25	Accidents & Prevention	0.24	Lower Priority	48%	6.0	6.9	0.9	>
14	Technological maturity of transport system	0.34	Concentrate here	51%	7.0	7.4	0.4	>
41	Financial security	0.23	Keep up the good work	56%	7.7	8.0	0.4	>
9	Ecological system	0.34	Keep up the good work	60%	8.3	8.6	0.3	>
46	Capacity	0.19	Lower Priority	46%	6.3	6.6	0.3	>
32	Community Involvement	0.33	Lower Priority	44%	6.3	6.4	0.0	>
39	Costs to (private) company (Financial feasibility)	0.22	Keep up the good work	54%	8.0	7.7	-0.3	<
35	Distance	0.17	Lower Priority	44%	6.7	6.3	-0.3	<
12	Studies of environmental impacts	0.26	Lower Priority	38%	6.0	5.5	-0.5	<
36	Modal split/ Transit integration	0.2	Keep up the good work	53%	8.3	7.7	-0.7	<
44	Land development	0.18	Lower Priority	29%	5.0	4.1	-0.9	<
3	Water Pollution	0.26	Keep up the good work	61%	9.7	8.8	-0.9	<
37	General mobility	0.19	Possible Overkill	49%	8.0	7.1	-0.9	<
23	Social Equity & Inclusion	0.12	Lower Priority	32%	5.7	4.7	-1.0	<
34	Speed	0.13	Lower Priority	34%	6.0	5.0	-1.0	<
29	Driver's level of capability	0.18	Lower Priority	36%	6.3	5.2	-1.2	<
2	Waste Pollution/ Production	0.21	Keep up the good work	50%	8.7	7.3	-1.4	<
7	Infrastructure & Vehicle Materials Consumption	0.16	Lower Priority	36%	6.7	5.2	-1.5	<
16	Convenience	0.2	Possible Overkill	45%	8.0	6.5	-1.5	<
15	Comfort	0.15	Lower Priority	35%	6.7	5.0	-1.7	<
28	Passenger's perception of & satisfaction with safety level	0.16	Lower Priority	33%	6.7	4.7	-2.0	<
27	Emergency situation control	0.15	Lower Priority	29%	6.3	4.2	-2.1	<
30	Vehicle & Road condition	0.14	Lower Priority	28%	6.3	4.1	-2.3	<
20	General Customer Satisfaction	0.17	Possible Overkill	39%	8.0	5.7	-2.3	<
50	Overall efficiency (impressions)	0.18	Possible Overkill	43%	8.7	6.2	-2.4	<
26	Crime	0.13	Lower Priority	26%	6.3	3.8	-2.5	<
48	Information systems (ICT) / Travel information	0.14	Possible Overkill	33%	7.3	4.7	-2.6	<
18	Driver attitude & appearance	0.11	Lower Priority	25%	6.3	3.6	-2.8	<
40	Governmental costs (Financial feasibility)	0.14	Possible Overkill	34%	7.7	4.8	-2.8	<
11	Land-use	0.2	Possible Overkill	36%	8.0	5.2	-2.8	<
49	Way-finding information	0.09	Lower Priority	21%	6.3	3.1	-3.3	<
4	Noise Pollution	0.15	Possible Overkill	34%	9.3	5.0	-4.4	<
47	Maintenance	0.11	Possible Overkill	27%	8.7	3.8	-4.8	<
19	Image/ Attractiveness/ Aesthetics	0.1	Possible Overkill	23%	8.7	3.4	-5.3	<
5	Light Pollution	0.07	Possible Overkill	16%	8.0	2.3	-5.7	<

From the final results, we can consider both the quadrant, and the distance from the "aim-diagonal" for each indicator to establish whether the indicator is performing satisfactorily. The overall results in Table 8-6 for the case study indicated that the top five underperforming indicators are: 1) *Socio-*

economic development, 2) *Availability*, 3) *Customer accessibility to transport system*, 4) *Government Interoperability*, and 5) *Time*. Dedicating resources and improved strategic actions towards these indicators would significantly improve *Mellowcab's* sustainability index (SI).

The top five overperforming indicators are: 1) *Light Pollution,* 2) *Image/ Attractiveness/Aesthetics*, 3) *Maintenance*, 4) *Noise Pollution* and 5) *Way-finding information*. Thus, resources unnecessarily dedicated to these indicators could be shifted to rather focus on the underperforming indicators with minimum adverse effects on the company's overall sustainability index.

As expected, a strong correlation between the indicators' distance from the "aim-diagonal" and their quadrant is observed. The top five underperforming indicators are all in the 'Concentrate here' quadrant, while the top five overperforming indicators all fall within the 'Possible overkill' quadrant.

Similar to the results in Table 8-6, the results when considering each domain separately are given in Appendix E for the sake of brevity. The top five underperforming indicators when only considering each domain are summarised in Table 8-7. Improving these top five indicators listed under each domain would significantly improve that domain's sustainability index (SI_{dom}). It is noted that the indicator Socio-economic development is at the top of each domain's list as well as the overall list in Table 8-6. This is explained by the relatively high importance rating that it has, the significant contribution it has to each domain, and the fact that it is the second lowest ranked indicator based on the satisfaction ratings of individuals from *Mellowcabs*. The *Availability* indicator is also ranked as the second biggest underperforming indicator overall and is also found in both the 'Social' and 'Economic' domains' top five lists, and as such is also crucial to be improved.

Table 8-7 Top five underperforming indicators for each domain

Environmental	*Social*	*Economic*
42 - Socio-economic development	**42** - Socio-economic development	**42** - Socio-economic development
12 - Studies of environmental impacts	**24** - Availability	**24** - Availability
13 - Investments dedicated to environmental protection **14** - Technological maturity of transport system	**22** - Transport system accessibility to other locations **25** - Accidents & Prevention	**21** - Customer accessibility to transport system
33 - Time	**17** - Reliability **21** - Customer accessibility to transport system	**17** - Reliability **31** - Government Interoperability **33** - Time **43** - Social development

8.3 Stage 3.3 – Case Study Interview

Finally, the efficiency, effectiveness, validity and applicability of the framework are recognised and confirmed through a final interview held with a *Mellowcabs* manager as illustrated with the validation process in Figure 8-1 towards the finalised framework. A summary of the case study interview is provided in Table 8-8.

Table 8-8 Summary of the final Mellowcabs case study interview

Quality factor	Descriptive Question	Comments (Answer)
Effectiveness	Does the tool have the capacity to achieve the expected outputs, results, and outcomes?	"Yes – the tool is effective, and as complete as we would want it to be."
Efficiency	Does the tool have the capacity to be effective at a reasonable cost?	"Yes – Taking into account that the tool can be used and implemented by almost anyone."
Applicability & Validity	Is the tool adequate in its means to achieving objectives?	"Yes – It plays a part in decision-making. It influences our product-life evolution, as well as decision-making in the production-process."

Following the conclusion of the framework validation process through conducting the third and final interview round, the enhanced conceptual framework is confirmed as effective, efficient, applicable, and valid. The extensive process preceding the final interview allowed for the development of a comprehensive and complete framework to such extent that no modifications were recommended in the final interview. No adjustments thus had to be made, and only positive feedback was received.

8.4 Chapter 8: Conclusion

The validated enhanced conceptual framework was applied as a management tool to a case study in this chapter towards finalising the conceptual framework and the validation thereof. The *Mellowcabs* initiative was used as case study towards this purpose. The tool delivered an overall sustainability index of $SI = 7.35$ based on the perceived performance of company employees and thus falls into the 'Satisfied' category (between 7 and 8). This value is however based on indicator satisfaction ratings and not performance ratings, meaning that it is limited to the company's perception and satisfaction through value-judgement. The index thus cannot be used to compare *Mellowcabs* to other microtransit companies, but rather only has meaning to the company itself as it provides a perceived standard from which it can aim to further improve this rating (by identifying and improving high-priority indicators). The Importance-Satisfaction analysis allowed for easily identifying high-priority as well as over performing indicators. Presenting the results in the third and final round of interviews to a *Mellowcabs* manager delivered only positive feedback where it was stated that the tool was as complete as they would want it to be. Through confirming that the conceptual framework is effective, efficient, applicable, and valid, the framework was finalised.

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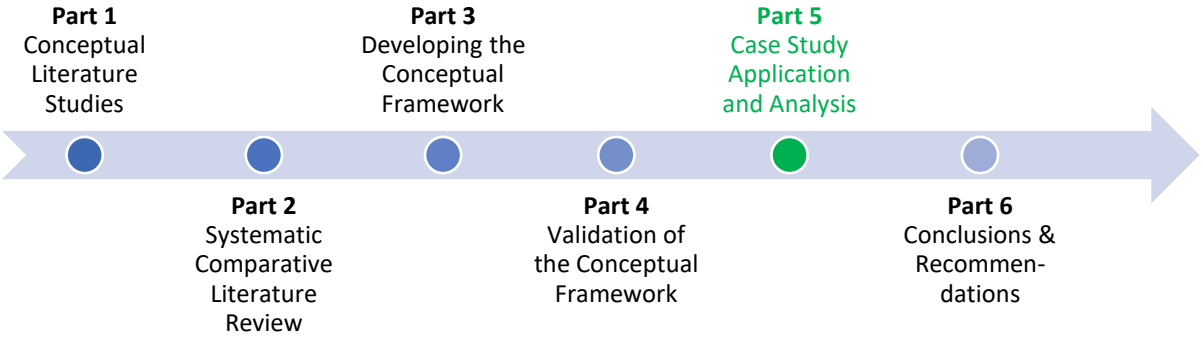
Chapter 9 Case Study Application: GoMetro

Document Structure														
Research Plan	Part 1		Part 2		Part 3			Part 4		Part 5			Part 6	
Stages in Study	1. Two Conceptual Literature Studies		2. Systematic Literature Review					3. Validation			4. Case Study		5. Conclusions & Recommendations	
	Stage 1.1: (Conceptual) Literature Study on Microtransit	Stage 1.2: (Conceptual) Literature Study on M&E	Stage 2.1: Scoping and Planning	Stage 2.2: Identification (Searching)	Stage 2.3: Extensive reading and categori-sation of data	Stage 2.4: Results, Analysis and Interpre-tation	Stage 2.5: Conceptual Framework Development	Stage 3.1: Semi-structured interviews	Stage 3.2: Indicator-weighting interviews	Stage 3.3: Case study interviews	Stage 4.1: Application of the Framework to a Case Study	Stage 4.2: Importance-Satisfaction Analysis (ISA)	Stage 5.1 Conclusions	Stage 5.2 Recommen-dations
Objectives	I.	II.	III.	III.	III. & IV.	III. & IV.	IV.	V.	V.	V.	VI. & VII.	VI. & VII.	-	-
Chapter	Chapter 3	Chapter 4	Chapter 1	Chapter 5	Chapter 6			Chapter 7		Chapter 8 & 9			Chapter 10	

While the conceptual framework was finalised in the previous chapter and validated through case study application, this chapter continues with testing the generalisability of the finalised conceptual framework as a management tool in the broader context of ITS through application to an additional case study: *GoMetro*. Part 5 of the research plan is thus repeated in this chapter to this end. The *GoMetro* initiative is introduced and discussed in Section 9.1.1. Satisfaction ratings and the sustainability index (SI) are then determined in Sections 9.1.2 and 9.1.3 respectively. These results are then used to conduct importance-satisfaction analysis in Section 9.2. Final case study interviews were conducted and the feedback presented and discussed in Section 9.3.

Chapter key outcomes	Introduction to *GoMetro* for case study application
	Satisfaction (perceived performance) measurement
	Determination of sustainability index (SI) values
	Conduct and analyse importance satisfaction analysis (ISA)
	Retrieve feedback through case study interviews and conduct critical reflection
	Compare and discuss the *GoMetro* case study results with the first case study, *Mellowcabs*, towards determining the generalisability of the framework



9.1 Stage 4.1 – Application of the Framework to a Case Study

In order to test the generalisability of the framework in the broader context of ITS, the final framework is applied to a second case study: *GoMetro*. From the research plan, Part 5 is thus repeated towards generating information based on *GoMetro* as a case study. This process will establish whether the final framework which was validated (through the *Mellowcabs* case study for microtransit) is also efficient, effective, applicable, and valid in the broader context of ITS, by case study application through *GoMetro*. The process for the second case study application is illustrated in Figure 9-1. Only following the discussion of what it is that *GoMetro* does (Section 9.1.1), can it be explained why they were identified as the ideal company to use for determining the generalisablity of the framework. Context is thus first provided in Section 9.1.1 and this section then concludes with why *GoMetro* was chosen for the second case study.

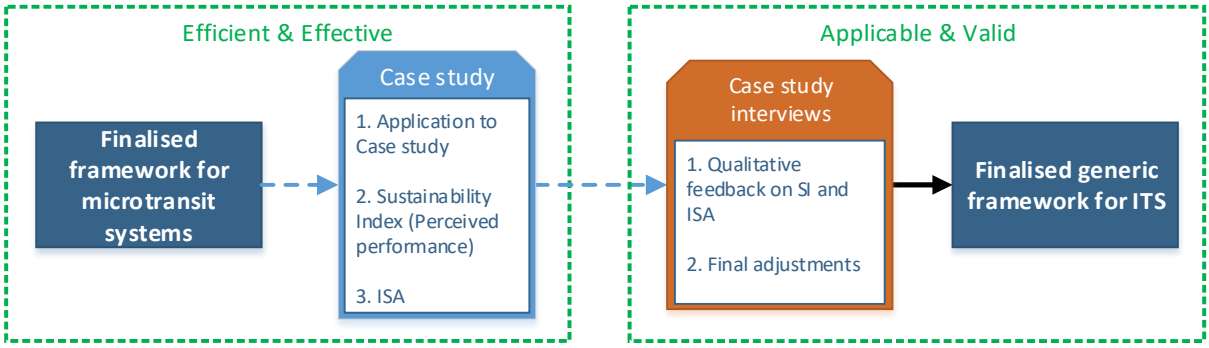


Figure 9-1 Method for case study application towards the finalised M&E framework

9.1.1 Introduction to the GoMetro initiative: A Case Study

GoMetro (Pty) Ltd, hereafter referred to as *GoMetro*, was founded in 2012 in Cape Town, South Africa. The start-up mobility company has developed a data software tool to analyse, plan and roll out transport routes.

GoMetro's self-service application was developed for transport planners for mapping and planning transport routes. This business intelligence and planning platform links with a data manager and planning tool which produces real-time maps and graphs from data that is collected from the smartphone application. The application is however multi-functional as it can be used by transport planners to track any form of mobility: "from walking, to minibus taxis and buses" as stated by the founder and CEO, Justin Coetzee.

According to Coetzee, the platform would enable its users (transport planners and developers) to calculate valuable information such as revenue per specific vehicle on certain routes as well as specific routes that vehicles prefer to take. Companies with fleets would also be able to track their vehicle/bus fleet in real-time and determine through this monitoring when a vehicle is not on route. Users of the platform would still however have to set parameters of a project and do fieldwork based on their unique mobility system (Timm, 2018).

A key focus of Coetzee is to move from the idea of transport to the idea of mobility since simply adding extra lanes would not solve the problem of congestion, and would simply add more cars. Often the solution lies in transport being smaller and more flexible to accommodate people's movements (AllAfrica Global Media, 2018).

GoMetro's approach to improving the way we move is summarised with the following four M's: Measure, Model, Manage, and Move. Movement software was developed based on these elements by combining experience in public transport with technology towards addressing customers' specific transport needs by designing and delivering transport solutions for the future. These elements are discussed in Table 9-1.

Table 9-1 GoMetro's four M's towards improving the way we move

4 M's	Description	Examples
Measure demand	The demand for the transport service considered should be understood and measured to provide insight and enable planning.	a. Measure by surveying ○ Onboard surveys ○ Cordon counts ○ Rank/Terminal counts ○ Passenger satisfaction survey ○ Accessibility survey b. Measure by tracking ○ Location tracking & geofencing ○ Trip route enhanced motion data awareness ○ Seamless integration with any application for ongoing passenger surveying
Model the service	The ratio between supply and demand, as well as inefficiencies are determined from which actionable plans with the right rules, design, and service are generated towards delivering goals.	a. Business rules – The service objective is defined: Network Discovery, Supply and Demand Analysis, Service Network Optimization b. Current system – The supply and demand data of the current system is analysed to identify system inefficiencies and areas to optimize towards improving the service offering. c. Optimize – Various scenarios for service optimization and improvement on inefficiencies are determined. The most viable scenario is selected, and the service optimization outcomes are modelled
Manage operations	Modelling the case-specific rules, design, and service enables the customer to meet specific requirements and deliver specific goals.	a. Planning – Routes & Timetables b. Dispatching – Drivers & Vehicles c. Monitoring – Schedule trip and duty adherence & on-board functionality d. Information – Real-time passenger information and journey planning e. Analytics – Business Intelligence (BI) reporting
Move people	An effective technology-enabled transport solution is delivered for fixed and	The lightweight and cost-effective broad operations solution is supported by software development and advanced technology to ultimately ensure that the transport system improves continuously and adapt

	flexible transport service operations.	to efficient operations and overall improved mobility of people.

While *GoMetro* itself is not a transport company owning vehicles or providing direct transport, they do however provide intelligent transport solutions to existing traditional transport companies. *GoMetro* thus have multiple clients from different contexts of transportation. Through application of their business model with the four M's strategy to specific cases of transport, they then in a sense transform these traditional transport systems into intelligent / "smart mobility" transport companies.

Since *GoMetro*'s approach is not to focus on one specific type of transport (like microtransit), but rather to consider different unique cases of mobility (various clients) and determine how to improve that specific case towards a "smart mobility" solution, *GoMetro* was identified as the ideal company for the second case study for determining whether the developed framework in this research would be applicable to a wider audience of ITS and "smart mobility" besides microtransit for which it was originally designed for and thus generalisable to the broader context of ITS (Coetzee, 2019).

9.1.2 Satisfaction measurement

As in Section 8.1.2, the process for determining the 'perceived performance' through satisfaction ratings will be repeated in this section based on the second case study. While some data might be available for *GoMetro* where it was not yet available for microtransit as it has not yet been fully deployed, satisfaction ratings will again have to be used. This would allow fair comparison between the two case studies since the data will be normalised. As discussed in Section 8.1.2, using satisfaction ratings also makes the evaluation process more feasible, meaning continuous monitoring would be practical for evaluators. Based on the indicator satisfaction ratings, a sustainability index (SI) can again be determined and the data analysed through application of Importance-Satisfaction Analysis (ISA) as a management tool for sustainability assessment.

During application to the second case study, it would be recognised whether the conceptual framework might be used as a management tool through performance measurement. This would enable the company to do Importance-Performance Analysis (IPA), which should give more accurate results as these would be based on real-world performance data. While this was not yet possible for microtransit systems, the second case study might indicate whether this would be possible and practical at this stage.

The survey was thus repeated, but this time focused on *GoMetro*. Since *GoMetro* is a small start-up company, only three individuals were identified as managers/strategists that could be interviewed towards this purpose. These individuals had to provide satisfaction ratings to each of the 50 indicators based on a 10-point satisfaction (perceived performance) Likert-scale as was done in the *Mellowcabs* case study. The same seven categories identified by Freitas (2013), as was shown previously in Table 8-1, was used.

In this case study, the interviewees had to make value-judgements on each indicator based on his/her knowledge and opinion of *GoMetro*'s performance. The results are presented and analysed in Table 9-2. Included are the average (Avg), standard deviation (StDev) and coefficient of variance (CV) for each indicator.

Table 9-2 Indicator satisfaction ratings and analysis

				Satisfaction (perceived performance) & Analysis					
N	Evaluation categories (AoS)	i	Indicators	S1	S2	S3	Avg	StDev	CV
1	Pollution	1	Air Pollution	9	9	8	8.7	0.6	7%
		2	Waste Pollution/ Production	7	8	7	7.3	0.6	8%
		3	Water Pollution	6	7	8	7.0	1.0	14%
		4	Noise Pollution	6	8	9	7.7	1.5	20%
		5	Light Pollution	6	6	8	6.7	1.2	17%
2	Transport resource consumption (renewable & non-renewable)	6	Energy Consumption	7	9	9	8.3	1.2	14%
		7	Infrastructure & Vehicle Materials Consumption	7	8	9	8.0	1.0	13%
		8	Vehicle fuel consumption	9	10	10	9.7	0.6	6%
3	Ecological & Geographical damage / impacts	9	Ecological system	8	5	8	7.0	1.7	25%
		10	Climate change / GHG emissions	9	9	10	9.3	0.6	6%
		11	Land-use	9	9	10	9.3	0.6	6%
4	Initiatives for environmental protection	12	Studies of environmental impacts	7	7	8	7.3	0.6	8%
		13	Investments dedicated to environmental protection	7	5	8	6.7	1.5	23%
		14	Technological maturity of transport system	9	10	10	9.7	0.6	6%
5	(Customer) Service Quality (Level of Service)	15	Comfort	7	7	9	7.7	1.2	15%
		16	Convenience	8	9	10	9.0	1.0	11%
		17	Reliability	8	9	10	9.0	1.0	11%
		18	Driver attitude & appearance	8	7	10	8.3	1.5	18%
		19	Image/ Attractiveness/ Aesthetics	7	6	9	7.3	1.5	21%
		20	General Customer Satisfaction	8	9	10	9.0	1.0	11%
6	Accessibility & Availability	21	Customer accessibility to transport system	9	10	10	9.7	0.6	6%
		22	Transport system accessibility to other locations	8	10	10	9.3	1.2	12%
		23	Social Equity & Inclusion	9	9	9	9.0	0.0	0%
		24	Availability	9	10	9	9.3	0.6	6%
7	Safety & Security	25	Accidents & Prevention	9	10	10	9.7	0.6	6%
		26	Crime	9	6	8	7.7	1.5	20%
		27	Emergency situation control	8	8	6	7.3	1.2	16%
		28	Passenger's perception of & satisfaction with safety level	9	10	9	9.3	0.6	6%
		29	Driver's level of capability	9	9	9	9.0	0.0	0%
		30	Vehicle & Road condition	9	6	10	8.3	2.1	25%
8	Government & Community Involvement	31	Government Interoperability	9	9	8	8.7	0.6	7%
		32	Community Involvement	9	5	8	7.3	2.1	28%
9	Mobility (Travel & Transfer)	33	Time	9	9	10	9.3	0.6	6%
		34	Speed	8	8	10	8.7	1.2	13%
		35	Distance	8	7	8	7.7	0.6	8%
		36	Modal split/ Transit integration	9	10	10	9.7	0.6	6%
		37	General mobility	9	10	9	9.3	0.6	6%
10	Financial Perspective (Costs)	38	Affordability to customer	8	8	9	8.3	0.6	7%
		39	Costs to (private) company (Financial feasibility)	7	6	9	7.3	1.5	21%
		40	Governmental costs (Financial feasibility)	9	9	8	8.7	0.6	7%
		41	Financial security	8	7	9	8.0	1.0	13%
11	Socio-economic	42	Socio-economic development	9	9	8	8.7	0.6	7%
		43	Social development	9	9	8	8.7	0.6	7%
		44	Land development	9	9	8	8.7	0.6	7%
12	(Economic) Productivity of the system	45	Demand	9	9	10	9.3	0.6	6%
		46	Capacity	9	9	10	9.3	0.6	6%
		47	Maintenance	9	9	9	9.0	0.0	0%
		48	Information systems (ICT) / Travel information	9	9	10	9.3	0.6	6%
		49	Way-finding information	9	10	10	9.7	0.6	6%
		50	Overall efficiency (impressions)	9	10	9	9.3	0.6	6%
							Overall average:	0.9	11%

The results obtained from the three individuals from *GoMetro* who were identified as acceptable candidates for making value-judgements based on their level of satisfaction (perceived performance)

with each indicator, again delivered adequate and useful results when analysed. An overall average standard deviation (StDev) for all indicators of 0.9 was obtained and an average coefficient of variance (CV) of only 11% indicating that participants provided similar ratings and were consistent in providing similar value judgements. The indicators that had the most inconsistent ratings and thus the highest coefficients of variance are: Community Involvement (28%), Ecological system (25%), and Vehicle & Road condition (25%).

As with the previous case study, the satisfaction ratings still give an indication of which indictors are performing better or worse than others even though the data might be considered less accurate than factual figures that would be based on hard data. As explained in Section 8.1.2, a normalisation process will not be required in this study since satisfaction ratings already have the same unit and is thus considered normalised. The data in Table 9-2 obtained from the second case study interviews can thus be used to determine the Sustainability Index (SI) value for *GoMetro*.

9.1.3 Determining the Sustainability Index (SI)

In section 8.1.3 it was established that the conceptual framework developed in this study was constructed to deliver a single final value expressing the sustainability performance of the microtransit system under consideration, called the sustainability index (SI). In the second case study, the process for determining a final sustainability index (SI) through aggregation will be identical to the process that was established earlier for microtransit systems. All equations as per section 8.1.3 are thus used to determine the SI and SI_{dom} values for the *GoMetro* case study.

The sustainability index (SI) for the *GoMetro* case study was determined and delivered a final value of $SI = 8.62$. It should be kept in mind that this value is based on internal value-judgements and as such cannot be used to accurately compare the company's relative sustainability performance with similar companies. Sustainability index values could also be determined for each sustainability domain (SI_{dom}). The sustainability indices for each domain were obtained as follows: $SI_{env} = 8.47$; $SI_{soc} = 8.67$; and $SI_{eco} = 8.67$.

Based on the satisfaction (perceived performance) value-judgements of three individuals from *GoMetro*, it can be assumed that the company performs better regarding social and economic development compared to environmental development at this stage. All average index ratings were however between 8 and 9 meaning they fall in the B-Category of Table 8-1 indicating that *GoMetro* is 'Very satisfied' with their sustainability performance based on the participants' results. Similar to the previous case study, these indices are however only indicative of the company's view, and can only be used by the company as benchmarks for future improvements.

9.2 Stage 4.2 – Importance-Satisfaction Analysis (ISA)

While ideally, the importance-performance analysis (IPA) technique originally suggested by Martilla & James (1977) would be preferred for analysing the *GoMetro* case study (Martilla and James, 1977), in Sections 8.1.2 and 9.1.2 it was established that determining performance through variable determination was not a feasible solution at this stage. To allow fair comparison between the two case studies, the exact same approach had to be followed as was done for the *Mellowcabs* case study.

Since satisfaction ratings were used to determine the Sustainability Index (SI) values for *GoMetro*, this means that the result values are normalised and as such can thus be used to conduct Importance-Satisfaction Analysis (ISA). The approach for conducting Importance-Satisfaction Analysis (ISA) was explained in Section 8.2. An approach for clearly distinguishing between indicators' performance values based on their relative importance was introduced in Section 8.2.1 with the development of the 'aim-diagonal'. This would indicate to what extent indicators are 'overperforming' and 'underperforming' considering their relative importance and perceived performance ratings to indicate which indicators must be addressed and prioritised. This approach was used again when determining the final ISA-graphs to analyse the data obtained from the *GoMetro* case study interviews.

9.2.1 Final ISA results and analysis

Using the relative importance values for each indicator that was established previously with the indicator-weighting interviews (Table 8-3) along with the satisfaction value results from the *GoMetro* case study interviews (Table 9-2), the approach for plotting the ISA-graphs, and the approach for determining the 'aim-diagonal', the final ISA-graph for the *GoMetro* case study was determined and is illustrated in Figure 9-2. This process was repeated for each domain specifically based on the relative importance values of each indicator for that domain. The environmental, social, and economic ISA-graphs are depicted in Figure 9-3, Figure 9-4, and Figure 9-5 respectively.

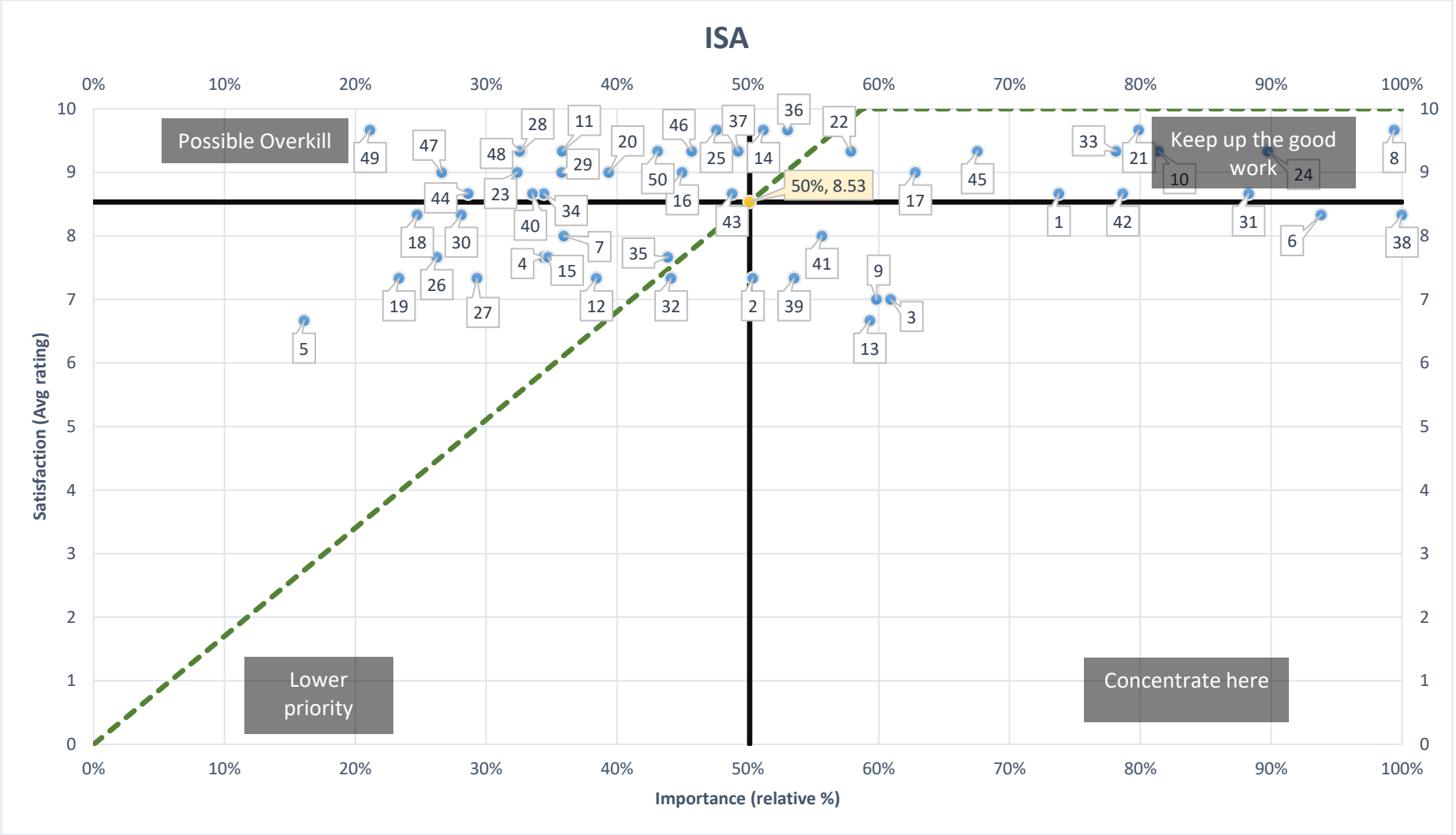


Figure 9-2 Importance-satisfaction analysis (ISA) diagram (GoMetro)

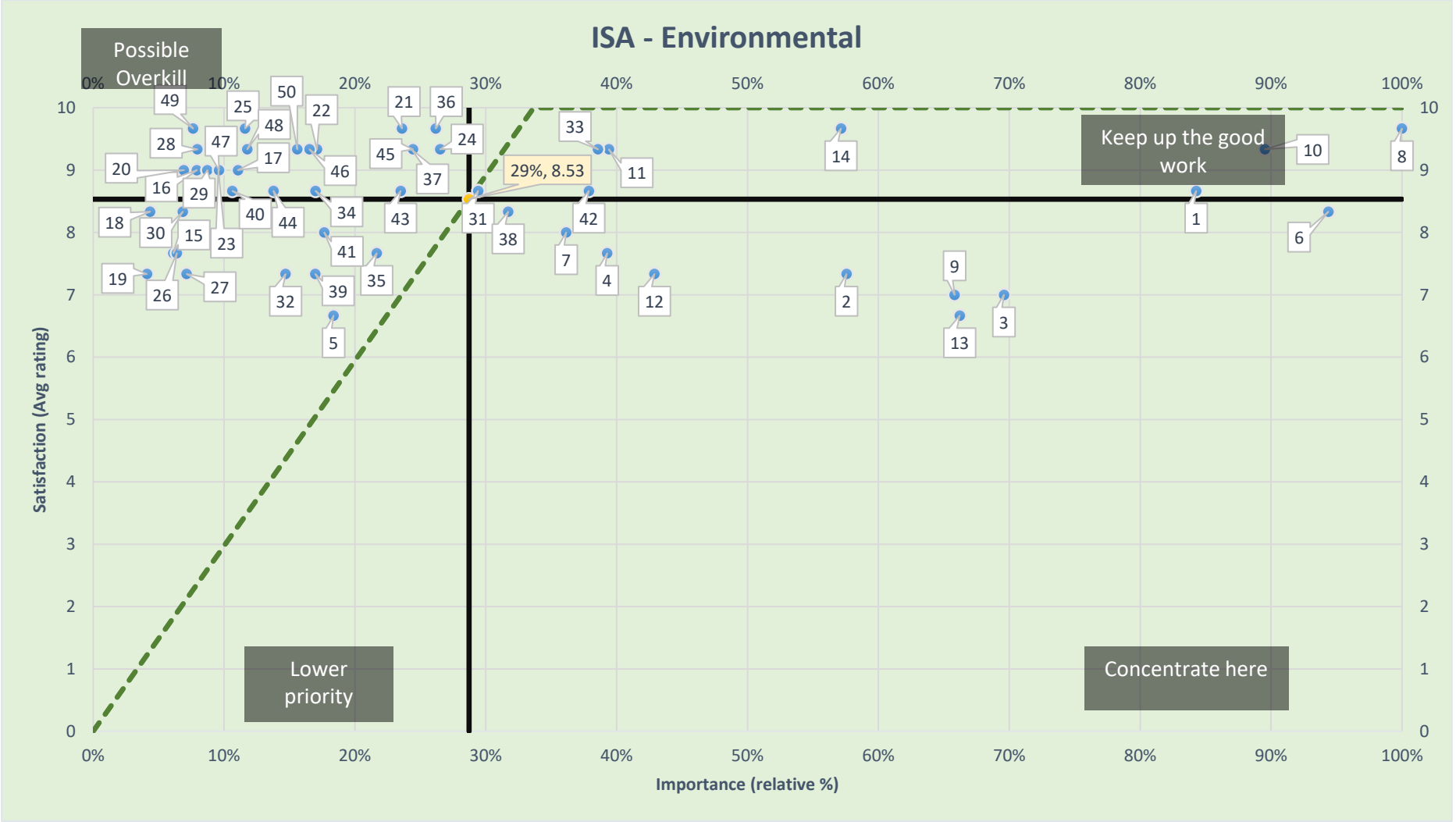


Figure 9-3 Importance-satisfaction analysis (ISA) diagram: Environmental (GoMetro)

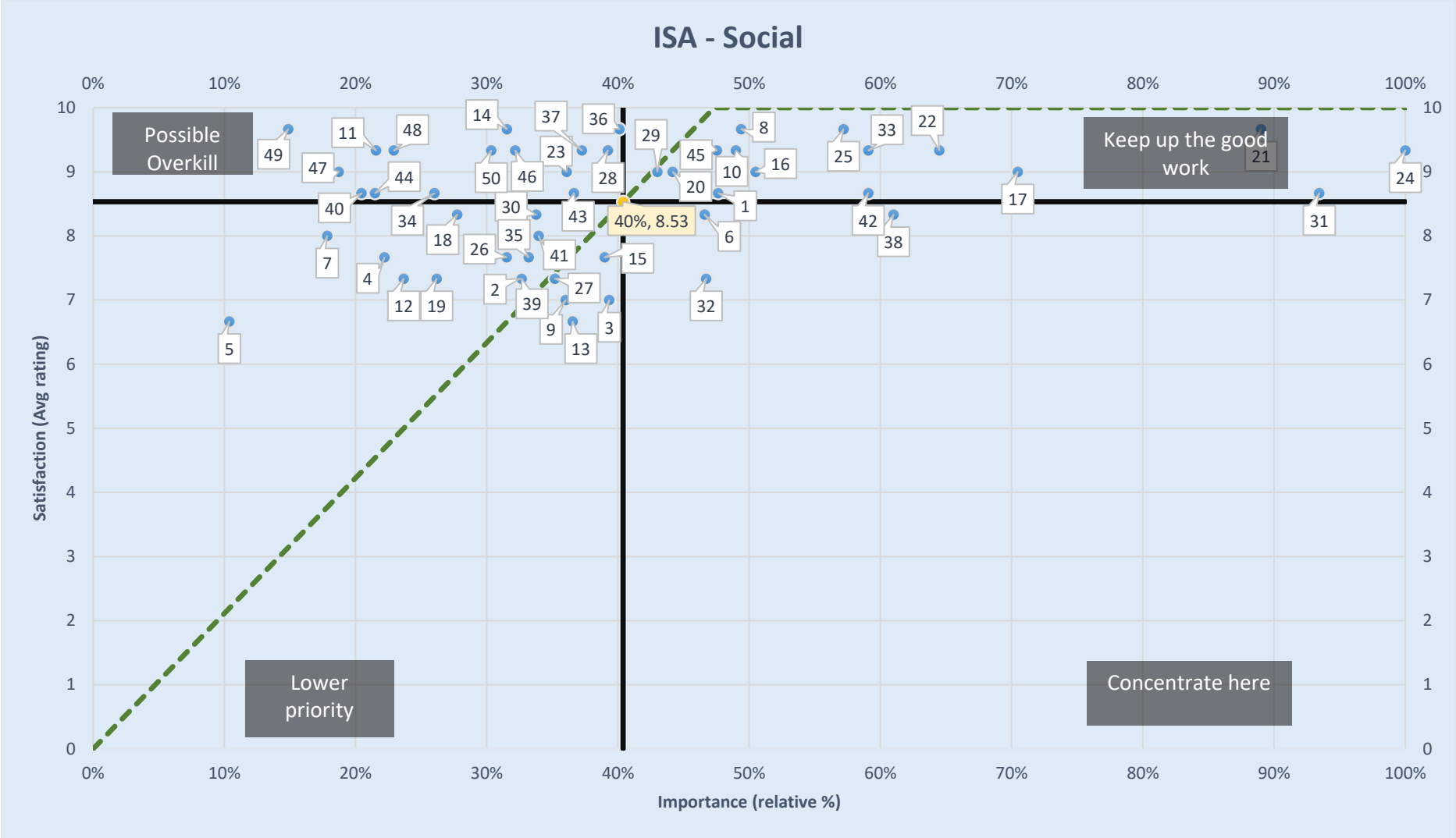


Figure 9-4 Importance-satisfaction analysis (ISA) diagram: Social (GoMetro)

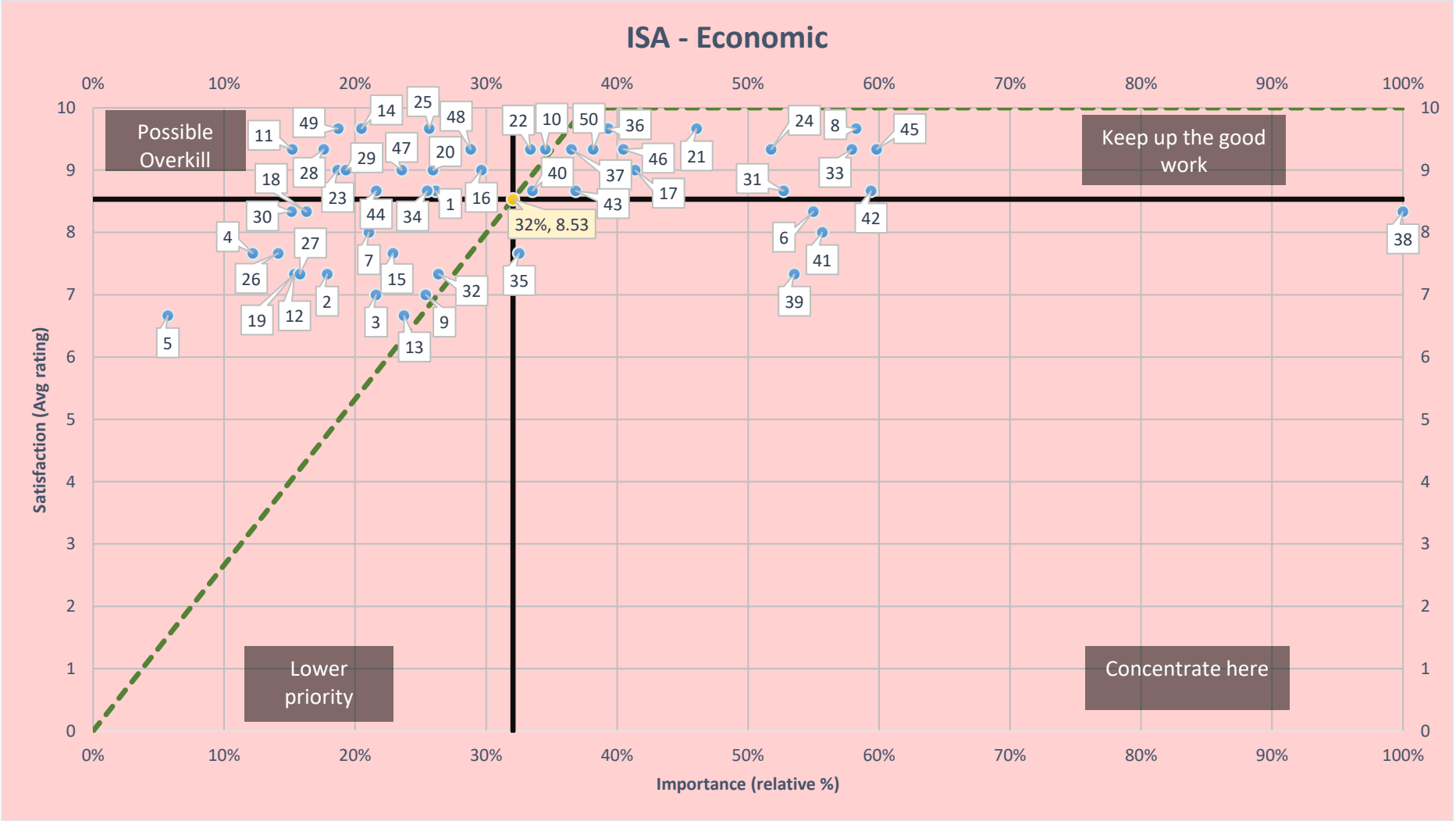


Figure 9-5 Importance-satisfaction analysis (ISA) diagram: Economic (GoMetro)

The results from Figure 9-2 are presented in table-format in Table 9-3. This table includes the vertical distances between each indicator and the "aim-diagonal" as illustrated in the 'Difference' column. The 'Direction' column indicates whether the indicator needs to be improved (>) since it is underperforming and by how much, or whether it is overperforming (and by how much), and resources dedicated to this indicator can be reduced (<).

Table 9-3 Summary of ISA results (GoMetro)

i	*Indicators*	$W_{N,i}$	*Quadrant*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
13	Investments dedicated to environmental protection	0,4	Concentrate here	59%	6,7	10,0	3,3	>
3	Water Pollution	0,26	Concentrate here	61%	7,0	10,0	3,0	>
9	Ecological system	0,34	Concentrate here	60%	7,0	10,0	3,0	>
39	Costs to (private) company (Financial feasibility)	0,22	Concentrate here	54%	7,3	9,1	1,8	>
6	Energy Consumption	0,41	Concentrate here	94%	8,3	10,0	1,7	>
38	Affordability to customer	0,41	Concentrate here	100%	8,3	10,0	1,7	>
41	Financial security	0,23	Concentrate here	56%	8,0	9,5	1,5	>
1	Air Pollution	0,31	Keep up the good work	74%	8,7	10,0	1,3	>
31	Government Interoperability	0,67	Keep up the good work	88%	8,7	10,0	1,3	>
42	Socio-economic development	0,5	Keep up the good work	79%	8,7	10,0	1,3	>
2	Waste Pollution/ Production	0,21	Concentrate here	50%	7,3	8,6	1,2	>
17	Reliability	0,27	Keep up the good work	63%	9,0	10,0	1,0	>
10	Climate change / GHG emissions	0,46	Keep up the good work	81%	9,3	10,0	0,7	>
24	Availability	0,35	Keep up the good work	90%	9,3	10,0	0,7	>
33	Time	0,3	Keep up the good work	78%	9,3	10,0	0,7	>
45	Demand	0,29	Keep up the good work	68%	9,3	10,0	0,7	>
22	Transport system accessibility to other locations	0,22	Keep up the good work	58%	9,3	9,9	0,5	>
8	Vehicle fuel consumption	0,43	Keep up the good work	99%	9,7	10,0	0,3	>
21	Customer accessibility to transport system	0,31	Keep up the good work	80%	9,7	10,0	0,3	>
32	Community Involvement	0,33	Lower Priority	44%	7,3	7,5	0,2	>
35	Distance	0,17	Lower Priority	44%	7,7	7,5	-0,2	<
43	Social development	0,31	Possible Overkill	49%	8,7	8,3	-0,4	<
36	Modal split/ Transit integration	0,2	Keep up the good work	53%	9,7	9,0	-0,6	<
12	Studies of environmental impacts	0,26	Lower Priority	38%	7,3	6,5	-0,8	<
37	General mobility	0,19	Possible Overkill	49%	9,3	8,4	-0,9	<
14	Technological maturity of transport system	0,34	Keep up the good work	51%	9,7	8,7	-1,0	<
16	Convenience	0,2	Possible Overkill	45%	9,0	7,7	-1,3	<
46	Capacity	0,19	Possible Overkill	46%	9,3	7,8	-1,6	<
25	Accidents & Prevention	0,24	Possible Overkill	48%	9,7	8,1	-1,6	<
15	Comfort	0,15	Lower Priority	35%	7,7	5,9	-1,8	<
4	Noise Pollution	0,15	Lower Priority	34%	7,7	5,9	-1,8	<
7	Infrastructure & Vehicle Materials Consumption	0,16	Lower Priority	36%	8,0	6,1	-1,9	<
50	Overall efficiency (impressions)	0,18	Possible Overkill	43%	9,3	7,3	-2,0	<
20	General Customer Satisfaction	0,17	Possible Overkill	39%	9,0	6,7	-2,3	<
27	Emergency situation control	0,15	Lower Priority	29%	7,3	5,0	-2,3	<
34	Speed	0,13	Possible Overkill	34%	8,7	5,9	-2,8	<
29	Driver's level of capability	0,18	Possible Overkill	36%	9,0	6,1	-2,9	<
40	Governmental costs (Financial feasibility)	0,14	Possible Overkill	34%	8,7	5,7	-3,0	<
26	Crime	0,13	Lower Priority	26%	7,7	4,5	-3,2	<
11	Land-use	0,2	Possible Overkill	36%	9,3	6,1	-3,2	<
19	Image/ Attractiveness/ Aesthetics	0,1	Lower Priority	23%	7,3	4,0	-3,4	<
23	Social Equity & Inclusion	0,12	Possible Overkill	32%	9,0	5,5	-3,5	<
30	Vehicle & Road condition	0,14	Lower Priority	28%	8,3	4,8	-3,6	<
28	Passenger's perception of & satisfaction with safety level	0,16	Possible Overkill	33%	9,3	5,6	-3,8	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	33%	9,3	5,5	-3,8	<
44	Land development	0,18	Possible Overkill	29%	8,7	4,9	-3,8	<
5	Light Pollution	0,07	Lower Priority	16%	6,7	2,7	-3,9	<
18	Driver attitude & appearance	0,11	Lower Priority	25%	8,3	4,2	-4,1	<
47	Maintenance	0,11	Possible Overkill	27%	9,0	4,5	-4,5	<
49	Way-finding information	0,09	Possible Overkill	21%	9,7	3,6	-6,1	<

From the final results, we can consider both the quadrant, and the distance from the "aim-diagonal" for each indicator to establish whether the indicator is performing satisfactorily. The overall results in Table 8-6 for the *GoMetro* case study indicated that the top five underperforming indicators are: 1) *Investments dedicated to environmental protection,* 2) *Water Pollution*, 3) *Ecological system,* 4) *Costs to (private) company (Financial feasibility)*, and equally ranked at 5) *Energy Consumption* and

Affordability to Customer. Dedicating resources and improved strategic actions towards these indicators would lead to the most significant improvement of *GoMetro's* sustainability index (SI).

The top five overperforming indicators are: 1) *Way-finding information*, 2) *Maintenance*, 3) *Driver attitude & appearance*, 4) *Light Pollution*, and 5) *Land development*. Thus, resources unnecessarily dedicated to these indicators could be shifted to rather focus on the underperforming indicators with minimum adverse effects on the company's overall sustainability index.

Similar to the previous case study, a strong correlation between the indicators' distance from the "aim-diagonal" and their quadrant is observed. The top five underperforming indicators are all in the 'Concentrate here' quadrant, and three of the top five overperforming indicators fall within the 'Possible overkill' quadrant.

The results when considering each sustainability domain separately were also analysed for the second case study, and are presented in Appendix E for the sake of brevity. Each domain's specific five underperforming indicators were also identified and are listed in Table 9-4. As mentioned previously, a specific domain's sustainability index (SI_{dom}) can be improved significantly by improving its top five underperforming indicators. Three indicators (*Energy Consumption, Affordability to Customer,* and *Government Interoperability*) appear in two of the domains' top five underperforming indicator lists (social and economic domains), of which two are among the top five overall underperforming indicators (*Energy Consumption* and *Affordability to Customer*). The top three underperforming indicators in the environmental domain are all among the top five overall underperforming indicators. Improving these indicators are thus critical for improving *GoMetro*'s overall and domain-specific sustainability index values.

Table 9-4 Top five underperforming indicators for each domain

Environmental	*Social*	*Economic*
13 - Investments dedicated to environmental protection	**32** - Community Involvement	**39** - Costs to (private) company (Financial feasibility)
3 - Water Pollution **9** - Ecological system	**38** - Affordability to Customer	**41** - Financial security
2 - Waste Pollution/Production **12** - Studies of environmental impacts	**6** - Energy Consumption	**6** - Energy Consumption **38** - Affordability to Customer
	1 - Air Pollution **31** - Government Interoperability **42** - Socio-economic development **3** - Water Pollution	**31** - Government Interoperability **42** - Socio-economic development

9.3 Stage 3.3 – Case Study Interview

For the final step of the validation process (illustrated in Figure 9-1), the efficiency, effectiveness, validity and applicability of the framework was evaluated for the *GoMetro* case study, through conducting a case study interview with a *GoMetro* manager similar to what was done in the first case study interview. The same questions from the first case study were asked. The participant's responses are captured in Table 9-5.

Table 9-5 Summary of the final GoMetro case study interview

Quality factor	Descriptive Question	Comments (Answer)
Effectiveness	Does the tool have the capacity to achieve the expected outputs, results, and outcomes?	The participant indicated that the tool will be effective if an expert in the field of sustainability trains *GoMetro* how to use the tool and track the indicators. He recommended that guidance would be required for the first attempt or two of using the management tool, after which *GoMetro* would be able to effectively continue on their own.
Efficiency	Does the tool have the capacity to be effective at a reasonable cost?	If the management tool is used with satisfaction ratings, then yes, the tool can be implemented at a reasonable cost and would be time-efficient since it only requires a few hours to complete. The tool produces valuable output, requiring only a small amount of time.
Applicability & Validity	Is the tool adequate in its means to achieving objectives?	The participant indicated that the framework is all about focus. Since mobility objectives are constantly changing, this tool would assist in identifying what the market wants and needs, then changing the focus towards achieving these objectives. It indicates where time and resources should be spent and where it might be wasted, as well as what areas must be understood better. "For me the tool is both an 'upskilling' tool as well as a 'focus' tool." The tool links the theoretical and academic aspects and the first world requirements with the practical private sector needs. The tool is very good in the sense that it comprehensively captures the current state of sustainability of a specific mobility system. This can then easily be compared to the state of sustainability captured with the tool at any point in time in the future.

Finally, when asked to discuss the possibility of conducting performance measurement instead of satisfaction measurement, the participant indicated that the results from conducting performance analysis would not justify the time and resources it would require. Most of the data would require extensive research and monitoring, and/or the data is not available yet. To have the data readily available would be ideal since this could be used for retrieving capital investments through winning tenders or gaining new clients. Performance values would thus be better and more objective, but would not be feasible to determine due to the mentioned cost and time constraints. Academically this makes sense, but is not yet practical at this stage. Using the tool with satisfaction ratings however makes it feasible and practical to continuously monitor the indicators.

The final stage of the validation process was completed, and it was established that the conceptual framework originally developed for microtransit systems, implemented as a management tool, is also

efficient, effective, applicable, and valid in the broader context of ITS, through case study application to *GoMetro*. The extensive and systematic process towards developing the framework was comprehensive to such an extent that no modifications to the framework were necessary and the feedback received was only positive.

9.4 Chapter 9: Conclusion

The finalised microtransit conceptual framework was applied as a management tool to a second case study in this chapter towards establishing whether it is applicable to the broader context of ITS. The *GoMetro* initiative was used as case study towards this purpose. The tool delivered an overall sustainability index of $SI = 8.62$ based on the perceived performance of company employees and thus falls into the 'Very Satisfied' category (between 8 and 9). This value is however based on indicator satisfaction ratings and not performance ratings, meaning that it is limited to the company's perception and satisfaction through value-judgement. It does, however, have meaning to the company itself as it provides a perceived standard from which it can aim to further improve this rating (by identifying and improving high-priority indicators). The Importance-Satisfaction analysis allowed for easily identifying high-priority as well as overperforming indicators.

The final case study interview with a *GoMetro* manager delivered positive feedback regarding the tool's effectiveness, efficiency, applicability, and validity and confirmed that the conceptual framework originally developed for microtransit systems, implemented as a management tool, is generic in the sense that it can be used outside the scope of microtransit systems, and is also useful and transferable to the broader scope of "smart mobility" or ITS systems. The extensive and systematic process towards developing the framework was comprehensive to such an extent that no modifications to the framework were necessary and the feedback received was only positive.

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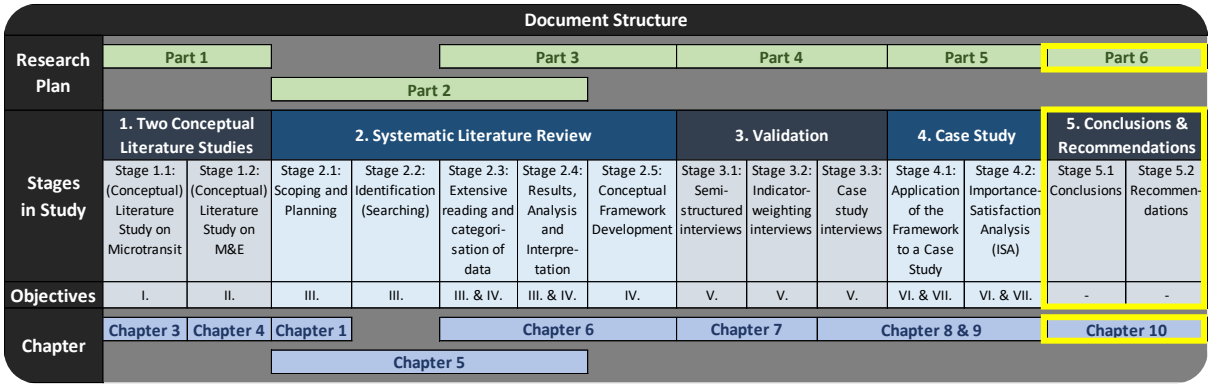
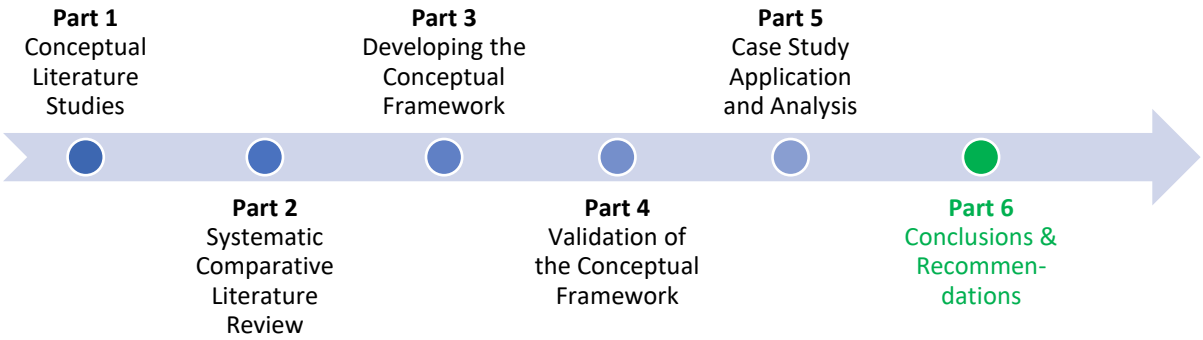
Chapter 10 **Conclusions and Recommendations**



The research study concludes with this chapter. Firstly, conclusions are drawn based on a comparison between the two case studies where the results are analysed and discussed. An overview summary of the different research parts is provided. Conclusions are then drawn pertaining to the objectives of this research and the processes followed in successfully reaching them. A concise description of distinctive contributions to practice is then provided followed by some critical reflection. The final section provides recommendations for future research related to this research study.

Chapter key outcomes	
	Summarise the research study based on the six research parts
	Provide concluding remarks pertaining to the research objectives and achieving them
	Reiteration and explanation of the research study limitations
	Concise description on the distinctive contributions of this research study
	Undergo critical reflection following completion of the research study
	Provide recommendations for framework application and future research



10.1 Stage 5.1 – Conclusions

All conclusions drawn from the research study are discussed in this section in the form of a case study comparison and discussion, an overview summary of the research parts, a discussion on achieving the research objectives, distinctive contributions of this research study, and critical reflection.

10.1.1 Comparing the two case studies

This research study set out to gain a comprehensive understanding of microtransit and develop a novel monitoring and evaluation framework for the sustainability assessment of microtransit systems. Once this was done, the framework was validated through case study application to *Mellowcabs*. This company was chosen since it is the only microtransit company within realistic geographical proximity to the researcher to his knowledge and since validating the framework for microtransit systems could only be done through using a company that is specific to that context. Once this was done, the researcher wanted to determine whether the conceptual framework, originally developed for microtransit systems specifically, is transferable to a broader context of "smart mobility"/ITS. In order to test the generalisability of the framework to this context, the framework had to be validated again, but this time through application to a case study in the context of "smart mobility"/ITS. The *GoMetro* company was identified as ideal towards this end since their approach is to improve various unique mobility systems through using business intelligence and technology: *GoMetro* developed a data software tool to analyse, plan and roll out transport routes, and mobility improvements are made through implementing their "four M's" (Measure, Model, Manage, and Move). While *GoMetro* isn't a transport company, they can be considered as a "smart mobility" company since they transform traditional transport systems into "intelligent" transport systems (ITS). Since *GoMetro* can apply their tool and business model to multiple transport systems and has a variety of clients, they were identified as the ideal company to validate whether the framework developed in this research is transferable to the context of ITS. Using *GoMetro* as case study thus validated the efficiency, effectiveness, applicability and validity of the tool in the context of ITS, since their perspective, background and experience include various transport systems that can be considered as "intelligent" transport systems. The above explanation and context of the case studies in this research study is illustrated simply with Figure 10-1.

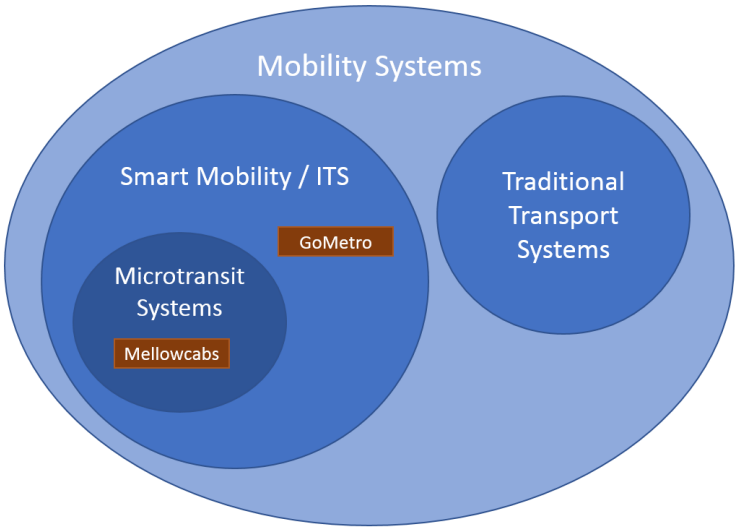


Figure 10-1 Various mobility system contexts

A simple summary of the mobility contexts considered with the two case studies in this research study is provided in Table 10-1.

Table 10-1 Mobility contexts of the two case studies

Element	Mellowcabs	GoMetro
The mobility context considered when evaluating the specific case study	Application to this case study is specific evaluation of the framework based on microtransit systems only.	Application of the framework to this case study means a wider audience of ITS is considered since *GoMetro*, a "smart mobility" company, has experience with a wide variety of "intelligent" transport systems. Generalisability of the final framework is thus tested.

The results from the two case studies are summarised and compared in Table 10-2 to Table 10-5, followed by a discussion on each of these elements' results.

Table 10-2 Comparing the case studies' overall standard deviation and coefficient of variance

Element	Mellowcabs	GoMetro
Overall Average Standard Deviation (StDev)	1.1	0.9
Coefficient of Variance (CV)	16%	11%

The standard deviation and the coefficient of variance for both case studies were low, indicating that participants were consistent in providing indicator ratings. *GoMetro* was slightly more consistent than *Mellowcabs* in providing similar ratings.

Table 10-3 Comparing the case studies' sustainability indices

Element	Mellowcabs	GoMetro
Sustainability Index (SI)	$SI = 7.35$	$SI = 8.62$
Environmental Sustainability Index (SI_{env})	$SI_{env} = 7.76$	$SI_{env} = 8.47$
Social Sustainability Index (SI_{soc})	$SI_{soc} = 7.14$	$SI_{soc} = 8.67$
Economic Sustainability Index (SI_{eco})	$SI_{eco} = 7.30$	$SI_{eco} = 8.67$

Since the sustainability index values are based on indicator satisfaction ratings (internal perceived performance) and not performance ratings, it cannot be used to compare the two case studies directly to each other towards assessing their relative sustainability performance. Instead, these values only have meaning to the company itself as it provides a perceived standard from which it can aim to further improve this rating (by identifying and improving high-priority indicators). At this stage, the meaning of the sustainability indices is limited to the company's perception and satisfaction through value-judgement.

These values can however be used to compare the sustainability of the companies based on their internal perception. Based on this, we see that *GoMetro* has an overall better perception of their sustainability performance than *Mellowcabs* does. The results show that *Mellowcabs* contribute more to environmental sustainable development compared to economic and social development, whereas *GoMetro* performs better with social and economic development compared to environmental development. These values are however open for interpretation and depend on the participants' views, and how critical they are when making these judgements.

Table 10-4 Comparing the case studies' top 5 over- and underperforming indicators

Element	Mellowcabs	GoMetro
Top 5 underperforming indicators	1) Socio-economic development 2) Availability 3) Customer accessibility to transport system 4) Government Interoperability 5) Time	1) Investments dedicated to environmental protection 2) Water Pollution 3) Ecological system 4) Costs to (private) company (Financial feasibility) 5) Energy Consumption AND
Top 5 overperforming indicators	1) ***Light Pollution*** 2) Image/Attractiveness /Aesthetics 3) ***Maintenance*** 4) Noise Pollution 5) ***Way-finding information***	1) ***Way-finding information*** 2) ***Maintenance*** 3) Driver attitude & appearance 4) ***Light Pollution*** 5) Land development

During the final case study interviews, the participants indicated in both cases that the top five identified underperforming and overperforming indictors makes sense. In Table 10-4 it is noted that the top five indicators that performed worst, were completely different in both cases. Different areas were thus identified that the companies must focus on. Improving these indicators will significantly improve their overall sustainability performance. This can be done by shifting the focus and resources spent on overperforming indicators to the underperforming indicators where possible. In Table 10-4 we see that three indicators occurred in both case studies' top five overperforming indicators: *Maintenance*, *Light Pollution, and Way-finding information*. While not a lot of resources are necessarily spent to perform well regarding noise and light pollution for example, some of the other overperforming indicators might have too much resources allocated to them, which might be better spent in underperforming areas.

Table 10-5 Comparing the case studies' effectiveness, efficiency, applicability, and validity

Element	Mellowcabs	GoMetro
Effectiveness - Does the tool have the capacity to achieve the expected outputs, results, and outcomes?	"Yes – the tool is effective, and as complete as we would want it to be."	The participant indicated that the tool will be effective if an expert in the field of sustainability trains *GoMetro* how to use the tool and track the indicators. He recommended that guidance would be required for the first attempt or two of sing the management tool, after which *GoMetro* would be able to effectively continue on their own.
Efficiency - Does the tool have the capacity to be effective at a reasonable cost?	"Yes – Taking into account that the tool can be used and implemented by almost anyone."	If the management tool is used with satisfaction ratings, then yes, the tool can be implemented at a reasonable cost and would be time-efficient since it only requires a few hours to complete. The tool produces valuable output, requiring only a small amount of time.
Applicability & Validity - Is the tool adequate in its means to achieving objectives?	"Yes – It plays a part in decision-making. It influences our product-life	The participant indicated that the framework is all about focus. Since mobility objectives are constantly changing, this tool would assist in identifying what the market wants and needs, then changing the focus towards achieving these objectives. It indicates where time and resources should be

	evolution, as well as decision-making in the production-process."	spent and where it might be wasted, as well as what areas must be understood better. "For me the tool is both an 'upskilling' tool as well as a 'focus' tool." The tool links the theoretical and academic aspects and the first world requirements with the practical private sector needs. The tool is very good in the sense that it comprehensively captures the current state of sustainability of a specific mobility system. This can then easily be compared to the state of sustainability captured with the tool at any point in time in the future.

In Table 10-5 the effectiveness, efficiency, applicability, and validity of the conceptual framework implemented as a management tool are compared between both case studies. Regarding the effectiveness and efficiency, both case studies indicated that the tool is indeed effective and efficient if it is used with satisfaction ratings as was recommended. While *Mellowcabs* indicated that the tool is as complete as they would want it to be and can be implemented by almost anyone, *GoMetro* pointed out that they would require guidance the first few attempts, after which they will be able to use the tool effectively, requiring only a small amount of time and delivering valuable output. In both cases only positive feedback was obtained regarding the applicability and validity of the tool, as it captures the current state of sustainability, and plays a part in decision-making towards shifting the focus and upskilling certain indicators towards addressing needs and improving the over sustainability performance of the company.

Table 10-6 Comparing the possibility of performance instead of satisfaction analysis for both case studies

Element	Mellowcabs	GoMetro
Possibility of conducting performance analysis instead of satisfaction analysis	Not a feasible solution at this stage since microtransit has not yet been fully deployed and data (minimum and maximum benchmark values) are not yet known.	Not a feasible solution since the output it would present, although more accurate than satisfaction ratings, would not justify the resources required to determine these values. The tool is effective with using satisfaction ratings. Performance evaluation should however be feasible in the near future.

In both case studies it was concluded, as stated in Table 10-6, that performance analysis based on hard data is not a feasible solution at this stage, but might be possible and practical in the future.

During the final *GoMetro* interview, the participant pointed out how the framework takes all aspects of sustainability evaluation into consideration which must be considered, especially as would be done and would be possible in first world countries. It was pointed out that in developing world countries, several of the indicators are not even considered as the goal is still 'primitive' in the sense that delivering basic mobility needs and solving current immediate needs are the focus. This is why *GoMetro*'s social and economic sustainability indicators performed better than the environmental sustainability indicators. Their focus is still on delivering basic mobility needs which is different from *Mellowcabs* where their environmental sustainability index outperformed their social and economic

sustainability performance index values due to the niche market that is being targeted. The participant did however point out that the market in developing countries is changing and the need for considering all of these factors would eventually be essential, especially the focus on environmental considerations would increase.

While some of these indicators are difficult to measure and monitor, this should become easier in the near future as the market develops, data becomes available, more emphasis and the need for sustainability increases, and as evolving technology simplifies the way of continuously monitoring the indicators e.g. through automation, using sensors, big data, and machine learning etc. It was also pointed out that the management tool is already helpful since the importance of all the indicators have already been measured.

Comparing the results from the two case studies confirmed that the developed conceptual framework implemented as a management tool is generic in the sense that it is applicable outside the scope of microtransit systems, and useful and transferable to the broader context of "smart mobility"/ITS systems. This instantly increases the value of the framework since it can be used, not only by managers, decisions-makers, or other stakeholders from microtransit systems, but also by similar individuals from the wider context ITS.

10.1.2 Overview summary of research parts

In summary, Table 10-7 provides an overview of the research study and salient points based on its previously defined six parts of the research plan from Section 2.4 in Chapter 2.

Table 10-7 Summary and salient points of each part of the research plan

Part	*Summary & salient points*
Part 1 - Conceptual Literature Studies	Initially, a gap was identified regarding an emerging mode of transport, microtransit, which aims at addressing several current real-world problems and thus would require continuous monitoring and evaluation once it has been rolled out. The research study began with part 1 to set the context and gain a comprehensive understanding of two core concepts of this research study, namely: microtransit, and M&E, through conducting two separate conceptual literature studies. As a greater understanding of the two concepts was gained and the ideas were being integrated, the researcher found that, based on the real-world problems that microtransit aims to address and at the core of microtransit M&E, is the concept of sustainable transport development. The introductory chapter and first conceptual literature study on microtransit were expanded and the research was seen in a new light. From the second conceptual literature study a comprehensive understanding of M&E and its various main paradigms is gained. Put simply, M&E is recognised as a vital aspect for any organisation or institution that aims at progressively improving the performance of any particular activity or service, and reaching goals by achieving certain results. Its major goal is to improve the management of outcomes and outputs by establishing links between past, present and future procedures and decisions. It is recognised that planning and implementation of microtransit systems should be informed by evidence-based M&E to ensure good decision-making, accountability, and efficient management and operation. Since these innovations are relatively new, research on the relationship between sustainability theory and these businesses in a sharing economy is

	scarce. Against this backdrop, the need for a carefully designed M&E framework with appropriate indicators (KPIs) for microtransit systems regarding sustainability assessment is identified.
Part 2 - Systematic Comparative Literature Review	A method was developed for conducting the SLR which comprises two parts. The first is to conduct the systematic comparative literature review in which studies are considered comparatively with high level interpretation and analysis. By exploring the literature with keywords derived from research questions, the gap in literature regarding microtransit systems was confirmed. From a set of identified relevant studies, an overview understanding was first obtained through high-level reading and statistical analysis before constructing the framework based on the studies. The statistical analysis yielded some noteworthy findings. The majority of studies are journal articles (84%) followed by conference papers and reviews (13%). Year of publication analysis delivered a literature publications timeline which illustrated a noticeable increase in research studies, indicative of an increase in interest in the topic in recent years. A geographical analysis indicated a broad spectrum of studies from different countries were gathered thus eliminating geographic biases. However, it was noted that 64% of the publications were conducted by researchers from developed countries. Main components and recurring themes were identified among the final set of publications. Based on frequency of appearance, the three dominant themes identified in the 'Transport' category are 'Urban', 'Public transport' and 'Sustainable', and within the 'M&E' category were 'Framework', 'Strategies, Tools & Planning' and 'Policies/Government' all appearing in about 50% of the identified set of relevant publications. The fact that 'microtransit' appears in only four publications supports the notion that a gap concerning transport exists in literature.
Part 3 - Developing the Conceptual Framework	The first part of the SLR paved the way for the development of the conceptual framework. The final set of relevant studies identified in the first part of the SLR was used towards this purpose. A comprehensive understanding was gained through extensive reading of these studies and extracting data based on the following categories: relevance rating, main objective of study, identified KPIs, number of KPIs, impacts, quantitative/qualitative, methodology (analysis process), and the research approach. The extracted data was used to conduct data analysis, specifically on the study approaches. The most common approach was to determine sustainability performance in some way either through qualitative analysis of its performance or quantitative analyses through typically determining a sustainability index. The latter is closely connected to the second most common approach which is KPI identification. Also among the top five approaches are public perception/customer satisfaction, service quality/level of service (LoS), and conducting surveys. Several of the approaches identified in these papers, including sustainability performance measurement through KPIs, surveys, interviews, public perception and satisfaction, ISA/IPA, and case study application, were used in this research study. While 48% of the studies had a qualitative approach, 30% had a quantitative approach. The rest (23%) conducted both qualitative and quantitative analysis. Some might however argue that studies always contain both approaches to some degree. New relevance ratings were assigned to each paper after extensive reading and analysis. Based on the new relevance ratings and the categorised data, 21 studies were identified from which 807 concepts were identified, deconstructed, categorised, and integrated into 12 AoS, 50 indicators, and 198 variables based on their relevance to and importance to microtransit systems. The occurrence of each concept per publication and per transport type was also identified. From these results, an initial conceptual framework was constructed.

Part 4 - Validation of the Conceptual Framework	The SLR concludes with the validation of the initial conceptual framework towards an enhanced weighted conceptual framework. A separate methodology was designed for completing the validation of the framework. Firstly, a semi-structured interview was conducted with a microtransit company CEO to confirm that the initial conceptual framework is credible, confirmable, relevant, and needed. The option of adding, removing, or modifying any element of the framework was given towards finalising the indicator set. Secondly, elucidation was provided on different indicator-weighting techniques (EWA, AHP, and Likert-scale) followed by conducting indicator-weighting interviews with 7 experts identified by the researcher as appropriate for questioning based on these techniques. The data from these interviews was then analysed and it was decided that due to inconsistencies the results from one of the participants should be removed from consideration for determining the AoS and indicator weights. The framework was then updated and presented as the final enhanced weighted conceptual framework.
Part 5 - Case Study Application and Analysis	The conceptual framework was applied as a management tool to a case study towards validating the framework for microtransit systems. The *Mellowcabs* company was used towards this purpose. Some background information was provided on the company. Performance measurement was considered against determining the perceived performance (satisfaction). The researcher concluded that performance measurement at this stage was not feasible, and as such conducted interviews with three *Mellowcabs* strategists/management individuals for capturing their level of satisfaction regarding each indicator by making value-judgements on a Likert-scale. The method for determining a sustainability index (SI) was described and a value of SI = 7.35 was calculated. An SI was also determined for each sustainability sphere: SI_{env} = 7.76; SI_{soc} = 7.14; SI_{eco} = 7.30. By utilising the weights and the satisfaction ratings, importance-satisfaction analysis (ISA) could be conducted. The five most underperforming indicators were identified that *Mellowcabs* should focus on and aim to improve, as well as five indicators that are considered less important and might be overperforming. A final interview with a *Mellowcabs* manager confirmed the effectiveness, efficiency, applicability, and validity of the framework as a management tool. The generalisability of the framework was then tested in the broader context of ITS through a second case study application: *GoMetro*. Background information of the company was firstly provided. The same process as in the first case study was then followed to determine the sustainability index, SI = 8.62, as well as for each sustainability sphere: SI_{env} = 8.47; SI_{soc} = 8.67; SI_{eco} = 8.67. Importance-satisfaction analysis was conducted again and the five most under- and overperforming indicators were identified. A final case study interview was then conducted with a *GoMetro* manager, the results were discussed, and the effectiveness, efficiency, applicability, and validity of the framework as a management tool was again confirmed, but this time in the context of ITS.
Part 6 - Conclusions & Recommen-dations	In the sixth and final part of this research study, conclusions are drawn and recommendations made. Firstly, conclusions are drawn through comparing the two case studies. Following an overview summary of the different parts of this research, a discussion is provided on how each research objective has been achieved, limitations of this research are taken into account, distinctive contributions to the body of knowledge and to practice are explained, and critical reflection is undergone. The final section provides recommendations on the application of the tool for decision-makers and stakeholders, as well as recommendations to researchers and academics on future research.

10.1.3 Reaching the research objectives

The primary aim of this research is to contribute to the development of microtransit systems through constructing a conceptual M&E framework pertaining to sustainability. Six research objectives were introduced in Section 1.2.2 from Chapter 1 towards achieving this main goal:

I. Obtain a comprehensive understanding of microtransit and its current state of understanding
II. Explore and fully understand the process of Monitoring and Evaluation (M&E) and recognize. how to apply the obtained knowledge towards constructing a conceptual framework for microtransit systems.
III. Gain an overview understanding when combining the concepts of microtransit and M&E towards identifying key approaches and core concepts for a microtransit M&E framework.
IV. Develop the microtransit M&E conceptual framework.
V. Validate the microtransit M&E conceptual framework.
VI. Apply the validated framework to a case study as a management (M&E) tool for assessing its effectiveness and applicability in the context of an existing microtransit company.
VII. Test the generalisability of the finalised framework in the broader context of ITS by application to a second case study

Table 10-8 explains how each of the above-mentioned research objectives was achieved successfully.

Table 10-8 Conclusions pertaining to reaching the research objectives

Objective	*Stage(s)*	*Conclusions*	*Reference(s)*
I.	1.1	The first of two conceptual literature studies was undertaken exploring the concept of microtransit to complete the first objective. Background information is given on concepts fundamental to understanding microtransit systems: ✓ Sustainable development is defined and discussed ✓ Towards exploring transport sustainability ✓ The concept of a sharing economy ✓ Shared mobility/ride-sharing All available literature that could be found on microtransit was used to explore, discuss, and finally define microtransit. Potential strengths, weaknesses, opportunities and threats were then considered briefly.	Chapter 1, 3
II.	1.2	The second conceptual literature study focused specifically on Monitoring and Evaluation (M&E) to fully grasp what it entails. The following main points were explored towards this purpose: ✓ The history of evaluation ✓ Intervention logic/The logic model ✓ General definition of evaluation ✓ Types of evaluation ✓ Purposes of evaluation ✓ Main paradigms/theories in evaluation ✓ General definition of monitoring ✓ Types of monitoring ✓ Differences between monitoring and evaluation ✓ The concept of M&E toward framework development	Chapter 1, 4

		✓ Assessing the quality of M&E An extensive and comprehensive M&E literature study was considered critical for laying the theoretical foundation and ensuring the researcher has a good grasp on what the field entails. This ensured that the correct type of M&E is considered based on an appropriate main paradigm/theoretical lens in a way adequate for the purpose it is intended for.	
III.	2.1-2.4	For completing this objective, a systematic comparative literature review is conducted through stages 2.1-2.4, which constitutes the first part of the SLR. Key approaches and core concepts regarding M&E of microtransit were identified and discussed by completing the comparative review stages and an overview understanding was gained by conducting statistical analysis on the findings. The following was completed towards these purposes: ✓ Formulate research questions and identify keywords ✓ Specify inclusion and exclusion terms ✓ Identify and choose data sources ✓ Define data selection criteria and selection process ✓ Identify a set of studies relevant to the scope of this research ✓ Gain an overview understanding through high-level reading ✓ Conduct descriptive statistical analysis based on: o Number of publications per document type o Literature publications timeline o Geographic analysis o Relevance of publications o Citations o Recurring themes and frequency of appearance Following the data analyses, extensive reading of the final set of relevant studies enabled data extraction and categorisation. From the extracted data, key approaches and core concepts were identified.	Chapter 5, 6
IV.	2.3-2.5	From the final set of relevant studies, the second part of the SLR is executed towards completing the fourth objective. Conducting data analyses on the key approaches and core concepts identified through achieving the third objective paved the way for framework development. The extracted data was thus used to: ✓ Identify core concepts ✓ Deconstruct and categorise concepts ✓ Integrate concepts into an initial framework	Chapter 6, 7
V.	3.1-3.3	The fifth objective was achieved through developing a validation methodology, and completing its subsequent steps: ✓ Conduct a semi-structured interview with a microtransit expert to verify and finalise the list of indicators ✓ Elucidation on various techniques and methods (EWA, AHP, and Likert-scale) employed for weighing indicators ✓ Identify experts based on scope of research study	Chapter 6, 7

		✓ Conduct indicator-weighting interviews with experts ✓ Analyse data from interviews ✓ Update and present the final enhanced conceptual framework	
VI.	4.1-4.2	The sixth objective is achieved by applying the conceptual framework as a management tool to a microtransit case study towards confirming its efficiency and effectiveness. Application of the framework as a management tool is done by: ✓ Establishing company employees' perceived performance (level of satisfaction) of the indicators ✓ Compute the overall SI, as well as the SI values for each sustainability sphere ✓ Conduct ISA towards analysing the company and make recommendations based on the results. Feedback from the case study confirmed the effectiveness, efficiency, applicability and validity of the conceptual framework and the use thereof as a management tool in the context of microtransit systems.	Chapter 8
VII.	4.1-4.2	The final objective in establishing the generalisability of the framework in a broader context of mobility/ITS than microtransit, is achieved through application of the tool to a second case study. Application of the framework as a management tool is repeated: ✓ Establishing company employees' perceived performance (level of satisfaction) of the indicators ✓ Compute the overall SI, as well as the SI values for each sustainability sphere ✓ Conduct ISA towards analysing the company and make recommendations based on the results. Feedback from the second case study analysis evaluated the effectiveness, efficiency, applicability and validity of the conceptual framework and the use thereof as a management tool in the broader context of ITS/"smart mobility" systems. A comparison analysis between the two case studies tested and confirmed the generalisability of the framework as a management tool in the wider context of ITS.	Chapter 9

10.1.4 Distinctive contributions and implications of this research

This section provides a concise description on the distinctive contributions of this research study by answering the following questions:

I. <u>How does this study contribute to the body of knowledge?</u>

Comprehensive literature studies on M&E and microtransit systems combined with the extensive and systematic review process of research paper identification, concept identification, deconstruction, categorisation, integration, and synthesis allowed for the development of a novel conceptual framework for microtransit systems evaluation. A validation process through semi-structured and indicator-weighting interviews allowed for validating that the framework is credible, confirmable,

relevant and needed. It also ensured the reliability, usefulness, efficiency, effectiveness, applicability, and validity of the framework towards the final enhanced conceptual framework for monitoring and evaluating microtransit systems. The generalisability of this framework was then established and it was deemed usefull and transferable to the wider context of ITS.

II. For whom is the framework designed and who can utilise the tool?

While this research study sets out to develop a conceptual framework for monitoring and evaluating microtransit systems specifically, it ended up developing a framework that would be applicable to and useful for similar shared mobility or 'smart mobility'/ITS modes of transport as well. This includes any mode of transport that is based on the sharing economy and involve IoT and/or ICT and typically focus on first-and-last-mile transport in densely populated areas. The conceptual framework provides these alternative modes of transport with a tool which they can use to assess their current contribution to sustainable development (sustainability performance) in a variety of areas and by determining an overall sustainability index (SI) which can then be compared to other mobility systems based on perceived performance. An environmental, social, and economic sustainability index can also be determined and compared to other mobility systems.

The developed framework is not meant for application to traditional transport systems. Although the conceptual framework with its approach to determining a sustainability index and conduct ISA or IPA does not fit all transport contexts, the approach employed in this study in developing such a framework and its method of analysis towards a management tool is universally transferable to different contexts.

III. What are the short- and long-term implications of this research?

For companies, managers, policy-makers or any stakeholder of an ITS/microtransit system to gain an improved understanding of its sustainability performance, quantification such as an index framework is essential. By using such frameworks, its comprehensive outcomes could provide new perspectives differing from conventional transportation metrics. These results would prove useful for short-term system evaluations and provide guidance on decision-making. In the long-term, it would prove useful in achieving overall goals iteratively through continuous monitoring and conducting regular evaluations.

10.1.5 Critical reflection

Similar to realistic evaluation discussed in Section 4.3.3 and Figure 4-8 where a mechanism is applied to a regularity to aim at changing the outcome, the developed conceptual M&E framework was applied as a management tool to a case study to determine the perceived performance of certain indicators. By identifying underperforming indicators, activities could be adjusted/applied to these areas to address them. Through continuous monitoring of the indicators, it is possible to see how their (perceived) performance change and whether the newly applied/adjusted activities (mechanisms) had the desired effects (outcomes). It is important to determine whether the applied M&E framework is in line with strategic objectives and has the desired impacts and also whether it is in line with operational objectives and has the desired results. While it is clear that a transport system like microtransit requires a tool to monitor and evaluate the system, it is just as important to continuously also evaluate the tool itself. This is considered further in Section 10.2.1.

It is also significant to note that while some AoS consists of several indicators, others might only have two or three indicators under them. This influenced the weight distribution since the sum of the indicators was always equal to 1 for each AoS. Fewer indicators would thus automatically mean higher weightings per indicator of that AoS. It was however believed that also weighting each AoS would account for the aforementioned problem since the relative importance of each AoS will be known and influence the indicators it is comprised of. Also, it is not realistic to have an equal number of indicators under each AoS as a variety of factors make up each AoS.

It was also noted that technological maturity was not ranked as important as the researcher expected it to be. This was surprising since technology (ICT and ITS) is essentially at the core of microtransit systems and "smart mobility" modes of transport. It might be that this was not stated clearly enough to the expert participants, or that they merely did not believe that it is as essential for sustainability considerations as the researcher of this study expected it to be. Future application of the framework once the microtransit systems have been fully deployed would further clarify the importance of indicators and elucidate whether the 'technological maturity' indicator, as well as other indicators, should be weighted differently.

10.1.6 Limitations of this research: Reiteration and reflection

When interpreting the findings of this research study, the following limitations should be recognised and taken into account:

- The researcher recognises that while a systematic sampling approach was employed and yielded a useful final set of relevant articles, some relevant studies may have failed to be identified. However, it is believed that prior literature reviewal and proper keyword identification mitigated this risk.
- Being an extremely wide-ranging, multi-disciplinary and complex field, sustainability could only be considered comprehensively on a conceptual level through indicator identification. While some variables are suggested for calculating indicators, the researcher recognises that additional field-specific research regarding each indicator is needed towards refinement and improved accuracy of the conceptual framework.
- The developed conceptual framework thus serves as a 'foundational skeleton' for institutions, organisations or any stakeholders to which variables could easily be added, removed and/or modified. The framework is thus conceptual and would require further additional research and validation through experts prior to achieving a generic model for application to any particular microtransit system.
- Geographically, the conceptual framework was developed for application to small-scale transport systems within urban areas (e.g. cities) or other densely populated areas (e.g. towns where many people reside, universities etc.), and not rural areas with sparse populations.
- From a technological perspective, the conceptual framework was developed for application to microtransit systems (or similar ITS or 'smart mobility' transport) utilising ICT and IoT towards a demand-responsive and/or shared mobility service, and not for traditional modes of transport.
- The validation of the framework was dependent on and partially restricted by the availability, willingness, and scarcity of identified experts in the field of microtransit or even more generally 'smart mobility'. Also, no government officials could be included in the final set of

experts interviewed due to unavailability. A total of seven experts were interviewed of which the value-judgements of six delivered useful results.

While the conceptual framework could be used as a management tool, the application thereof by means of a case study in this research is limited due to the following reasons:

- The management tool can only be applied towards satisfaction measurement, and not performance measurement since required data for several variables are not available at this stage as microtransit systems have not yet been fully deployed, and some data are not available for ITS systems.
- The tool is applied through limited satisfaction measurement interviews as only three respondents from each case study company, *Mellowcabs* and *GoMetro*, had adequate knowledge and were available.
- The number of case study applications at this stage is limited by the contemporary nature of ITS and microtransit systems and the existence of such companies. No iterative process was undergone for improving the tool based on multiple practical case study applications to similar companies – the tool could only be applied once to a single microtransit company, *Mellowcabs*, as case study since it is the only company within realistic geographical proximity to the researcher to his knowledge, and once to an ITS company, *GoMetro*, that was identified as ideal towards determining the generalisability of the framework.

10.2 Stage 5.2 – Recommendations

For the final stage of this research study, recommendations are suggested to 1) decision-makers, policy-makers or any stakeholder who plan on utilising the management tool developed from the conceptual framework, as well as to 2) researchers and academics for possible future research.

10.2.1 Recommendations to stakeholders concerning tool application

It should be noted that sufficient knowledge of the transport system under consideration is required prior to application of the conceptual framework as a management tool. This is to ensure that the tool developed in this research study is suitable for the transport system requiring evaluation, and that application of the tool is conducted adequately.

Once ITS and microtransit systems have been fully deployed and hard data become available so that the framework can be applied in its current form towards determining performance values (and not having to rely on less accurate satisfaction ratings) for each indicator, the framework should be assessed based on the quality of its M&E. Based on Table 4-8 in Section 4.5 which provides the standard criteria for assessing the quality of M&E, Table 10-9 below can be used towards this purpose by providing discussions and critical reflection on the framework after it has been applied several times.

Table 10-9 Criteria for assessing the quality of M&E

Criteria	*Description*	*Reflecting on M&E framework*
Utility	The M&E framework serves the practical information needs of its intended users.	*Conduct critical reflection*

Feasibility	The M&E methods, timing, sequences and procedures for processing are realistic, prudent, and cost-effective and thus both efficient and effective.	*Conduct critical reflection*
Propriety	All M&E activities are conducted legally and ethically. The welfare of those affected by the results is also considered.	*Conduct critical reflection*
Accuracy	The outputs from the M&E system will reveal and convey information that is technically adequate, trustworthy, and dependable.	*Conduct critical reflection*

Through application of the M&E framework developed in this research to ITS and microtransit systems once they have been fully deployed, the M&E framework must be evaluated continuously according to above-mentioned criteria to determine where, if any, adjustments would be necessary.

10.2.2 Recommendations to researchers for future work

A contribution to the body of knowledge in the form of a conceptual framework for ITS and microtransit systems is presented by this research study. However, throughout the research process and following completion thereof, recommendation for future studies was recognised:

- While the framework is very extensive, it is considered necessary at this stage in order to consider all significant factors. Future work might be to simplify or reduce the list (make it shorter and easier to determine) even further without sacrificing its comprehensiveness while still increasing its effectiveness.
- Re-consideration of the conceptual framework through the eyes of researchers from multiple disciplines relevant to sustainable development since sustainability is a vast field and can be considered through various lenses and perspectives as researchers from different disciplines could prioritise different elements.
- In-depth research into each of the 50 indicators can be undertaken by experts in the respective fields toward further validation, modification and addition of their key variables, their units for measurement, and appropriate relative weightings based on the priority of the variables pertaining to that particular expert's field.
- Further research could be undertaken into the respective indicators as mentioned above, especially re-evaluating the role of technology and technological maturity in microtransit systems and similar "smart mobility" modes of transport since the researcher believes these indicators should be weighted more heavily. The case studies however revealed that this would not be possible at this stage since not enough data is available, but can be considered in the future.
- While the developed index framework was designed for the specific context of microtransit systems, the approach employed in this study in developing such a framework and its method of analysis towards a management tool can easily be repeated and is universally transferable to different contexts.

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Appendix A – Final set of relevant articles for SLR

Table A-1 Final list of identified relevant articles used in SLR

ID	Year	Author(s)	Title	Reference
1	2017	C. Frei, M. Hyland, H. Mahmassani	Flexing service schedules: Assessing the potential for demand-adaptive hybrid transit via a stated preference approach	(Frei, Hyland and Mahmassani, 2017)
2	2017	Lin, Liang-Tay	Role of governance in the achievement of 20-fold increase in bus ridership – A case study of Taichung City	(Lin *et al.*, 2017)
3	2017	Munira, Sirajum	Examining public perception over outcome indicators of sustainable urban transport in Dhaka city	(Munira and Santoso, 2017)
4	2016	Rohde J., Völz B., Mielenz H., Zöllner J.M.	Precise vehicle localization in dense urban environments	(Rohde *et al.*, 2016)
5	2016	Lanka S., Jena S.K.	On-road vehicle information processing framework for Advanced Traveler Information Systems	(Lanka and Jena, 2016)
6	2016	Shaheen S., Chan N.	Mobility and the sharing economy: Potential to facilitate the first-and last-mile public transit connections	N/A
7	2016	Cheyne, M. Imran	Shared transport: Reducing energy demand and enhancing transport options for residents of small towns	(Cheyne and Imran, 2016)
8	2016	Reynolds J.H., Knutson M.G., Newman K.B., Silverman E.D., Thompson W.L.	A road map for designing and implementing a biological monitoring program	(Reynolds *et al.*, 2016)
9	2016	Mulley, Corinne	Workshop 8 report: The wider economic, social and environmental impacts of public transport investment	(Mulley and Weisbrod, 2016)
10	2016	Boltze, Manfred	Approaches to Achieve Sustainability in Traffic Management	(Boltze and Tuan, 2016)
11	2016	Gschwender, Antonio	Using smart card and GPS data for policy and planning: The case of Transantiago	(Gschwender, Munizaga and Simonetti, 2016)
12	2016	Ustaoglu, Eda	Integrating CBA and land-use development scenarios: Evaluation of planned rail investments in the Greater Dublin Area, Ireland	(Ustaoglu, Williams and Murphy, 2016)
13	2016	Hernandez, Sara	Urban transport interchanges: A methodology for evaluating perceived quality	(Hernandez, Monzon and de Oña, 2016)

ID	Year	Author(s)	Title	Reference
14	2016	Emerson, David	A theoretical analysis of business models for urban public transport systems, with comparative reference to a Community Franchise involving Individual Line Ownership	(Emerson, Mulley and Bliemer, 2016)
15	2016	Machado-León, José Luis	The role of involvement in regards to public transit riders' perceptions of the service	(Machado-León, de Oña and de Oña, 2016)
16	2016	Fuggini, Clemente	Towards a Comprehensive Asset Integrity Management (AIM) Approach for European Infrastructures	(Fuggini *et al.*, 2016)
17	2016	Yang, Chih-Hao	Incorporating carbon footprint with activity-based costing constraints into sustainable public transport infrastructure project decisions	(Yang, Lee and Chen, 2016)
18	2016	de Oña, Juan	Index numbers for monitoring transit service quality	(de Oña *et al.*, 2016)
19	2016	[No author name available]	Between public and private mobility: Examining the rise of technology-enabled transportation services	N/A
20	2015	Allam A., Onori S., Marelli S., Taborelli C.	Battery Health Management System for Automotive Applications: A retroactivity-based aging propagation study	(Allam *et al.*, 2015)
21	2015	Born P.H., Dumm R.E., Eger R.J., III	Developing a framework for financial achievability of department of transportation research and development projects	(Born, Dumm and Iii, 2015)
22	2015	Imran, Muhammad	Auckland's first spatial plan: Ambitious aspirations or furthering the status quo?	(Imran and Pearce, 2015)
23	2015	Placido, Antonio	A Methodology for Assessing the Feasibility of Fleet Compositions with Dynamic Demand	(Placido and D'Acierno, 2015)
24	2015	Corazza, Maria Vittoria	The European Bus System of the Future: Research and Innovation	(Musso and Corazza, 2015)
25	2015	Ricci, Miriam	Bike sharing: A review of evidence on impacts and processes of implementation and operation	(Ricci, 2015)
26	2015	Jennings, Gail	Finding our balance: Considering the opportunities for public bicycle systems in Cape Town, South Africa	(Jennings, 2015)
27	2015	Macharis, Cathy	Reviewing the use of Multi-Criteria Decision Analysis for the evaluation of transport projects: Time for a multi-actor approach	(Macharis and Bernardini, 2015)
28	2014	Onatere J.O., Nwagboso C., Georgakis P.	Performance indicators for urban transport development in Nigeria	(Onatere, Nwagboso and Georgakis, 2014)

ID	Year	Author(s)	Title	Reference
29	2014	Kesten A.S., Ögüt K.S.	A New Passenger-Oriented performance Measurement framework for public Rail transportation systems	(Kesten and Ögüt, 2014)
30	2014	Stanley, John	Workshop 6 Report: Delivering sustainable public transport	(Stanley and Lucas, 2014)
31	2014	Georgiadis, Georgios	Measuring and improving the efficiency and effectiveness of bus public transport systems	(Georgiadis, Politis and Papaioannou, 2014)
32	2014	Isabello, Andrea	Reviewing Efficiency and Effectiveness of Interurban Public Transport Services: A Practical Experience	(Isabello *et al.*, 2014)
33	2014	Liou, James J.H.	Improving transportation service quality based on information fusion	(Liou, Hsu and Chen, 2014)
34	2013	Ozbay K., Bartin B., Mudigonda S., Iyer S.	ASSIST-ME	(Ozbay *et al.*, 2013)
35	2013	López-Lambas M.E., Corazza M.V., Monzon A., Musso A.	Rebalancing urban mobility: A tale of four cities	N/A
36	2013	Şimşek B., Pakdil F., Dengiz B., Testik M.C.	Driver performance appraisal using GPS terminal measurements: A conceptual framework	(Simsek *et al.*, 2013)
37	2013	Stanley, John	Workshop 3A: Governance, contracting, ownership and competition issues in public transport: Looking up not down	(Stanley and Smith, 2013)
38	2013	Zhao, Jinhua	Unified estimator for excess journey time under heterogeneous passenger incidence behavior using smartcard data	(Zhao *et al.*, 2013)
39	2013	Nelson, John D.	The impact of the application of new technology on public transport service provision and the passenger experience: A focus on implementation in Australia	(Nelson and Mulley, 2013)
40	2013	Tsamboulas, D.	Transport infrastructure provision and operations: Why should governments choose private–public partnership?	(Tsamboulas, Verma and Moraiti, 2013)
41	2013	Gwilliam, Kenneth	Cities on the move – Ten years after	(Gwilliam, 2013)
42	2013	Klinger, Thomas	Dimensions of urban mobility cultures – a comparison of German cities	(Klinger, Kenworthy and Lanzendorf, 2013)
43	2013	Freitas, André Luís Policani	Assessing the quality of intercity road transportation of passengers: An exploratory study in Brazil	(Freitas, 2013)

ID	Year	Author(s)	Title	Reference
44	2013	Zheng, Jason	Guidelines on developing performance metrics for evaluating transportation sustainability	(Zheng *et al.*, 2013)
45	2012	Zheng, Jie	Strategic policies and demonstration program of electric vehicle in China	(Zheng *et al.*, 2012)
46	2012	Medda, Francesca	Land value capture finance for transport accessibility: a review	(Medda, 2012)
47	2012	Politis, Ioannis	Integrated Choice and Latent Variable Models for evaluating Flexible Transport Mode choice	(Politis, Papaioannou and Basbas, 2012)
48	2012	Lindholm, Maria	Challenges in urban freight transport planning – a review in the Baltic Sea Region	(Lindholm and Behrends, 2012)
49	2012	Miranda, Hellem de Freitas	Benchmarking sustainable urban mobility: The case of Curitiba, Brazil	(Miranda and Rodrigues da Silva, 2012)
50	2012	Diana, Marco	Measuring the satisfaction of multimodal travelers for local transit services in different urban contexts	(Diana, 2012)
51	2011	Yi-Zhong F.	Performance measurement of the U.S.'s service management and its enlightment to China: Examples from the transportation service subsidy of the United States	N/A
52	2011	Moreland K., Ogle J., Chowdhury M.R., Dunning A.	Transit-system evaluation process: From planning to realization	(Mand *et al.*, 2011)
53	2011	Skordylis A., Trigoni N.	Efficient data propagation in traffic-monitoring vehicular networks	(Skordylis and Trigoni, 2011)
54	2010	Eisele W.L., Schrank D.L.	Conceptual framework and Trucking application for estimating impact of congestion on Freight	(Eisele and Schrank, 2010)
55	2010	Behrendt, Hannah	Part II: Policy instruments for sustainable road transport	(Santos, Behrendt and Teytelboym, 2010)
56	2010	Stanley, John	Workshop report – A successful contractual setting	(Stanley and Longva, 2010)
57	2010	Macário, Rosário	Competing for level of service in the provision of mobility services: Concepts, processes and measures	(Macário, 2010)
58	2010	Muñoz, Juan Carlos	On the development of public transit in large cities	(Muñoz and de Grange, 2010)

ID	Year	Author(s)	Title	Reference
59	2009	Borzacchiello M.T., Torrieri V., Nijkamp P.	An operational information systems architecture for assessing sustainable transportation planning: principles and design	(Borzacchiello, Torrieri and Nijkamp, 2009)
60	2009	Gudmundsson H., Ericsson E., Hugosson M.B., Rosqvist L.S.	Framing the role of Decision Support in the case of Stockholm Congestion Charging Trial	(Gndsson *et al.*, 2009)
61	2008	da Silva, Antônio Nélson Rodrigues	Multiple views of sustainable urban mobility: The case of Brazil	(da Silva, da Silva Costa and Macedo, 2008)
62	2007	Barceló J., Grzybowska H., Pardo S.	Vehicle Routing and scheduling models, simulation and City Logistics	N/A
63	2007	Tricker, Reginald C.	Assessing cumulative environmental effects from major public transport projects	(Tricker, 2007)
64	2006	Van Geldermalsen T., O'Fallon C., Wallis I., Melsom I.	Travel behaviour change evaluation procedures and guidelines	N/A
65	2005	Costa M.S., Silva A.N.R., Ramos R.A.R.	Sustainable urban mobility: A comparative study and the basis for a management system in Brazil and Portugal	N/A
66	2005	Loo B.P.Y., Hung W.T., Lo H.K., Wong S.C.	Road safety strategies: A comparative framework and case studies	(Loo *et al.*, 2005)
67	2005	Jeon C.M., Amekudzi A.	Addressing sustainability in transportation systems: Definitions, indicators, and metrics	(Mihyeon Jeon and Amekudzi, 2005)
68	2005	Hull, Angela	Integrated transport planning in the UK: From concept to reality	(Hull, 2005)
69	2002	Proost, S	How large is the gap between present and efficient transport prices in Europe?	(Proost *et al.*, 2002)
70	1999	Turner D., Dix M., Gardner K., Beevers S.	Setting traffic reduction targets for London	N/A
71	1985	Pake Bruce E., Demetsky Michael J., Hoel Lester A.	EVALUATION OF BUS MAINTENANCE OPERATIONS.	N/A

Table A-2 List of additional articles added following completion of the SLR towards updating the conceptual framework

ID	Year	Author(s)	Title	Reference

1	2019	Taecharungroj V., Boonchaiyapruek P., Muthuta M.	Three-pronged sustainability assessment of ten towns in the vicinity of Bangkok, Thailand	(Taecharungroj, Boonchaiyapruek and Muthuta, 2019)
2	2019	Croce A.I., Musolino G., Rindone C., Vitetta A.	Sustainable mobility and energy resources: A quantitative assessment of transport services with electrical vehicles	(Croce *et al.*, 2019)
3	2019	K. Anastasiadou, S. Vougias	"Smart" or "sustainably smart" urban road networks The most important commercial street in Thessaloniki as a case study	(Anastasiadou and Vougias, 2019)
4	2019	Almeida, Ana C.L.	Multi actor multi criteria analysis (MAMCA) as a tool to build indicators and localize sustainable development goal 11 in Brazilian municipalities	(Almeida, 2019)
5	2019	Sdoukopoulosa A., Pitsiava-Latinopouloua M., Basbasb S., Papaioannoua P.	Measuring progress towards transport sustainability through indicators: Analysis and metrics of the main indicator initiatives	(Sdoukopoulos *et al.*, 2019)
6	2018	Mozos-Blanco M.A., Pozo-Menéndez E., Arce-Ruiz R., Baucells-Aletà N.,	The way to sustainable mobility. A comparative analysis of sustainable mobility plans in Spain	(Mozos-Blanco *et al.*, 2018)
7	2018	Diez J.M., Lopez-Lambas M.E., Gonzalo H., Rojo M., Garcia-Martinez A.	Methodology for assessing the cost effectiveness of Sustainable Urban Mobility Plans (SUMPs). The case of the city of Burgos	(Diez *et al.*, 2018)
8	2018	Mlinarić T.J., Đorđević B., Krmac E.	Evaluation framework for key performance indicators of railway ITS	(Mlinarić, Đorđević and Krmac, 2018)
9	2018	Mugion R.G., Toni M., Raharjo H., Di Pietro L., Sebathu S.P.	Does the service quality of urban public transport enhance sustainable mobility?	(Mugion *et al.*, 2018)
10	2018	Strulak-Wójcikiewicz R., Lemke J.	Concept of a Simulation Model for Assessing the Sustainable Development of Urban Transport	(Strulak-Wójcikiewicz and Lemke, 2019)
11	2018	Zope R., Vasudevan N., Arkatkar S.S., Joshi G.	Benchmarking: A tool for evaluation and monitoring sustainability of urban transport system in metropolitan cities of India	(Zope *et al.*, 2019)
12	2018	Bandeira R.A.M., D'Agosto, M.A. Ribeiro S.K., Bandeira A.P.F., Goes G.V.	A fuzzy multi-criteria model for evaluating sustainable urban freight transportation operations	(Bandeira *et al.*, 2018)
13	2017	Buldeo Rai H., van Lier T., Meers D., Macharis C.	Improving urban freight transport sustainability: Policy assessment framework and case study	(Buldeo Rai *et al.*, 2017)

14	2017	Perra V.M., Sdoukopoulos A., Pitsiava-Latinopoulou M.	Evaluation of sustainable urban mobility in the city of Thessaloniki	(Perra, Sdoukopoulos and Pitsiava-Latinopoulou, 2017)

Appendix B – Data analysis of relevant articles

Table B-1 Summary of comprehensive data analysis of the identified relevant articles

#	ID	Rele-vance	New rele-vance	Main goal/objective of paper (Distinctive contribution)	Number of KPIs	KPIs of study	Impacts	Quantitative/ Qualitative	(Research) Methodology (Analysis Process)	Approach (Type of Analysis / Theoretical lense)
1	3	5	5	Developed a framework for investigating transport sustainability performance with subjective indicators while considering public perception and acceptability (for Dhaka).	14 KPIs	Not listed	Sustainability encompasses 3 main domains: Economic, Environmental and Social, but KPIs were not classified accordingly since they overlap too much and cohere to each other	Mostly Quantitative	1) Identified subjective Indicators 2) Validation of subjective indicators by 7 experts 3) Surveys (Likert scale 1-5) to determine public perception on (1) Indicator performance satisfaction and (2) Indicator Imporatance 4) Determined Heterogeneous customer satisfaction index (HCSI) 5) Cross tabulation analysis of (1) and (2) above, Disgruntled users, Ranked Indicators 6) Variation of perceptions of (1) and (2) above determined through T-tests and ANOVA analysis 7) Post-hoc tests to determine significance of differences between groups	KPIs, Public perception (sustainability performance)
2	12	5	5	Evaluated KPIs of potential changes from new railway investments. Evaluation framework is constructed by combining land development scenarios and a CBA approach to assess the impacts of potential rail investments in the Greater Dublin Area.	32 KPIs (4 main categories)	Not listed	1) Direct Impacts of transport infrastructure 2) Socio-economic Impacts 3) Transport network Effects 4) Energy & Environmental Impacts	Qualitative & Quantitative	1) General info on study area identified 2) Scenario Analysis 3) Impacts & Indicators identified 4) Cost-Benefit Analysis (CBA) 5) Qualitative & Quantitative Analysis of indicators that can't be described with monetary values (Evaluation Matrix) 6) Sensitivity Analysis	KPIs, Scenario Analysis (rail) approach integrated with CBA, MCA (Multi-Criterialysis)
3	28	5	5	Performance indicators are identified for urban transport development (measure and improve the performance of urban transport services) in Nigeria.	85 KPIs (6 main categories)	Not listed	No specific impacts were discussed	Qualitative & Quantitative	Performance Measurement Process: 1) Identification 2) Monitoring 3) Evaluation I 4) Implementation 5) Evaluation II 6) Recycle	KPIs
4	44	5	5	This paper focuses on the process of developing metrics for evaluating transportation sustainability in the form of a composite index. The paper provides guidance on the selection of an appropriate index or the development of your own.	19 KPIs (12 elements, 3 domains)	Not listed	Sustainability encompasses 3 main domains: Economic, ronmental and Social. KPI's are classified accordingly	Mostly Quantitative	1) Literature on indicator selection criteria is reviewed: (a) Conceptualisation of sustainability (b) How performance metrics (composite index) function 2) Develop TISP (Transport Index for Sustainable Places): (a) Conceptual/theoretical framework (b) Domains (c) Elements (d) Indicators & Variables (e) Normalisation & Weighting (f) Aggregation & determining TISP	KPIs, Sustainability performance
5	8	4	5	Road map for designing and implementing a biological (natural resource) monitoring programme that delivers useful information. (synthesising multiple aspects of a monitoring programme into a single overarching framework)	0 KPIs	Not listed	No specific impacts were discussed	Qualitative (but refers to quantifying qualitative data)	Phase 1 - Frame the problem Step 1: Define problem /question Step 2: State the objectives Step 3: Sketch conceptual model of the system Step 4: Specify management or policy actions or confirm none planned	Qualitative Road Map No specific analysis was done, only a complete overview of the process was provided. EDA (Exploratory Data Analysis) and statistical data analysis of qualitative data is however advised

									Phase 2 - Design Step 5: Decide on approach 5a Status and trends monitoring Not listed 5b Threshold monitoring 5c Effectiveness monitoring 5d Adaptive management framework Step 6: Translate the conceptual model from step 3 into quantitative form Step 7: Design the (a) survey, the (b) analytical approach, and the (c) data management system Phase 3 - Implement & Learn Step 8: Collect and manage data Step 9: Analyse data and report results Step 10: Update models, assess, or plan and implement actions, when relevant Phase 4 - Learn & Revise	
6	24	4	5	Innovative solutions for European Bus Systems of the future is tested in 7 use cases. Efficiency and transferability were assessed.	25 KPIs (11 areas of investigation, 4 evaluation categories)	Not listed	4 evaluation categories: I. Customer Satisfaction II. Urban Environment and integration III. Productivity of the system IV. Quality of the bus service	Qualitative & Quantitative	2-step Methodology: 1) Process evaluation - Realising the output of the measures to test 2) Impact evaluation - Assessing the outcome of the measures by the use of qualitative and quantitative indicators (KPIs)	KPIs, Efficiency & Transferability
7	29	4	5	Passenger-oriented performance measurement framework for public rail transportation systems. Passenger-Oriented Performance Index (POPIX) was developed	25 KPIs (6 measures)	Not listed	No specific impacts were discussed	Qualitative & Quantitative	No specific methodology was proposed, but the steps through the paper are as follows: 1) Passenger satisfaction surveys 2) Indicator performance index (IPI) of each indicator is calculated 3) Measures Performance Index (MPI) is calculated 4) Passenger-oriented performance index (POPIX) is determined with IPI and MPI 5) Comparison of annual performance change	KPIs, Customer Satisfaction, Performance measurement, Service Quality, Surveys
8	52	4	5	A transit-system evaluation process is presented from planning to realisation. The primary objective of the study was to integrate planning, operations, and performance measurement into a comprehensive framework designed to evaluate a fixed-route transit system in the context of overall mobility for a city with a predominate academic institution or the institution itself.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	Refer to Figure.	Evaluation framework, Planning, Operations, Performance measurement
9	57	4	5	Competing for level of service in the provision of mobility services: Concepts, processes and measures	129 KPIs (18 Concepts)	Not listed	No specific impacts were discussed	Qualitative	No method for the research study was presented; however, a method for monitoring the policy process is presented in a figure following these steps: 1. Sustainable development context 2. Mobility aspirations 3. Objectives of the Urban Mobility System 4. Inputs 5. Processes	Level-of-Service (LoS), Quality of Service (QoS), Accounting framework, KPIs

									6. Outputs 7. System results (internal quality) 8. Impacts (external quality)	
10	67	4	5	Addressing Sustainability in Transportation Systems: Definitions, Indicators, and Metrics This paper reviews major transportation system initiatives in North America, Europe, and Oceania. The purpose is to characterize the emergent thinking on what constitutes transportation sustainability and how to measure it.	174 KPIs (5 Domains)	Not listed	Impacts-Based Frameworks (Economic, social, and environmental impacts) are discussed	Qualitative	No methodology was presented	KPIs, Sustainability performance
11	49	3	5	Sustainable urban mobility is measured with I_SUM (Index of sustainable urban mobility). This index is used to determine the current mobility conditions of any city and can also be applied for policy formulation. This study applies I_SUM in the city Curitiba, Brazil. It also evaluates the index method itself.	87 KPIs (37 themes, 9 domains)	Not listed	3 dimensions: Social, Economic, Environmental	Mostly Quantitative	1) Select appropriate indicators (input data) 2) Availability evaluation of data for indicators - remove indicators of which data isn't available 3) Redistribute weighting 4) Determine the overall index value I_SUM 5) Evaluation of results	KPIs, Sustainability (urban mobility) performance
12	21	5	4	Developed a financial analysis framework for assessing research projects better: Identification of potential research projetcs, Monitoring ongoing projects, Evaluating final research reports. Framework is a decision framework based on costs and benefits.	0 KPIs	Not listed	No specific impacts were discussed	Quantitative	1) Identify, capture, valuation of relevant costs and benefits (weighting accordingly) 2) Consider 5 measures	Integrated decision tool incorporating 5 measures (next column), CBA
13	7	4	4	Shows how flexible shared transport can be an improved alternative for small towns (rural areas) regarding social and economic well-being.	0 KPIs	Not listed	Economic, Environmental and Social impacts	Qualitative & Quantitative	Phase 1: Analysis of Census data and recent trends of small towns Phase 2: Data collection through questionnaires Phase 3: Semi-structured Interviews	Cross-tabulation and Descriptive Statistical Analysis using… Case studies (census data), Surveys (public perspectives & experiences), Interviews
14	9	4	4	A report is presented on a workshop concerning: The wider economic, social and envirnomental impacts of public transport investment	0 KPIs	Not listed	Economic, Environmental and Social impacts	Qualitative	No methodology was presented	Summary of a Workshop concentrating on wider impacts. States that CBA is seen as lacking in capturing enough of the benefits to make a case of implementatuin acceptable. Proposes using EIA(Ecnomic impact analysis) along CBA
15	18	4	4	Index numbers for monitoring transit service quality over time (The index numbers were calculated on the basis of data collected from Customer Satisfaction Surveys addressed to the passengers of the metropolitan public service of Granada, Spain)	14 KPIs	Not listed	No specific impacts were discussed	Mostly Quantitative	Methodology for monitoring service quality: Chain-weighted CPI No specific methodology process was presented	Customer Satisfaction Surveys (Public perception), Service quality, Theoretical framework, Chain-weighted CPI
16	30	4	4	A report is presented on a workshop on sustainable public transport discussing issues of need, system design, institutional arrangements, environmental improvements and social aspects of service	0 KPIs (6 goals)	Not listed	Social and environmental sustainability, governance, institutional design. Refer to the 6 goals for related impacts.	Qualitative	No methodology was presented	Summary of a Workshop: Public transport sustainability
17	42	4	4	This study aims to address differences in supply and usage of urban transport systems by a comparative approach. It captures the	23 KPIs (5 categories)	Not listed	Economic and social challenges	Mostly Quantitative	No specific methodology was presented; however, the analysis was done in the following sequence:	KPIs, Factor and cluster analysis

				subjective dimension of urban mobility by integrating satisfaction and perception-related indicators at a city-level. (comparison of German cities)					1) Factor analysis 2) Cluster analysis	
18	**43**	4	4	This paper presents a methodological approach to assess the quality of intercity road transportation of passengers, according to the customers' perspective. (Case study: Busses; Rio de Janeiro, Brazil)	0 KPIs (6 "dimensions of quality", 18 criteria)	Not listed	No specific impacts were discussed	Quantitative	a. Object of the problem b. Relevant criteria c. Scales of measurement d. Questionnaire design e. Importance–Satisfaction Analysis (ISA) f. Service Quality Indices and Sorting Procedure	Service quality, Customer satisfaction, Importance–Satisfaction Analysis (ISA) and an assignment procedure were used in order to obtain: (i) the main factors (criteria) that influence the quality of service intercity road transportation of passengers, (ii) the importance degree of criteria related to road transportation of passengers, (iii) the satisfaction of the users of road transportation under the considered criteria, (iv) the critical criteria/items, and (v) the categories which best represent the quality of service intercity road transportation according to the passengers' perspective
19	**10**	3	4	This paper aims to set a framework for traffic management and ITS applications in urban areas to help address the traffic problems at regional level: 10 Approaches are developed to achieve sustainability in traffic management	0 KPIs (10 approaches to sustainability were however identified)	Not listed	Sustainability is considered under the following: capacity, safety, environmental compatibility, and economic efficiency	Qualitative	No methodology was presented	Traffic Management, ITS applications, Sustainability
20	**27**	3	4	An overview is given on the use of Multi-Criteria Decision Analysis (MCDA) for transport analysis. The review allowed for deriving a general frame for the evaluation of transport projects.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative & Quantitative	Systematic objective review Methodology: 1) Formulation of the problem 2) Determination of the data collection strategy 3) Evaluation of the retrieved data 4) Analysis and interpretation of the literature is reviewed 5) Presentation of the results: kind of decisions, methodology, multi-actor involvement	Systematic review: Multi-Criteria Decision Analysis (MCDA)
21	**40**	3	4	Consideration of implementing transport infrastructure projects through Public-Private Partnerships (PPP) vs through conventional procurement. An evaluation framework is created to assess which of these two alternative schemes for transport projects financing is preferable for the public. The proposed framework was applied to a pilot Bus Rapid Transit (BRT) corridor infrastructure project in the city of Indore, India, in order to demonstrate its validity.	0 KPIs (11 criteria)	Not listed	Impacts include among others the social attributes of a particular scheme, job creation, environmental impacts and safety and security aspects. Refer to criteria.	Qualitative & Quantitative	Framework steps: Step 1: Cost-benefit analysis (CBA) Step 2: Value for Money estimation Step 3: Application of MCA	Private-public partnership (PPP), Multi-Criteria Analysis (MCA), Value for Money (VM) approach
22	**13**	2	4	This study proposes a useful methodological framework to identify the potential strengths and weaknesses of urban transport interchanges and to manage resources more efficiently.	0 KPIs (37 Variables, 8 Categories)	Not listed	No specific impacts were discussed	Quantitative	Step 1: Obtaining the 'derived importance' Step 2: Importance-performance analysis (IPA)	Survey (Questionnairre), Classification and regression tree model, **Importance-performance analysis (IPA)**, Customer Satisfaction/ Public perception/ Perceived Quality

23	55	2	4	Policy instruments for sustainable road transport	0 KPIs (3 types of policies)	Not listed	Economic, Environmental and Social impacts	Qualitative	No methodology was presented	Sustainability, Policies
24	63	1	4	This article identifies links between Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), using the Cross River Tram in London as an illustrative case study. From a literature review and local authority interviews, a framework and recommendations for the assessment of major transport projects are set out	0 KPIs (10 components)	Not listed	Economic, Environmental and Social impacts	Qualitative	Steps in the reporting of cumulative impacts: Step 1: Characterisation of future, present, and past baselines, including description of indirect impacts as well as direct project impacts. Valued environmental components and sites likely to experience impacts identified on a borough-by-borough basis. Collection of data using a matrix Step 2: Descriptive summary of alteration effects across all impact sites in terms of access, encroachment, and induced-growth Step 3: Identification of impacts on individual valued environmental components, including direct impacts from project components as well as indirect impacts of alterations; Step 4: Analysis of cause–effect pathways between project components/ indirect causes of impacts and the overall VEC, using a network (or causal chain) analysis	Sustainability, Cumulative effects assessment, Interviews, Questionnaire, Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA)
25	2	4	3	This paper analysis the strategies and policies that resulted in the successful implementation of bus reforms in Taichung City.	0 KPIs (4 key strategies)	Not listed	Political impacts through policies (government is responsible as the initiator). Neoclassical economics and new institutional economics	Qualitative	No methodology was presented	Neoclassical economics and **new institutional economics**. Policy planning (governmental focus). Market orientated framework (public choice theory), Case study
26	15	4	3	Research is presented on the involvement of public transit customers (passenger's perceptions) w.r.t. Light Rail Transit	0 KPIs (20 criteria)	Not listed	No specific impacts were discussed	Quantitative	I. Structural equation modeling (SEM) approach II. Data collection (Surveys - Public perception & Involvement) III. CFA & MCFA	Confirmatory factor analysis (CFA), Nested model strategy, Multiple Group Confirmatory Analysis (MCFA)
27	17	4	3	An integrated decision model is developed to evaluate sustainable public transport infrastructure projects without sacrificing profit margins and sustainable environment.	0 KPIs (4 critical perspectives, 12 evaluation criteria)	Not listed	**4 critical perspectives:** ST: Sustainable transport SD: Social development FF: Financial feasibility EI: Environmental impact	Qualitative & Quantitative	Application of integrated model: Step 1: Evaluate relationships among perspectives and criteria with DEMATEI Step 2: Find priority weight derived by ANP Step 3: Calculate direct cost and allocating indirect cost according to ABC Step 4: Compute the carbon footprint Step 5: Use ZOGP to obtain an optimal portfolio for sustainable public transport	Mulit-criteria decision-making (MCDM), Activity-based costing (ABC)
28	26	4	3	Examining the degree to which a public bicycle system could meet needs of people from Cape Town, SA.	0 KPIs	Not listed	Consideration of economic, sustainability, and mobility needs	Qualitative	1) Data gathering through literature review, 2) policy and media (including socialmedia) analysis, and 3) interviews 4) Discussion	Feasibility study, Shared bicycle system model, transport disadvantaged
29	56	4	3	A report is presented on a workshop: A succesful contractual setting.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Summary of a Workshop: A successful contractual setting
30	61	4	3	The aim of this work is to identify key factors of a sustainable urban mobility concept in a particular context. A multiple criteria decision analysis method was developed to identify the main variables associated to the concept	0 KPIs (10 primary elements of evaluation (PEE) was identifed)	Not listed	Strategies were classified in one of the dimensions: Social, Economic and Environmental. Some fundamental view points (FVP) were identified for each of these dimensions in different contexts	Qualitative	MCDA Stages: 1. Problem definition 2. Evaluation 3. Conclusions and recommendations This study refers to other studies for a detailed definition of its methodology.	Multiple criteria decision analysis (MCDA): The method is used to support decision-making processes in different ways: (i) to clearly identify the objectives, (ii) to evaluate the relative importance of those objectives, and (iii) to assess the impact of different alternatives on the objectives
31	25	3	3	A review is presented on bike-sharing. Identification and critical interpretation of all	0 KPIs	Not listed	Impacts regarding the use of bike-sharing are considered:	Qualitative	No methodology was presented	Review, Sustainability

				available evidence on bike-sharing is presented: users, usage, impacts, and the process of bike-sharing implementation and operation are discussed.			1) Transport mode substitution 2) Users' travel behaviour 3) Public transport use 4) Impacts on attitudes to cyclists 5) Environmental impacts 6) Health impacts 7) Economic impacts on users and businesses 8) Financial viability & wider economic impacts			
32	47	3	3	An Integrated Framework for the ex ante evaluation of a Flexible Transport Mode Schemes, is presented.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative & Quantitative	Evaluation process has 3 phases (refer to figure of the framework in the study): 1) Survey Design and Research Implementation Phase 2) Evaluation and Classification Phase 3) Implementation and Assessment Phase	Questionnaire (Surveys), Structural Equation Modelling and hybrid choice model
33	50	3	3	This paper shows how satisfaction measures can be exploited to gain insights on the relationship between personal attitudes, transit use and urban context. Nine satisfaction measures of urban transit services is considered as expressed by a sample of multimodel travelers.	0 KPIs (9 measures)	Not listed	No specific impacts were discussed	Mostly Quantitative	1) Correspondence analysis 2) Combining satisfaction measures into one score - a new compounding method 3) Application of the method and results	Customer Satisfaction, Correlations and correspondence analysis
34	31	2	3	Data Envelopment Analysis (DEA) is used to evaluate the performance of individual bus lines composing the public transport network in Thessaloniki, Greece.	0 KPIs	Not listed	No specific impacts were discussed	Mostly Quantitative	1) DEA efficiency scores 2) Sensitivity analysis of DEA scores 3) DEA-based clustering	Data Envelopment Analysis (DEA), Descriptive Statistics
35	48	2	3	This study presents a qualitative view of the current state of freight transport in urban areas as well as a framework highlighting the apparent shortcomings in urban freight transport planning, based on a case study of twelve cities.	0 KPIs (4 factors identified)	Not listed	Economic, Environmental and Social impacts	Qualitative	1) Case study approach used for analysing urban trasport planning. The empirical data was collected in three steps: 1.1 A holistic self-assessment of the cities' transport system including passenger and freight transport 1.2 A holistic peer-review of on the basis of the cities' self-assessment and 1.3 An in-depth review of the cities' freight transport 2) Data collection and analysis	Review, Sustainability
36	23	4	2	A methodology for assessing the feasibility of fleet compositions with dynamic demand (Rail)	0 KPIs	Not listed	No specific impacts were discussed	Mostly Quantitative	Methodology for assessing the effecs of different fleet compositions on customers and rail operators: based on a microscopic simulation of both rail traffic and passenger flows for analysing the rail service	Microscopic simulation, Service quality
37	32	4	2	This paper describes the methodology and the analysis tool developed for a study (by SiTI (2012)) aimed at the reorganisation of the interurban public transport services of the Piedmont region of Italy. Reviewing efficiency & effectiveness of public transport.	5 out of 70 KPIs are considered in the study	Not listed	No specific impacts were discussed	Qualitative	1) Definition of the objectives; 2) Choice of unit of analysis; 3) Development of a geo-database merging available data on services; 4) Identification of indicators relevant to the objectives; 5) Identification of the typical issues; 6) Development of a tool to visualise and analyse data on services and indicators; 7) Scrutiny of the available data to find typical issues and quantify their magnitude.	Efficiency and effectiveness
38	33	4	2	Improving transportation service quality based on information fusion	0 KPIs (4 dimensions, 12 criteria)	Not listed	No specific impacts were discussed	Qualitative & Quantitative	1) Problem description 2) Survey criteria 3) Data collection 4) Measuring the relationship between dimensions and criteria	Service Quality, Information fusion, Fuzzy integral-based integrated approach, Case study

									5) Integrated weighted gaps using fuzzy integral 6) Discussion	
39	36	4	2	A thorough assessment is done on how objective and fair performance appraisals of drivers can be conducted. A conceptual framework is provided for evaluation of safety interventions and operational performance through monitoring quantitative driver performance measures.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative & Quantitative	Performance appraisal framework to manage drivers' operational and safety performance: 1) Determine performance appraisal objectives 2) Determine performance appraisal criteria 3) Determine a performance appraisal method 4) Collect data 5) Perform statistical analysis and evaluate performance 6) Utilise performance appraisal outcomes 7) Conduct feedback interviews	Performance appraisal, statistical process control (SPC)
40	38	4	2	This paper characterises transit service quality with EJT (Excess journey time) under heterogeneous incidence behaviour.	0 KPIs	Not listed	No specific impacts were discussed	Quantitative	No methodology was presented	Service Quality, Passenger's perspective, Operator's perspective, Analytical framework
41	58	4	2	This article presents a summary of analysis and recommendations (directed towards improving the efficiency, service quality and sustainability of mass public transportation systems in major cities) from specialists to improve a new transit system in Transiago, Chile.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Interviews with specialists: efficiency, service quality, sustainability
42	1	3	2	This paper assesses the demand for a flexible, demand-adaptive transit service, using the Chicago region as an example. A stated-preference survey was designed and implemented to (1) identify potential users of flexible transport, and (2) inform the service design of the flexible transit mode.	0 KPIs	Not listed	No specific impacts were discussed	Quantitative	No methodology was presented	Stated-preference survey, Mode choice model Multinomial logit, mixed-logit, and panel mixed-logit choice models were estimated using the data obtained from the survey.
43	5	3	2	A context-aware framework is proposed for monitoring both road traffic and vehicle travel behaviour at a single stretch using GPS traces. Existing map matching algorithms are studied for generating accurate roadmaps. Multiple ways of extracting useful information from the roadmaps were also discussed.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented An architectural overview of road traffic and vehicle behaviour monitoring system was however presented in a Figure	Information Processing Framework, Multiple transportation problems system
44	11	3	2	This paper describes a successful collaboration between academia and a public transport authority where a tool is developed based on passive data processing. Methods for obtaining valuable information (like public transport trips origin-destination matrices, speed profiles of buses and service quality indicators, etc.) are described. Examples are presented of how this data can be used for public transport policy and planning.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Big data analysis, Level of Service (LoS)
45	16	3	2	This paper starts by analysing the current state of the art solutions in assets management. It then proposes a comprehensive Asset Integrity Management (AIM) approach that aims at replacing current time-based approaches with a performance-based approach that can	0 KPIs	Not listed	Economic and Social impacts	Qualitative	Moving from a move from current time-based approach in Asset Integrity Management (AIM) to performance-based approach: Step 0: Stoate of the Art - deterministic Step 1: From a deterministic to a probabilistic approach Step 2: From a probabilistic to a predictive approach	Asset Integrity Management (AIM), Decision support

				systematically take into account the dynamic nature of the transport network.						
46	20	3	2	This paper focuses on battery management system (BMS) tasks related to the battery health management (monitoring battery health status, charge control, and cell balancing together with the evaluation of state of charge, state of health, and state of life)	0 KPIs	Not listed	Environmental and Energy challenges were considered briefly	Quantitative	No methodology was presented	Battery cycle life aging
47	22	3	2	This paper critically assesses the transport strategies proposed by Auckland's spatial plan from a broad spectrum of sustainability perspectives. The plan aims to transform the city from a car-dominant system into an integrated public transport network.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Spatial Planning, Transport Planning, Liveability
48	34	3	2	This paper presents Advanced Software for Statewide Integrated Sustainable Transportation System Monitoring and Evaluation (ASSIST-ME), an application for visualizing and analysing the output of transportation planning models in a geographic information system environment. It offers four key functionalities: data visualization, demand analysis, path analysis, and benefit–cost analysis.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative & Quantitative	1) User Input 2) Selection Method 3) Feature Selection 4) Databases 5) Display & Save Output	Data Visualisation, Demand Analysis, Cost / Path Analysis, Benefit-Cost Analysis
49	37	3	2	A report is presented on a workshop: Governance, contracting, ownership and competition issues in public transport: Looking up not down	0 KPIs	Not listed	Six social goals: Economic competitiveness; Fiscal sustainability; Environmental sustainability; Social inclusion; Liveability, health and safety; Regional development	Qualitative	No methodology was presented	Summary of a Workshop: Governance, contracting, ownership and competition issues in public transport: Looking up not down
50	45	3	2	This paper reviews relevant policies and reported a survey with pilot cities to better understand the current status, problems and uncertainties existed in the EV deployment in China. Recommendations are developed from the survey findings.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Review, Survey
51	53	3	2	This paper investigates the problem of efficiently collecting and disseminating traffic information in an urban setting. Two routing algorithms for vehicular networks are introduced. A framework is proposed that jointly optimises the two key processes associated with monitoring traffic.	0 KPIs	Not listed	Social, economic impacts	Mostly Quantitative	No methodology was presented	Algorithmic (D-Greedy as the data delivery algorithm), Traffic monitoring sensor networks, Simulation
52	59	3	2	This paper offers the description of an integrated information system framework for the assessment of transportation planning and management.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	SIMT architectue design process: 1) User needs 2) Functional Architecture 3) Physical Architecture	Information system framework, Performance Monitoring, Decision-making, Transport Planning
53	69	3	2	A common modelling methodology is used to estimate the gap between present and efficient prices for passenger and freight transport in six zones in Europe.	0 KPIs	Not listed	Economic welfare	Mostly Quantitative	No step by step methodology was presented. Only an extended discussion was provided	Pricing model (TRENEN models)

54	39	2	2	This paper provides a comparative analysis of Intelligent Transport Systems (ITS) policy between Europe and Australia. With a focus on the applications and methods adopted in the use of ITS in the public transport sector in Australia the paper critiques their effectiveness in enhancing passenger experience, operator effectiveness and the likely effect on patronage.	0 KPIs	Not listed	Saftey, Mobility, Environment	Qualitative & Quantitative	No methodology was presented	Comparative Analysis
55	41	2	2	An urban transport strategy review "Cities on the move" is presented, analysing urban transport problems in developing and transitional economies.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Review
56	54	2	2	This research developed a conceptual framework to help transportation professionals communicate, visualise, and understand factors affecting freight mobility and reliability; a methodology with which to estimate congestion for the conceptual framework; and two applications of the methodology to truck freight	0 KPIs	Not listed	No specific impacts were discussed	Qualitative & Quantitative	Freight Box Concept Methodology: 1. Estimate tonnage and dollar amount of each commodity traveling through a metropolitan area. 2. Estimate tonnage and dollar amount of each commodity type that originates in or is destined for a metropolitan area. 3. Estimate tonnage and dollar amount for each commodity type that travels within a metropolitan area. 4. Estimate delay and cost to trucks by commodity.	Survey, Freight Box Concept
57	60	2	2	This paper paves the way for investigating the use and role of decision support in the Stochholm Congestion charging experiment.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	No methodology was presented	Decision support, Congestion Charging, Case study
58	66	2	2	This paper proposes a nine-component analytical framework for developing, comparing, and evaluating road safety strategies	0 KPIs	Not listed	Road safety	Qualitative	9-component Comparative Framework: (1) vision; (2) objectives; (3) targets; (4) action plan; (5) evaluation and monitoring; (6) research and development; (7) quantitative modelling; (8) institutional framework; and (9) funding	Analytical Comparative Framework, Administration-based Analysis
59	68	2	2	This paper explores the need for new planning authority practices and structures that can accommodate new policy demands, synergies and approaches to urban management in the UK	0 KPIs	Not listed	Economic, Environmental and Social impacts	Qualitative	No methodology was presented	Sustainability, Policy integration
60	4	2	1	A framework is introduced for precise vehicle localization in dense urban environments.	0 KPIs	Not listed	No specific impacts were discussed	Quantitative	No methodology was presented	Localisation (Mapping), Algorithmic
61	46	2	1	The study reviews the main land value capture finance (LVC) mechanisms (betterment tax, accessibility increment contribution, and joint development) in relation to increased transport accessibility.	0 KPIs	Not listed	No specific impacts were discussed	Qualitative	LVC implementation process: 1) Setting accessibility targets 2) Reviewing planning and fiscal urban framework 3) Selecting LVC mechanisms 4) Engagement 5) Monitoring	Review, Land value capture finance (LVC)
62	51	2	1	N/A	N/A		N/A	N/A	N/A	N/A

Appendix C – Approach analysis of relevant articles

Table C-1 Relevant article approach analysis

Article ID	3	8	12	24	28	29	44	49	52	57	67	7	9	10	13	18	21	27	30	40	42	43	55	63	2	15	17	25	26	31	47	48	50	56	61	1	5	11	16	20	22	23	32	33	34	36	37	38	39	41	45	53	54	58	59	60	66	68	69	4	46	51	Total
New relevance	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	
Sustainability (performance) / Performance measurement	x					x	x	x	x		x			x					x				x	x			x	x				x														x								x	x			x					17
KPI's	x		x	x	x	x	x	x		x	x										x																																										10
Public perception / Customer satisfaction	x					x						x			x	x						x			x								x															x															9
Service Quality (QoS) / Level of Service (LoS)						x				x						x						x																x				x		x				x						x									9
Survey (Questionnaire)						x						x			x	x								x							x					x															x		x										9
(Evaluation/ Theoretical/ Conceptual/ Analytical) Framework									x	x						x	x								x																					x		x									x						8
Decision-making tool / Decision support																	x	x							x		x												x			x													x	x							8
(Systematic) Review																		x										x				x																		x	x										x		6
CBA / Value for Money			x										x				x			x																									x																	5
MCA / MCDA (Multi-criteria decision analysis) / MAMCA (Multi-actor multi-criteria analysis)			x														x		x								x							x																												5
Case study												x													x																		x												x	x						5
Workshop (summary)													x						x														x													x																4
Efficiency (effectiveness) & Transferability				x																																							x											x									3
Interview												x												x																														x									3
Policies (planning/ integration)																							x		x																																	x					3
Correlations and correspondence analysis / Comparative analysis																																	x																x								x						3
Economic Impact Assessment (EIA)													x											x																																						2
Descriptive Statistical Analysis												x																		x																																	2
(Microscopic) Simulation																																										x										x											2
Information Processing Framework																																					x																		x								2
Transport Planning																																									x															x								2
Algorithmic																																																				x								x			2
Importance-Satisfaction Analysis (ISA)																						x																																									1
Importance-Performance Analysis (IPA)															x																																																1
Scenario Analysis			x																																																												1
Qualitative Road Map		x																																																													1
Cross-tabulation												x																																																			1
Chain-weighted CPI																x																																															1
ITS / Traffic Management														x																																																	1
Private-public partnership (PPP)																				x																																											1
Factor and cluster analysis																					x																																										1

Article ID	3	8	12	24	28	29	44	49	52	57	67	7	9	10	13	18	21	27	30	40	42	43	55	63	2	15	17	25	26	31	47	48	50	56	61	1	5	11	16	20	22	23	32	33	34	36	37	38	39	41	45	53	54	58	59	60	66	68	69	4	46	51	Total
New relevance	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	
New institutional economics																									x																																						1
Cumulative Effects Assessment																								x																																							1
Confirmatory factor analysis (CFA)/ Multiple Group Confirmatory Analysis (MCFA)																										x																																					1
Activity-based costing (ABC)																											x																																				1
Feasibility study																													x																																1
Structural Equation, Modelling and hybrid choice model																															x																														1
Data Envelopment Analysis (DEA)																														x																															1
Information fusion																																												x																			1
Statistical process control (SPC)																																														x																	1
Preference / Choice Model																																				x																											1
Big data analysis																																						x																									1
Asset Integrity Management (AIM)																																							x																								1
Battery cycle life aging																																								x																							1
Spatial Planning/ Liveability																																									x																						1
Demand Analysis																																													x																		1
Cost / Path Analysis																																													x																		1
Pricing model (TRENEN models)																																																											x				1
Freight Box Concept																																																					x										1
Congestion Charging																																																								x							1
Administration-based Analysis																																																									x						1
Localisation (Mapping)																																																												x			1
Land value capture finance (LVC)																																																													x		1

Appendix D – Interviews

Appendix D1 – Written consent letter

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jou kennisvennoot • your knowledge partner

STELLENBOSCH UNIVERSITY
WRITTEN CONSENT TO PARTICIPATE IN RESEARCH

TITLE OF RESEARCH PROJECT:	Development of a Monitoring and Evaluation Framework concerning Microtransit towards penetrating public sector verticals
REFERENCE NUMBER:	ING-2018-04-11-1646
PRINCIPAL INVESTIGATOR:	Reinhart Buenk
ADDRESS:	Department of Industrial Engineering, Stellenbosch University, South Africa
CONTACT NUMBER:	079 479 6583
E-MAIL:	17100836@sun.ac.za

Dear prospective participant

Kindly note that I am a PhD student at the Department of Industrial Engineering at Stellenbosch University, and I would like to invite you to participate in a research project entitled *Development of a Monitoring and Evaluation Framework concerning Microtransit towards penetrating public sector verticals.*

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study. This study has been approved by the Research Ethics Committee (REC) at Stellenbosch University and will be conducted according to accepted and applicable national and international ethical guidelines and principles.

1. **INTRODUCTION:**
As an emerging new field, microtransit is still in developing stages. In order to ensure mutually beneficial partnerships and to prove business cases the microtransit start-up company, Mellowcabs, needs to ensure that appropriate monitoring is taking place where initiatives are rolled out. This will require carefully designed Monitoring and Evaluation (M&E) frameworks to be developed.

2. **PURPOSE:**

- To obtain a comprehensive understanding of what microtransit is through the process of a systematic literature review;
- To fully understand the process of M&E through extensive literature analysis and recognise how to apply the obtained knowledge towards building a microtransit framework;
- To develop the generic M&E framework that can be used by small scale transportation organisations to analyse performance and impacts of microtransit systems (assisting in proving business cases) and;
- To evaluate the effectiveness (Validation) of the developed M&E framework in the context of an existing real microtransit company namely Mellowcabs.

3. **PROCEDURES:**

Please read through and complete this consent form to know what would be expected from you prior to participating in the research. The procedure and expectations of the participant are as follows:

i. Some questions will be asked during an interview 1) regarding the interviewee (kept anonymous) and 2) regarding the research conducted.
ii. A definition of microtransit is provided to the interviewee.
iii. Areas of sustainability (AoS) and sustainability key performance indicators (KPIs) were identified for microtransit systems via a systematic literature review. The interviewee will be asked to identify which of the AoS and KPIs he believes are relevant (to keep) and which are irrelevant (remove) to microtransit systems. This will enable the researcher to know which to keep/remove from the Monitoring and Evaluation (M&E) framework.
iv. Following the interview, the interviewee will be asked to complete a survey in order to assign weightings to the identified relevant AoS and KPIs.

4. **TIME:**

The interview is expected to take 40 minutes. Completion of the Survey should take an additional 20 minutes.

5. **RISKS:**

This interview has no risk of causing harm or any negative experiences/ discomforts.

6. **BENEFITS:**

Participation in this interview will greatly contribute to the completion of this research and the development of a generic microtransit M&E framework.

7. **PARTICIPATION AND WITHDRAWAL:**

The interview is entirely voluntary and participation can be withdrawn at any time during the interview with no negative consequences. Participants may choose not to answer certain questions. If information is refused (not answered), research will commence without it and be based on the relevant information that can well be disclosed. If, however, the interviewee decides to withdraw completely from the interview and the research study, all data will be destroyed and will not be used for the research.

8. **CONFIDENTIALITY:**

All information obtained from the individual(s) will represent the company rather than the individuals – the individuals will thus remain anonymous. The information obtained from the interview will be considered as opinion rather than fact. Voice recordings of the interviews instead of video recordings will ensure the interviewee's privacy. Voice recordings will be made with the investigator's phone which is password protected. No personal questions or personal details will be asked. All hard copy consent forms with personal information (e.g. signature) will be scanned and kept on the investigator's laptop which is password protected and kept in a secure location,

and always locked or shut down when left unattended. All digital and hard copies of the consent forms will be destroyed within five years or after completion of the PhD thesis and the completion of journal article publication(s) within the five-year period.

9. **RECORDINGS:**

Please note that a voice recording will be made of the interview. Please indicate to the interviewer if you are not comfortable with this.

10. **DATA STORAGE:**

Voice recordings of the interviews instead of video recordings will ensure the interviewee's privacy. Voice recordings will be made with the investigator's phone which is password protected. The survey will not require the participant to provide personal details - only the company represented, the participant's field of expertise, and years of experience will be asked. Hard copies of the surveys will be kept by the investigator at all times – the hard copies will however not reveal any personal information about the interviewees or be identifiable. Only the investigator and his supervisor will have access to these data. Any other data that might possibly be considered confidential will be stored on the investigator's private computer which is password protected and kept in a secure location, and always locked or shut down when left unattended. All digital and hard copies of the consent forms, surveys, and interviews will be deleted within five years or after completion of the Master's thesis and the completion of journal article publication(s) within the five-year period.

If you have any questions or concerns about this research project, please feel free to contact me via email (17100836@sun.ac.za) or telephonically (079 479 6583). Alternatively, feel free to contact my supervisor, Sara Grobbelaar, via email (ssgrobbelaar@sun.ac.za) or telephonically (082 576 8123).

RIGHTS OF RESEARCH PARTICPANTS: You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché (mfouche@sun.ac.za / 021 808 4622) at the Division for Research Development. You have the right to receive a copy of this Consent form.

If you are willing to participate in this research project, please sign the Declaration of Consent below and hand it to the investigator.

DECLARATION BY THE PARTICIPANT

As the **participant** I hereby declare that:

- I have read the above information and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- If the principal investigator feels that it is in my best interest, or if I do not follow the study plan as agreed to, then I may be asked to leave the study before it has finished.
- All issues related to privacy, and the confidentiality and use of the information I provide, have been explained to my satisfaction.

By signing below, I _____ agree to take part in this research study, as conducted by Reinhart Buenk.

_____ _____

Signed at *(place)* **Date**

_____

Signature of Participant

DECLARATION BY THE PRINCIPAL INVESTIGATOR

As the **principal investigator** I hereby declare that the information contained in this document has been thoroughly explained to the participant. I also declare that the participant has been encouraged (and has been given ample time) to ask any questions. In addition I would like to select the following option:

	The conversation with the participant was conducted in a language in which the participant is fluent.
	The conversation with the participant was conducted with the assistance of a translator, and this "Consent Form" is available to the participant in a language in which the participant is fluent.

_____ _____

Signed at *(place)* **Date**

_____

Signature of Principal Investigator

Appendix D2 – Semi-structured Expert Interview Guide

Expert Interview Guide:

Sustainability of Microtransit Systems

Company		**Date**	___ / ___ / 2018

1. Greetings and Introduction

Good afternoon. My name is Reinhart Buenk and I will be conducting the interview with you today.

2. Confidentiality and permission

The interview is entirely voluntary and participation can be withdrawn at any time during the interview with no negative consequences. Participants may choose not to answer certain questions. If information is refused (not answered), research will commence without it and be based on the relevant information that can well be disclosed. All information obtained from the individual(s) will represent the company rather than the individuals – the individuals will thus remain anonymous. The information obtained from the interview will be considered as opinion rather than fact.

3. Background on research project and purpose

As an emerging new field, microtransit is still in developing stages. In order to ensure mutually beneficial partnerships and to prove business cases the microtransit start-up company, Mellowcabs, needs to ensure that appropriate monitoring is taking place where initiatives are rolled out. This will require carefully designed Monitoring and Evaluation (M&E) frameworks to be developed.

The purpose of the project is the following:

- To obtain a comprehensive understanding of what microtransit is through the process of a systematic literature review;
- To fully understand the process of M&E through extensive literature analysis and recognise how to apply the obtained knowledge towards building a microtransit framework;
- To develop the generic M&E framework that can be used by small scale transportation organisations to analyse performance and impacts of microtransit systems (assisting in proving business cases) and;
- To evaluate the effectiveness (Validation) of the developed M&E framework in the context of an existing real microtransit company namely Mellowcabs.

4. Questioning

<u>Line of questioning regarding interviewee:</u>

1.1. What is your profession?
1.2. Who do you work for?
1.3. What is your area of expertise in the transport industry and what role do you play?
1.4. How many years' experience do you have in your role as _____?
1.5. Within your field of transport, how do you measure (sustainability) performance?
   a. Do you use a model/framework or what mechanism is used to evaluate performance?
   b. Is it monitored and evaluated qualitatively or quantitatively?
   c. Have you identified indicators to measure performance? If yes, what are these indicators and how do you monitor them?
   d. How was this business case/ model/ framework developed?

Line of questioning concerning my personal research:

2.1. Have you heard about microtransit before?

2.2. If yes, how would you describe/define microtransit?

Provide our own definition and continue interview. ("First-and-last-mile problem")

2.3. Considering the three pillars of sustainability – social, economic, and environmental – what impacts do you think are crucial to consider for a microtransit system?

Present a list of all identified key performance indicators (KPIs) and explain the process how I got them and ended up with the presented sample.

2.4. Which of the following Evaluation categories (Areas of Sustainability) / Indicators / Variables would you consider as
1) <u>irrelevant</u> to sustainable M&E of microtransit systems and should not be used; and
2) <u>relevant</u> to sustainable M&E of microtransit systems and crucial to consider (should be used)

Evaluation categories (Areas of Sustainability) Indicators *Variables*	Relevant (keep)	Irrelevant (remove)
1. Pollution		
Air Pollution		
Carbon dioxide (CO2) emissions per capita		
Sulphur dioxide (SO2) emissions per capita		
Carbon monoxide (CO) emissions per capita		
Particulates (PM10) per capita		
Volatile organic compounds (VOCs) per capita		
Oxides of Nitrogen (NOx) emissions per capita		
Old vehicles still in use (number) per capita		
Black smoke (yes/no)		
Lead emissions (yes/no)		
Waste Pollution/ Production		
Transportation Solid Waste per capita (tonne)		
Number of vehicles scrapped annually		
Hazardous materials incidents		
Lead acid batteries in municipal solid waste streams		
% recycleable/ re-useable materials of vehicle		
Water Pollution		
Per capita vehicle fluid losses & oil spills incidents		
Per capita hardened "impervious" surface area (e.g. highways & parking lots) leading to increase in stormwater runoff		
Management of used oil, leaks and stormwater		
Noise Pollution		
Level of noise from urban transport (Decibels)		
% Population exposed to transport related noise > 55 dB		
Light Pollution		
Lumen (lm)		
2. Transport resource consumption (renewable & nonrenewable)		
Energy Consumption		
Transport energy use per capita		
Overall energy efficiency		
How clean/green is the energy used?		
Infrastructure & Vehicle Materials Consumption		

	Tonnes of materials used for vehicles & infrastructure(tonnes)		
Vehicle fuel consumption			
	Litres fossil fuel consumed per passenger		
	Litres non-fossil fuel consumed per passenger		
	Fuel efficiency		
3. Ecological & Geographical damage/ impacts			
Ecological system			
	Loss of wetlands/agricultural lands/deforestation (acres) per population growth		
	No of wild life/ animal collisions per capita		
	Fragmentation of ecosystems and habitats		
	Vibration caused by transport system		
GHG emmisions/Climate change			
	CO2 emissions per capita / Total emmisions per capita		
	Change in earth's temperature		
Land-use			
	Land consumption (m2) for transport infrastructure (roads, parking)		
	Land area lost due to erosion caused (m2)		
4. Initiatives for environmental protection			
Studies of environmental impacts			
	Number of studies on environmental impacts		
Investments dedicated to environmental protection			
	Total sum of investements		
Technological maturity of transport system			
	How technologically advanced & mature is the system?		
5. (Customer) Service Quality (Level of Service)			
Comfort			
	Occupancy rate/ availability of seating (Crowding)		
	Space in vehicle (per individual)		
	Cleanliness of vehicle		
	Temperature inside vehicle (shelter, ventilation, air conditioning)		
	Quaking level		
	Noise level		
	Overall riding comfort		
	Comfort due to presence of information screens		
	Comfort while waiting at bus/vehicle stops (including cleanliness)		
Convenience			
	Electronic fare payment option / Ease of buying tickets		
	Number and variety of shops, cafés and restaurants near stops		
	Availability of Wifi & cellphone signals		
	Availability of cellphone charging facilities		
	Bathroom facilities in vehicle		
	Existence of differential services such as water, newspaper and blanket		
	Convenience of the vehicle schedules		
Reliability			
	Punctuality/delay/regularity		
	Uncertainty		
	Variability in time		
	Cancellations		
Driver attitude & appearance			
	Awareness		
	Courtesy and helpfulness of staff/driver		
	Law-abidingness		
	Complaint handling and effective complaint resolution		

	Driver appearance		
Image/ Attractiveness/ Aesthetics			
	Customer perception of vehicle appearance/ aesthetics		
	Customer perception of waiting areas/ vehicle stops aesthetics		
	Preservation of heritage rating		
General Customer Satisfaction			
	Overall Satisfaction with the service		
	I feel that taking public transit is consistent with my lifestyle		
	How likely are you to recommend this service to others?		
	How likely are you to use this service again?		
	Percentage of complaints from all passengers		
6. Accessibility & Availability			
Customer accessibility to transport system			
	NMT facilities to transport system (Quality of surrounding walking and cycling conditions)		
	Accessibility to terminals/where vehicle stops from work/home		
	Easiness to get on/off the vehicle		
	Numbers of stations/stops		
Transport system accessibility to other locations			
	Accessibility to public buildings		
	Accessibility to essential services		
	Accessibility to open spaces		
Social Equity & Inclusion			
	Accessibility to women		
	Accessibility to users with special needs (disabilities)		
	Accessibility to those with low income		
	Accessibility to children		
Availability			
	Availability during peak hours		
	Number of vehicles in operation at any given time		
	Frequency of vehicles (service)		
	Operating hours		
	Network coverage (km of network related to population or area)		
	Length of reserved PT routes related to area or population		
	Percentage of customers having direct journeys		
7. Safety & Security			
Accidents & Prevention			
	Number of (traffic & pedestrians) accidents (per km)		
	Number of fatalities and injuries (per km)		
	Use of seatbelts (%)		
	Use of crash helmets (%)		
	Testing the crashworthiness of vehicles and rating (effectiveness)		
	Sufficient vehicle lighting & use of reflective devices		
Crime			
	Incidences of stolen items reported by commuters		
	Incidences of commuters being attacked by armed robbers (number)		
	Number of stolen vehicles		
	Effective Police/Security patrol teams near service (number)		
Emergency situation control			
	Response time to emergency (minutes)		
	Availability of firefighting appliances		
	Information to improve your sense of security during emergency situations		
Passenger's perception of & satisfaction with safety level			
	Safety getting on and off transport		

	Safety on board		
	Feeling secure in transfer & waiting areas (during the day)		
	Feeling secure in transfer & waiting areas (evening/night)		
	Number of incidents of property damage (per total number of passengers)		
	Incidence of overloading (number)		
	Sufficient lighting at stops/station		
	Customer's perception of overall safety		
Driver's level of capability			
	Frequency of driver assessment		
	Drivers level of training / Percentage of trained/certified/experienced drivers (%)		
	Incidence of exceeding speed limit (numbers)		
	Incidence of driving under the influence of alcohol/drugs (number)		
	Incidence of red light running (traffic lights) (number)		
	Incidence of not stopping or yielding in junctions/ pedestrian crossings/ red lights (number)		
Vehicle & Road condition			
	Frequency of potholes (%)		
	Overall road quality (Satisfaction with road system condition)		
	Mechanically deficient vehicles still in use (%)		
	Old vehicles still in use (% or age of vehicles in use)		
8. Government & Community Involvement			
Government Interoperability			
	Government performance		
	Government financial support		
	Degree to which system comply with legislation (Contracts and limitations)		
Community Involvement			
	Public participation in decision-taking (degree to which public influence decisions)		
	Public response to transit system		
9. Mobility (Travel & Transfer)			
Time			
	Average time making use of NMT before using the transport service		
	Average waiting time at stop/pick-up/drop-off point		
	Average time taken to board vehicle		
	Average commuting/In-vehicle travel time (% of total trip)		
	Average parking search time		
	Delays due to congestion / Dwell time		
	Total average travel time to points of interest (per day)		
Speed (= Distance / Time)			
	Average speed of using NMT service before getting to stop/pick-up/drop-off point		
	Average commuting/In-vehicle speed		
	Total average transfer speed to points of interest		
Distance			
	Average distance of using NMT service before getting to stop/pick-up/drop-off point		
	Average commuting distance		
	Total average transfer distance		
	Proximity of the stops in km		
Modal split/ Transit integration			
	Level of contributing to modal split & transit integration via "First & Last mile" transport		
	Intermodal terminals		
	Adequacy of NMT services near transit system		

General mobility			
Number of public transport trips (Trips/ vehicle)			
Mobility of inhabitants (Trips/ inhabitant)			
Contribution to a reduction in congestion (motorised traffic)			
Overall ease of making transfers			
10. Financial Perspective (Costs)			
Affordability to customer			
Commute cost/ Fare of a ticket			
Total travel cost (affordability of monthly travel expense)			
The amount paid in relation to the service offered			
Discounts and free rides			
Costs to (private) company (Financial feasibility)			
Total operating & maintenance costs			
Total infrastructure costs			
Total environmental costs			
Total public service costs			
Governmental costs (Financial feasibility)			
Public cost for transport service (Marginal costs of public funds)			
Public transport investment expenditure in % of GDP			
Road network expenditure in % of GDP			
Resources efficiency (efficient use of government resource in city transport planning)			
Financial security			
Fare revenue			
Degree to which the transport system is economically selfsufficient			
Overall profitability			
11. Socio-economic			
Socio-economic development			
Socio-economic growth			
Wider economic impacts			
Area property values			
Regional acces to markets			
Ease of reaching economically important assets			
Support for local industries			
Social development			
Promotion of career opportunities /creation of jobs			
Promotion of local tourism			
Promotion of land-use			
Land development			
Green space preservation			
Land development patterns (Sprawled vs. compact development)			
Regeneration			
12. (Economic) Productivity of the system			
Demand			
Passenger's demand			
Demand for freight transport			
Capacity			
Seat capacity (space per person)			
Seating/Passenger capacity per vehicle			
Network capacity of vehicles, terminals & stops			
Storage area in vehicle capacity			
Maintenance			
Maintenance of facilities/stops			
Maintenance of vehicles			

		Vehicle failure		
		Ratio of non-working vehicles at any given time		
	Information systems / Travel information			
		Availability & Accessibility of real time travel information		
		Availability & Accessibility of travel information before your trip (e.g. timetable of service)		
		Accuracy and reliability of travel information displays		
		Ease of ticket purchasing		
		Quality of information systems		
		Information announcements on board		
	Way-finding information			
		Information about vehicle routes clearly indicated (Signboards & Instructions)		
		Signposting of different facilities and services		
		Signposting for transfers between transport modes		
		Information and assistance provided by staff		
	Overall efficiency			
		Service efficiency		
		Passengers / km		
		Annual number of passengers		
		Annual number of trips		
		Occupancy rate		

5. Conclusion and Thanks

Would you be prepared to complete a survey following this interview? Once all data from interviews is processed, you will be sent a survey in which key performance indicators (KPIs) will be rated on a Likert scale and weighted according to their importance and relevance to M&E of micortransit systems. Thank you very much for your time. Your input is appreciated and will greatly contribute to the completion of this research and the development of a generic microtransit M&E framework.

Appendix D3 – Expert interview: Indicator-weighting survey

Table D-1 Survey A (completed example)

On a scale of 1 to 7, how relevant (important) is each of the following Areas of Sustainbility (Evaluation categories) respectively to environmental, social or economic sustainability. The Areas of Sustability/Evaluation categories will be weighted according to the scale of each area's relative contribution based on these ratings. (Please type an 'x' in the desired cells)

	Relative contribution to the 3 dimensions of sustainability (Importance)																							
	I. Environmental								II. Social								III. Economic							
Areas of Sustainability	N/A	1	2	3	4	5	6	7	N/A	1	2	3	4	5	6	7	N/A	1	2	3	4	5	6	7
Pollution								x						x								x		
Transport resource consumption (renewable & nonrenewable)							x						x									x		
Ecological & Geographical damage/ impacts								x					x								x			
Initiatives for environmental protection							x							x							x			
(Customer) Service Quality (Level of Service)	x														x					x				
Accessibility & Availability	x														x						x			
Safety & Security	x														x							x		
Government & Community Involvement	x													x							x			
Mobility (Travel & Transfer)						x										x						x		
Financial Perspective				x										x								x		
Socio-economic					x								x									x		
(Economic) Productivity of the system				x											x							x		

If you had to assign weightings to these Areas of Sustainbility (Evaluation categories), how would you rate the importance of each area between 1 and 7 considering their relative contribution towards a sustainable microtransit system. Although you might feel all of the belowe categories are important, please think of answering the question as 'ranking' the categories. (Please type an 'x' in the desired cells)

	Sustainability						
Areas of Sustainability	1	2	3	4	5	6	7
Pollution					x		
Transport resource consumption (renewable & nonrenewable)						x	
Ecological & Geographical damage/ impacts				x			
Initiatives for environmental protection				x			
(Customer) Service Quality (Level of Service)				x			
Accessibility & Availability					x		
Safety & Security				x			
Government & Community Involvement		x					
Mobility (Travel & Transfer)						x	
Financial Perspective					x		
Socio-economic			x				
(Economic) Productivity of the system				x			

1	Not at all important
2	Slightly important
3	Somewhat important
4	Moderately important (Neutral)
5	Quite important
6	Very important
7	Extremely important

Table D-2 Survey B (completed example)

	Extremely important	Very Strongly more important	Strongly more important	Moderately more important	Equally important	Moderately more important	Strongly more important	Very Strongly more important	Extremely important	
1. Pollution										
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Air Pollution						x												Waste Pollution/ Production
Waste Pollution/ Production											x							Water Pollution
Water Pollution			x															Noise Pollution
Noise Pollution							x											Light Pollution
Air Pollution									x									Water Pollution
Waste Pollution/ Production				x														Noise Pollution
Water Pollution		x																Light Pollution
Air Pollution			x															Noise Pollution
Waste Pollution/ Production					x													Light Pollution
Air Pollution		x																Light Pollution
2. Transport resource consumption																		
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Energy Consumption											x							Infrastructure & Vehicle Materials Consumption
Infrastructure & Vehicle Materials Consumption							x											Vehicle fuel consumption
Energy Consumption										x								Vehicle fuel consumption
3. Ecological & Geographical impacts																		
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Ecological system									x									GHG emissions/Climate change
GHG emissions/Climate change						x												Land-use
Ecological system								x										Land-use
4. Initiatives for environmental protection																		
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Studies of environmental impacts									x									Investments dedicated to environmental protection
Investments dedicated to environmental protection												x						Technological maturity of transport system
Studies of environmental impacts										x								Technological maturity of transport system
5. (Customer) Service Quality (Level of Service)																		
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Comfort									x									Convenience
Convenience												x						Reliability
Reliability						x												Driver attitude & appearance
Driver attitude & appearance							x											Image/ Attractiveness/ Aesthetics
Image/ Attractiveness/ Aesthetics											x							General Customer Satisfaction
Comfort												x						Reliability
Convenience							x											Driver attitude & appearance
Reliability					x													Image/ Attractiveness/ Aesthetics
Driver attitude & appearance											x							General Customer Satisfaction
Comfort							x											Driver attitude & appearance
Convenience								x										Image/ Attractiveness/ Aesthetics
Reliability								x										General Customer Satisfaction
Comfort							x											Image/ Attractiveness/ Aesthetics
Convenience										x								General Customer Satisfaction
Comfort										x								General Customer Satisfaction
6. Accessibility & Availability																		
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Customer accessibility to transport system							x											Transport system accessibility to other locations
Social Equity & Inclusion											x							Availability
Transport system accessibility to other locations									x									Social Equity & Inclusion
Customer accessibility to transport system								x										Social Equity & Inclusion

Transport system accessibility to other locations											x						Availability
Customer accessibility to transport system										x							Availability
7. Safety & Security																	
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Accidents & Prevention							x											Crime
Crime										x								Emergency situation control
Emergency situation control									x									Passenger's perception of & satisfaction with safety level
Passenger's perception of & satisfaction with safety level								x										Driver's level of capability
Driver's level of capability							x											Vehicle & Road condition
Accidents & Prevention						x												Emergency situation control
Crime									x									Passenger's perception of & satisfaction with safety level
Emergency situation control								x										Driver's level of capability
Passenger's perception of & satisfaction with safety level									x									Vehicle & Road condition
Accidents & Prevention						x												Passenger's perception of & satisfaction with safety level
Crime							x											Driver's level of capability
Emergency situation control									x									Vehicle & Road condition
Accidents & Prevention						x												Driver's level of capability
Crime							x											Vehicle & Road condition
Accidents & Prevention						x												Vehicle & Road condition
8. Government & Community Involvement																	
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Government Interoperability									x									Community Involvement
9. Mobility (Travel & Transfer)																	
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Time									x									Speed (= Distance / Time)
Speed (= Distance / Time)									x									Distance
Distance											x							Modal split/ Transit integration
Modal split/ Transit integration											x							General mobility
Time									x									Distance
Speed (= Distance / Time)											x							Modal split/ Transit integration
Distance												x						General mobility
Time											x							Modal split/ Transit integration
Speed (= Distance / Time)												x						General mobility
Time												x						General mobility
10. Financial Perspective																	
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Affordability to customer									x									Costs to (private) company (Financial feasibility)
Governmental costs (Financial feasibility)											x							Financial security
Costs to (private) company (Financial feasibility)								x										Governmental costs (Financial feasibility)
Affordability to customer							x											Governmental costs (Financial feasibility)
Costs to (private) company (Financial feasibility)									x									Financial security
Affordability to customer											x							Financial security
11. Socio-economic																	
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Socio-economic development									x									Social development
Social development									x									Land development
Socio-economic development									x									Land development
12. (Economic) Productivity of the system																	
Indicator	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicator
Demand							x											Capacity
Capacity								x										Maintenance
Maintenance					x													Information systems / Travel information
Information systems / Travel information									x									Way-finding information
Way-finding information												x						Overall efficiency
Demand							x											Maintenance
Capacity			x															Information systems / Travel information
Maintenance						x												Way-finding information
Information systems / Travel information													x					Overall efficiency
Demand						x												Information systems / Travel information

Capacity							x									Way-finding information
Maintenance									x							Overall efficiency
Demand						x										Way-finding information
Capacity								x								Overall efficiency
Demand								x								Overall efficiency

Table D-3 Survey C (completed example)

				Satisfaction (perceived performance)									
N	*Evaluation categories (AoS)*	*i*	*Indicators*	1	2	3	4	5	6	7	8	9	10
1	Pollution	1	Air Pollution									x	
		2	Waste Pollution/ Production									x	
		3	Water Pollution										x
		4	Noise Pollution										x
		5	Light Pollution							x			
2	Transport resource consumption (renewable & non-renewable)	6	Energy Consumption								x		
		7	Infrastructure & Vehicle Materials Consumption						x				
		8	Vehicle fuel consumption									x	
3	Ecological & Geographical damage / impacts	9	Ecological system								x		
		10	Climate change / GHG emissions									x	
		11	Land-use								x		
4	Initiatives for environmental protection	12	Studies of environmental impacts								x		
		13	Investments dedicated to environmental protection								x		
		14	Technological maturity of transport system								x		
5	(Customer) Service Quality (Level of Service)	15	Comfort						x				
		16	Convenience							x			
		17	Reliability							x			
		18	Driver attitude & appearance						x				
		19	Image/ Attractiveness/ Aesthetics							x			
		20	General Customer Satisfaction							x			
6	Accessibility & Availability	21	Customer accessibility to transport system						x				
		22	Transport system accessibility to other locations					x					
		23	Social Equity & Inclusion					x					
		24	Availability					x					
7	Safety & Security	25	Accidents & Prevention					x					
		26	Crime					x					
		27	Emergency situation control						x				
		28	Passenger's perception of & satisfaction with safety level					x					
		29	Driver's level of capability					x					
		30	Vehicle & Road condition							x			
8	Government & Community Involvement	31	Government Interoperability							x			
		32	Community Involvement					x					
9	Mobility (Travel & Transfer)	33	Time					x					
		34	Speed							x			
		35	Distance							x			
		36	Modal split/ Transit integration								x		
		37	General mobility							x			
10	Financial Perspective (Costs)	38	Affordability to customer									x	
		39	Costs to (private) company (Financial feasibility)							x			
		40	Governmental costs (Financial feasibility)							x			
		41	Financial security								x		
11	Socio-economic	42	Socio-economic development						x				
		43	Social development						x				
		44	Land development					x					
12	(Economic) Productivity of the system	45	Demand								x		
		46	Capacity					x					
		47	Maintenance								x		
		48	Information systems (ICT) / Travel information						x				
		49	Way-finding information						x				
		50	Overall efficiency (impressions)								x		

Appendix E – Summary of final results for each domain

Table E-1 Summary of ISA results for environmental development (Mellowcabs)

I. Environmental								
i	*Indicators*	$W_{N,i}$	*Quadrant (Env)*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
42	Socio-economic development	0,5	Concentrate here	38%	5,3333	9,5	4,2	>
12	Studies of environmental impacts	0,26	Concentrate here	43%	6	10,0	4,0	>
13	Investments dedicated to environmental protection	0,4	Concentrate here	66%	7	10,0	3,0	>
14	Technological maturity of transport system	0,34	Concentrate here	57%	7	10,0	3,0	>
33	Time	0,3	Concentrate here	39%	7	9,7	2,7	>
7	Infrastructure & Vehicle Materials Consumption	0,16	Concentrate here	36%	6,6667	9,1	2,4	>
11	Land-use	0,2	Keep up the good work	39%	8	9,9	1,9	>
9	Ecological system	0,34	Keep up the good work	66%	8,3333	10,0	1,7	>
2	Waste Pollution/ Production	0,21	Keep up the good work	58%	8,6667	10,0	1,3	>
6	Energy Consumption	0,41	Keep up the good work	94%	8,6667	10,0	1,3	>
24	Availability	0,35	Lower Priority	27%	5,6667	6,7	1,0	>
1	Air Pollution	0,31	Keep up the good work	84%	9	10,0	1,0	>
8	Vehicle fuel consumption	0,43	Keep up the good work	100%	9	10,0	1,0	>
10	Climate change / GHG emissions	0,46	Keep up the good work	90%	9	10,0	1,0	>
43	Social development	0,31	Lower Priority	23%	5,3333	5,9	0,6	>
4	Noise Pollution	0,15	Keep up the good work	39%	9,3333	9,9	0,6	>
31	Government Interoperability	0,67	Concentrate here	29%	7	7,4	0,4	>
3	Water Pollution	0,26	Keep up the good work	70%	9,6667	10,0	0,3	>
38	Affordability to customer	0,41	Keep up the good work	32%	8	8,0	0,0	<
21	Customer accessibility to transport system	0,31	Lower Priority	24%	6,3333	5,9	-0,4	<
35	Distance	0,17	Lower Priority	22%	6,6667	5,5	-1,2	<
44	Land development	0,18	Lower Priority	14%	5	3,5	-1,5	<
22	Transport system accessibility to other locations	0,22	Lower Priority	17%	6	4,3	-1,7	<
34	Speed	0,13	Lower Priority	17%	6	4,3	-1,7	<
36	Modal split/ Transit integration	0,2	Possible Overkill	26%	8,3333	6,6	-1,7	<
37	General mobility	0,19	Possible Overkill	24%	8	6,1	-1,9	<
46	Capacity	0,19	Lower Priority	17%	6,3333	4,2	-2,2	<
45	Demand	0,29	Possible Overkill	24%	8,3333	6,2	-2,2	<
32	Community Involvement	0,33	Lower Priority	15%	6,3333	3,7	-2,6	<
25	Accidents & Prevention	0,24	Lower Priority	12%	6	2,9	-3,1	<
41	Financial security	0,23	Possible Overkill	18%	7,6667	4,4	-3,2	<
23	Social Equity & Inclusion	0,12	Lower Priority	10%	5,6667	2,4	-3,3	<
5	Light Pollution	0,07	Possible Overkill	18%	8	4,6	-3,4	<
17	Reliability	0,27	Lower Priority	11%	6,3333	2,8	-3,5	<
39	Costs to (private) company (Financial feasibility)	0,22	Possible Overkill	17%	8	4,3	-3,7	<
29	Driver's level of capability	0,18	Lower Priority	9%	6,3333	2,2	-4,1	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	12%	7,3333	3,0	-4,4	<
49	Way-finding information	0,09	Lower Priority	8%	6,3333	1,9	-4,4	<
27	Emergency situation control	0,15	Lower Priority	7%	6,3333	1,8	-4,5	<
30	Vehicle & Road condition	0,14	Lower Priority	7%	6,3333	1,7	-4,6	<
28	Passenger's perception of & satisfaction with safety level	0,16	Lower Priority	8%	6,6667	2,0	-4,7	<
26	Crime	0,13	Lower Priority	6%	6,3333	1,6	-4,7	<
50	Overall efficiency (impressions)	0,18	Possible Overkill	16%	8,6667	3,9	-4,7	<
40	Governmental costs (Financial feasibility)	0,14	Possible Overkill	11%	7,6667	2,7	-5,0	<
15	Comfort	0,15	Lower Priority	6%	6,6667	1,5	-5,1	<
18	Driver attitude & appearance	0,11	Lower Priority	4%	6,3333	1,1	-5,2	<
16	Convenience	0,2	Possible Overkill	8%	8	2,0	-6,0	<
47	Maintenance	0,11	Possible Overkill	10%	8,6667	2,4	-6,2	<
20	General Customer Satisfaction	0,17	Possible Overkill	7%	8	1,7	-6,3	<
19	Image/ Attractiveness/ Aesthetics	0,1	Possible Overkill	4%	8,6667	1,0	-7,6	<

Table E-2 Summary of ISA results for social development (Mellowcabs)

II. Social								
i	*Indicators*	$W_{N,i}$	*Quadrant (Soc)*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
42	Socio-economic development	0,5	Concentrate here	59%	5,3333	10,0	4,7	>
24	Availability	0,35	Concentrate here	100%	5,6667	10,0	4,3	>
22	Transport system accessibility to other locations	0,22	Concentrate here	64%	6	10,0	4,0	>
25	Accidents & Prevention	0,24	Concentrate here	57%	6	10,0	4,0	>
17	Reliability	0,27	Concentrate here	70%	6,3333	10,0	3,7	>
21	Customer accessibility to transport system	0,31	Concentrate here	89%	6,3333	10,0	3,7	>
31	Government Interoperability	0,67	Concentrate here	93%	7	10,0	3,0	>
33	Time	0,3	Concentrate here	59%	7	10,0	3,0	>
32	Community Involvement	0,33	Concentrate here	47%	6,3333	8,4	2,0	>
38	Affordability to customer	0,41	Keep up the good work	61%	8	10,0	2,0	>
29	Driver's level of capability	0,18	Concentrate here	43%	6,3333	7,7	1,4	>
43	Social development	0,31	Lower Priority	37%	5,3333	6,6	1,2	>
16	Convenience	0,2	Keep up the good work	50%	8	9,0	1,0	>
23	Social Equity & Inclusion	0,12	Lower Priority	36%	5,6667	6,5	0,8	>
28	Passenger's perception of & satisfaction with safety level	0,16	Lower Priority	39%	6,6667	7,0	0,4	>
15	Comfort	0,15	Lower Priority	39%	6,6667	7,0	0,3	>
45	Demand	0,29	Keep up the good work	48%	8,3333	8,5	0,2	>
27	Emergency situation control	0,15	Lower Priority	35%	6,3333	6,3	0,0	<
20	General Customer Satisfaction	0,17	Keep up the good work	44%	8	7,9	-0,1	<
8	Vehicle fuel consumption	0,43	Keep up the good work	49%	9	8,9	-0,1	<
10	Climate change / GHG emissions	0,46	Keep up the good work	49%	9	8,8	-0,2	<
30	Vehicle & Road condition	0,14	Lower Priority	34%	6,3333	6,1	-0,3	<
6	Energy Consumption	0,41	Keep up the good work	47%	8,6667	8,4	-0,3	<
13	Investments dedicated to environmental protection	0,4	Lower Priority	37%	7	6,6	-0,4	<
1	Air Pollution	0,31	Keep up the good work	48%	9	8,5	-0,5	<
46	Capacity	0,19	Lower Priority	32%	6,3333	5,8	-0,6	<
26	Crime	0,13	Lower Priority	32%	6,3333	5,6	-0,7	<
35	Distance	0,17	Lower Priority	33%	6,6667	5,9	-0,7	<
36	Modal split/ Transit integration	0,2	Possible Overkill	40%	8,3333	7,2	-1,1	<
44	Land development	0,18	Lower Priority	21%	5	3,9	-1,1	<
37	General mobility	0,19	Possible Overkill	37%	8	6,7	-1,3	<
34	Speed	0,13	Lower Priority	26%	6	4,7	-1,3	<
14	Technological maturity of transport system	0,34	Lower Priority	32%	7	5,7	-1,3	<
18	Driver attitude & appearance	0,11	Lower Priority	28%	6,3333	5,0	-1,4	<
41	Financial security	0,23	Possible Overkill	34%	7,6667	6,1	-1,6	<
12	Studies of environmental impacts	0,26	Lower Priority	24%	6	4,2	-1,8	<
9	Ecological system	0,34	Possible Overkill	36%	8,3333	6,5	-1,9	<
39	Costs to (private) company (Financial feasibility)	0,22	Possible Overkill	33%	8	5,9	-2,1	<
3	Water Pollution	0,26	Possible Overkill	39%	9,6667	7,1	-2,6	<
2	Waste Pollution/ Production	0,21	Possible Overkill	33%	8,6667	5,8	-2,8	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	23%	7,3333	4,1	-3,2	<
50	Overall efficiency (impressions)	0,18	Possible Overkill	30%	8,6667	5,4	-3,2	<
7	Infrastructure & Vehicle Materials Consumption	0,16	Lower Priority	18%	6,6667	3,2	-3,5	<
49	Way-finding information	0,09	Lower Priority	15%	6,3333	2,7	-3,7	<
19	Image/ Attractiveness/ Aesthetics	0,1	Possible Overkill	26%	8,6667	4,7	-4,0	<
40	Governmental costs (Financial feasibility)	0,14	Possible Overkill	20%	7,6667	3,7	-4,0	<
11	Land-use	0,2	Possible Overkill	22%	8	3,9	-4,1	<
47	Maintenance	0,11	Possible Overkill	19%	8,6667	3,4	-5,3	<
4	Noise Pollution	0,15	Possible Overkill	22%	9,3333	4,0	-5,4	<
5	Light Pollution	0,07	Possible Overkill	10%	8	1,9	-6,1	<

Table E-3 Summary of ISA results for economic development (Mellowcabs)

III. Economic								
i	*Indicators*	$W_{N,i}$	*Quadrant (Eco)*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
42	Socio-economic development	0,5	Concentrate here	59%	5,3333	10,0	4,7	>
24	Availability	0,35	Concentrate here	52%	5,6667	10,0	4,3	>
21	Customer accessibility to transport system	0,31	Concentrate here	46%	6,3333	10,0	3,7	>
17	Reliability	0,27	Concentrate here	41%	6,3333	9,3	3,0	>
31	Government Interoperability	0,67	Concentrate here	53%	7	10,0	3,0	>
33	Time	0,3	Concentrate here	58%	7	10,0	3,0	>
43	Social development	0,31	Concentrate here	37%	5,3333	8,3	3,0	>
46	Capacity	0,19	Concentrate here	40%	6,3333	9,1	2,8	>
41	Financial security	0,23	Keep up the good work	56%	7,6667	10,0	2,3	>
38	Affordability to customer	0,41	Keep up the good work	100%	8	10,0	2,0	>
39	Costs to (private) company (Financial feasibility)	0,22	Keep up the good work	54%	8	10,0	2,0	>
45	Demand	0,29	Keep up the good work	60%	8,3333	10,0	1,7	>
22	Transport system accessibility to other locations	0,22	Concentrate here	33%	6	7,5	1,5	>
6	Energy Consumption	0,41	Keep up the good work	55%	8,6667	10,0	1,3	>
8	Vehicle fuel consumption	0,43	Keep up the good work	58%	9	10,0	1,0	>
35	Distance	0,17	Concentrate here	33%	6,6667	7,3	0,7	>
36	Modal split/ Transit integration	0,2	Keep up the good work	39%	8,3333	8,9	0,5	>
37	General mobility	0,19	Keep up the good work	37%	8	8,2	0,2	>
50	Overall efficiency (impressions)	0,18	Keep up the good work	38%	8,6667	8,6	0,0	<
40	Governmental costs (Financial feasibility)	0,14	Keep up the good work	34%	7,6667	7,6	-0,1	<
44	Land development	0,18	Lower Priority	22%	5	4,9	-0,1	<
25	Accidents & Prevention	0,24	Lower Priority	26%	6	5,8	-0,2	<
34	Speed	0,13	Lower Priority	26%	6	5,8	-0,2	<
32	Community Involvement	0,33	Lower Priority	26%	6,3333	6,0	-0,4	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	29%	7,3333	6,5	-0,8	<
10	Climate change / GHG emissions	0,46	Keep up the good work	35%	9	7,8	-1,2	<
16	Convenience	0,2	Possible Overkill	30%	8	6,7	-1,3	<
23	Social Equity & Inclusion	0,12	Lower Priority	19%	5,6667	4,2	-1,4	<
15	Comfort	0,15	Lower Priority	23%	6,6667	5,2	-1,5	<
13	Investments dedicated to environmental protection	0,4	Lower Priority	24%	7	5,4	-1,6	<
7	Infrastructure & Vehicle Materials Consumption	0,16	Lower Priority	21%	6,6667	4,8	-1,9	<
29	Driver's level of capability	0,18	Lower Priority	19%	6,3333	4,4	-2,0	<
49	Way-finding information	0,09	Lower Priority	19%	6,3333	4,2	-2,1	<
20	General Customer Satisfaction	0,17	Possible Overkill	26%	8	5,9	-2,1	<
14	Technological maturity of transport system	0,34	Lower Priority	20%	7	4,6	-2,4	<
12	Studies of environmental impacts	0,26	Lower Priority	15%	6	3,5	-2,5	<
9	Ecological system	0,34	Possible Overkill	25%	8,3333	5,7	-2,6	<
18	Driver attitude & appearance	0,11	Lower Priority	16%	6,3333	3,7	-2,7	<
28	Passenger's perception of & satisfaction with safety level	0,16	Lower Priority	18%	6,6667	4,0	-2,7	<
27	Emergency situation control	0,15	Lower Priority	16%	6,3333	3,6	-2,8	<
30	Vehicle & Road condition	0,14	Lower Priority	15%	6,3333	3,4	-2,9	<
1	Air Pollution	0,31	Possible Overkill	26%	9	5,9	-3,1	<
26	Crime	0,13	Lower Priority	14%	6,3333	3,2	-3,1	<
47	Maintenance	0,11	Possible Overkill	24%	8,6667	5,3	-3,3	<
11	Land-use	0,2	Possible Overkill	15%	8	3,4	-4,6	<
2	Waste Pollution/ Production	0,21	Possible Overkill	18%	8,6667	4,0	-4,6	<
3	Water Pollution	0,26	Possible Overkill	22%	9,6667	4,9	-4,8	<
19	Image/ Attractiveness/ Aesthetics	0,1	Possible Overkill	15%	8,6667	3,5	-5,2	<
4	Noise Pollution	0,15	Possible Overkill	12%	9,3333	2,8	-6,6	<
5	Light Pollution	0,07	Possible Overkill	6%	8	1,3	-6,7	<

Table E-4 Summary of ISA results for environmental development (GoMetro)

I. Environmental								
i	*Indicators*	$W_{N,i}$	*Quadrant (Env)*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
13	Investments dedicated to environmental protection	0,4	Concentrate here	66%	6,6667	10,0	3,3	>
3	Water Pollution	0,26	Concentrate here	70%	7	10,0	3,0	>
9	Ecological system	0,34	Concentrate here	66%	7	10,0	3,0	>
2	Waste Pollution/ Production	0,21	Concentrate here	58%	7,3333	10,0	2,7	>
12	Studies of environmental impacts	0,26	Concentrate here	43%	7,3333	10,0	2,7	>
4	Noise Pollution	0,15	Concentrate here	39%	7,6667	10,0	2,3	>
7	Infrastructure & Vehicle Materials Consumption	0,16	Concentrate here	36%	8	10,0	2,0	>
6	Energy Consumption	0,41	Concentrate here	94%	8,3333	10,0	1,7	>
1	Air Pollution	0,31	Keep up the good work	84%	8,6667	10,0	1,3	>
42	Socio-economic development	0,5	Keep up the good work	38%	8,6667	10,0	1,3	>
38	Affordability to customer	0,41	Concentrate here	32%	8,3333	9,4	1,1	>
10	Climate change / GHG emissions	0,46	Keep up the good work	90%	9,3333	10,0	0,7	>
11	Land-use	0,2	Keep up the good work	39%	9,3333	10,0	0,7	>
33	Time	0,3	Keep up the good work	39%	9,3333	10,0	0,7	>
8	Vehicle fuel consumption	0,43	Keep up the good work	100%	9,6667	10,0	0,3	>
14	Technological maturity of transport system	0,34	Keep up the good work	57%	9,6667	10,0	0,3	>
31	Government Interoperability	0,67	Keep up the good work	29%	8,6667	8,7	0,1	>
5	Light Pollution	0,07	Lower Priority	18%	6,6667	5,5	-1,2	<
35	Distance	0,17	Lower Priority	22%	7,6667	6,4	-1,2	<
24	Availability	0,35	Possible Overkill	27%	9,3333	7,9	-1,5	<
43	Social development	0,31	Possible Overkill	23%	8,6667	7,0	-1,7	<
36	Modal split/ Transit integration	0,2	Possible Overkill	26%	9,6667	7,8	-1,9	<
45	Demand	0,29	Possible Overkill	24%	9,3333	7,3	-2,1	<
37	General mobility	0,19	Possible Overkill	24%	9,3333	7,2	-2,1	<
39	Costs to (private) company (Financial feasibility)	0,22	Lower Priority	17%	7,3333	5,0	-2,3	<
21	Customer accessibility to transport system	0,31	Possible Overkill	24%	9,6667	7,0	-2,7	<
41	Financial security	0,23	Lower Priority	18%	8	5,2	-2,8	<
32	Community Involvement	0,33	Lower Priority	15%	7,3333	4,4	-3,0	<
34	Speed	0,13	Possible Overkill	17%	8,6667	5,0	-3,6	<
22	Transport system accessibility to other locations	0,22	Possible Overkill	17%	9,3333	5,1	-4,3	<
46	Capacity	0,19	Possible Overkill	17%	9,3333	4,9	-4,4	<
44	Land development	0,18	Possible Overkill	14%	8,6667	4,1	-4,6	<
50	Overall efficiency (impressions)	0,18	Possible Overkill	16%	9,3333	4,6	-4,7	<
27	Emergency situation control	0,15	Lower Priority	7%	7,3333	2,1	-5,2	<
40	Governmental costs (Financial feasibility)	0,14	Possible Overkill	11%	8,6667	3,2	-5,5	<
17	Reliability	0,27	Possible Overkill	11%	9	3,3	-5,7	<
26	Crime	0,13	Lower Priority	6%	7,6667	1,9	-5,8	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	12%	9,3333	3,5	-5,8	<
15	Comfort	0,15	Lower Priority	6%	7,6667	1,8	-5,8	<
19	Image/ Attractiveness/ Aesthetics	0,1	Lower Priority	4%	7,3333	1,2	-6,1	<
47	Maintenance	0,11	Possible Overkill	10%	9	2,9	-6,1	<
23	Social Equity & Inclusion	0,12	Possible Overkill	10%	9	2,8	-6,2	<
25	Accidents & Prevention	0,24	Possible Overkill	12%	9,6667	3,4	-6,2	<
30	Vehicle & Road condition	0,14	Lower Priority	7%	8,3333	2,0	-6,3	<
29	Driver's level of capability	0,18	Possible Overkill	9%	9	2,6	-6,4	<
16	Convenience	0,2	Possible Overkill	8%	9	2,4	-6,6	<
20	General Customer Satisfaction	0,17	Possible Overkill	7%	9	2,1	-6,9	<
28	Passenger's perception of & satisfaction with safety level	0,16	Possible Overkill	8%	9,3333	2,4	-7,0	<
18	Driver attitude & appearance	0,11	Lower Priority	4%	8,3333	1,3	-7,0	<
49	Way-finding information	0,09	Possible Overkill	8%	9,6667	2,3	-7,4	<

Table E-5 Summary of ISA results for social development (GoMetro)

II. Social								
i	*Indicators*	$W_{N,i}$	*Quadrant (Soc)*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
32	Community Involvement	0,33	Concentrate here	47%	7,3333	9,9	2,5	>
38	Affordability to customer	0,41	Concentrate here	61%	8,3333	10,0	1,7	>
6	Energy Consumption	0,41	Concentrate here	47%	8,3333	9,8	1,5	>
1	Air Pollution	0,31	Keep up the good work	48%	8,6667	10,0	1,3	>
31	Government Interoperability	0,67	Keep up the good work	93%	8,6667	10,0	1,3	>
42	Socio-economic development	0,5	Keep up the good work	59%	8,6667	10,0	1,3	>
3	Water Pollution	0,26	Lower Priority	39%	7	8,3	1,3	>
13	Investments dedicated to environmental protection	0,4	Lower Priority	37%	6,6667	7,7	1,1	>
16	Convenience	0,2	Keep up the good work	50%	9	10,0	1,0	>
17	Reliability	0,27	Keep up the good work	70%	9	10,0	1,0	>
10	Climate change / GHG emissions	0,46	Keep up the good work	49%	9,3333	10,0	0,7	>
22	Transport system accessibility to other locations	0,22	Keep up the good work	64%	9,3333	10,0	0,7	>
24	Availability	0,35	Keep up the good work	100%	9,3333	10,0	0,7	>
33	Time	0,3	Keep up the good work	59%	9,3333	10,0	0,7	>
45	Demand	0,29	Keep up the good work	48%	9,3333	10,0	0,7	>
9	Ecological system	0,34	Lower Priority	36%	7	7,6	0,6	>
15	Comfort	0,15	Lower Priority	39%	7,6667	8,2	0,6	>
8	Vehicle fuel consumption	0,43	Keep up the good work	49%	9,6667	10,0	0,3	>
21	Customer accessibility to transport system	0,31	Keep up the good work	89%	9,6667	10,0	0,3	>
25	Accidents & Prevention	0,24	Keep up the good work	57%	9,6667	10,0	0,3	>
20	General Customer Satisfaction	0,17	Keep up the good work	44%	9	9,3	0,3	>
27	Emergency situation control	0,15	Lower Priority	35%	7,3333	7,4	0,1	>
29	Driver's level of capability	0,18	Keep up the good work	43%	9	9,1	0,1	>
39	Costs to (private) company (Financial feasibility)	0,22	Lower Priority	33%	7,3333	6,9	-0,4	<
2	Waste Pollution/ Production	0,21	Lower Priority	33%	7,3333	6,9	-0,5	<
35	Distance	0,17	Lower Priority	33%	7,6667	7,0	-0,7	<
41	Financial security	0,23	Lower Priority	34%	8	7,2	-0,8	<
43	Social development	0,31	Possible Overkill	37%	8,6667	7,7	-0,9	<
26	Crime	0,13	Lower Priority	32%	7,6667	6,7	-1,0	<
28	Passenger's perception of & satisfaction with safety level	0,16	Possible Overkill	39%	9,3333	8,3	-1,0	<
36	Modal split/ Transit integration	0,2	Possible Overkill	40%	9,6667	8,5	-1,2	<
30	Vehicle & Road condition	0,14	Lower Priority	34%	8,3333	7,1	-1,2	<
23	Social Equity & Inclusion	0,12	Possible Overkill	36%	9	7,6	-1,4	<
37	General mobility	0,19	Possible Overkill	37%	9,3333	7,9	-1,5	<
19	Image/ Attractiveness/ Aesthetics	0,1	Lower Priority	26%	7,3333	5,5	-1,8	<
12	Studies of environmental impacts	0,26	Lower Priority	24%	7,3333	5,0	-2,3	<
18	Driver attitude & appearance	0,11	Lower Priority	28%	8,3333	5,9	-2,5	<
46	Capacity	0,19	Possible Overkill	32%	9,3333	6,8	-2,5	<
50	Overall efficiency (impressions)	0,18	Possible Overkill	30%	9,3333	6,4	-2,9	<
4	Noise Pollution	0,15	Lower Priority	22%	7,6667	4,7	-3,0	<
14	Technological maturity of transport system	0,34	Possible Overkill	32%	9,6667	6,7	-3,0	<
34	Speed	0,13	Possible Overkill	26%	8,6667	5,5	-3,2	<
44	Land development	0,18	Possible Overkill	21%	8,6667	4,5	-4,1	<
7	Infrastructure & Vehicle Materials Consumption	0,16	Lower Priority	18%	8	3,8	-4,2	<
40	Governmental costs (Financial feasibility)	0,14	Possible Overkill	20%	8,6667	4,3	-4,3	<
5	Light Pollution	0,07	Lower Priority	10%	6,6667	2,2	-4,5	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	23%	9,3333	4,8	-4,5	<
11	Land-use	0,2	Possible Overkill	22%	9,3333	4,6	-4,8	<
47	Maintenance	0,11	Possible Overkill	19%	9	4,0	-5,0	<
49	Way-finding information	0,09	Possible Overkill	15%	9,6667	3,1	-6,5	<

Table E-6 Summary of ISA results for economic development (GoMetro)

III. Economic								
i	*Indicators*	$W_{N,i}$	*Quadrant (Eco)*	$(W_i)_{rel}$	$I_{N,i}$	*Aim*	*Difference*	*Direction*
39	Costs to (private) company (Financial feasibility)	0,22	Concentrate here	54%	7,3333	10,0	2,7	>
41	Financial security	0,23	Concentrate here	56%	8	10,0	2,0	>
6	Energy Consumption	0,41	Concentrate here	55%	8,3333	10,0	1,7	>
38	Affordability to customer	0,41	Concentrate here	100%	8,3333	10,0	1,7	>
31	Government Interoperability	0,67	Keep up the good work	53%	8,6667	10,0	1,3	>
42	Socio-economic development	0,5	Keep up the good work	59%	8,6667	10,0	1,3	>
43	Social development	0,31	Keep up the good work	37%	8,6667	9,8	1,1	>
17	Reliability	0,27	Keep up the good work	41%	9	10,0	1,0	>
35	Distance	0,17	Concentrate here	33%	7,6667	8,7	1,0	>
24	Availability	0,35	Keep up the good work	52%	9,3333	10,0	0,7	>
33	Time	0,3	Keep up the good work	58%	9,3333	10,0	0,7	>
45	Demand	0,29	Keep up the good work	60%	9,3333	10,0	0,7	>
46	Capacity	0,19	Keep up the good work	40%	9,3333	10,0	0,7	>
50	Overall efficiency (impressions)	0,18	Keep up the good work	38%	9,3333	10,0	0,7	>
37	General mobility	0,19	Keep up the good work	37%	9,3333	9,7	0,4	>
8	Vehicle fuel consumption	0,43	Keep up the good work	58%	9,6667	10,0	0,3	>
21	Customer accessibility to transport system	0,31	Keep up the good work	46%	9,6667	10,0	0,3	>
36	Modal split/ Transit integration	0,2	Keep up the good work	39%	9,6667	10,0	0,3	>
40	Governmental costs (Financial feasibility)	0,14	Keep up the good work	34%	8,6667	8,9	0,3	>
10	Climate change / GHG emissions	0,46	Keep up the good work	35%	9,3333	9,2	-0,1	<
9	Ecological system	0,34	Lower Priority	25%	7	6,8	-0,2	<
32	Community Involvement	0,33	Lower Priority	26%	7,3333	7,0	-0,3	<
13	Investments dedicated to environmental protection	0,4	Lower Priority	24%	6,6667	6,3	-0,3	<
22	Transport system accessibility to other locations	0,22	Keep up the good work	33%	9,3333	8,9	-0,4	<
16	Convenience	0,2	Possible Overkill	30%	9	7,9	-1,1	<
3	Water Pollution	0,26	Lower Priority	22%	7	5,8	-1,2	<
15	Comfort	0,15	Lower Priority	23%	7,6667	6,1	-1,6	<
48	Information systems (ICT) / Travel information	0,14	Possible Overkill	29%	9,3333	7,7	-1,7	<
1	Air Pollution	0,31	Possible Overkill	26%	8,6667	7,0	-1,7	<
34	Speed	0,13	Possible Overkill	26%	8,6667	6,8	-1,9	<
20	General Customer Satisfaction	0,17	Possible Overkill	26%	9	6,9	-2,1	<
7	Infrastructure & Vehicle Materials Consumption	0,16	Lower Priority	21%	8	5,6	-2,4	<
2	Waste Pollution/ Production	0,21	Lower Priority	18%	7,3333	4,8	-2,6	<
47	Maintenance	0,11	Possible Overkill	24%	9	6,3	-2,7	<
25	Accidents & Prevention	0,24	Possible Overkill	26%	9,6667	6,8	-2,8	<
44	Land development	0,18	Possible Overkill	22%	8,6667	5,8	-2,9	<
27	Emergency situation control	0,15	Lower Priority	16%	7,3333	4,2	-3,1	<
12	Studies of environmental impacts	0,26	Lower Priority	15%	7,3333	4,1	-3,2	<
19	Image/ Attractiveness/ Aesthetics	0,1	Lower Priority	15%	7,3333	4,1	-3,2	<
29	Driver's level of capability	0,18	Possible Overkill	19%	9	5,1	-3,9	<
26	Crime	0,13	Lower Priority	14%	7,6667	3,8	-3,9	<
18	Driver attitude & appearance	0,11	Lower Priority	16%	8,3333	4,3	-4,0	<
23	Social Equity & Inclusion	0,12	Possible Overkill	19%	9	5,0	-4,0	<
14	Technological maturity of transport system	0,34	Possible Overkill	20%	9,6667	5,5	-4,2	<
30	Vehicle & Road condition	0,14	Lower Priority	15%	8,3333	4,0	-4,3	<
4	Noise Pollution	0,15	Lower Priority	12%	7,6667	3,2	-4,4	<
28	Passenger's perception of & satisfaction with safety level	0,16	Possible Overkill	18%	9,3333	4,7	-4,6	<
49	Way-finding information	0,09	Possible Overkill	19%	9,6667	5,0	-4,7	<
5	Light Pollution	0,07	Lower Priority	6%	6,6667	1,5	-5,1	<
11	Land-use	0,2	Possible Overkill	15%	9,3333	4,0	-5,3	<