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BACHELOR PROJECT

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Evaluating Strategies for Sustainable Mobility

A Qualitative Comparison of Amsterdam, Delft and Leiden

Colophon

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Abstract

As part of the European Green Deal, the European Commission expressed its ambition to reduce greenhouse gas emissions with at least 55% in 2030 compared to 1990, with the final aim to become climate neutral in 2050. In the Netherlands the traffic and transport sector is one of the largest sources of CO_2 emissions, and thus drastic changes need to be made to make both cities and mobility sustainable. This raises the question to what extent current mobility policies are addressing challenges and opportunities, and what lessons different cities can learn from each other. This because there currently is little known about how mobility policies address sustainability challenges in practice and what is missing. The aim of this study is therefore to compare the approaches of Amsterdam, Delft and Leiden with regards to sustainable mobility in four categories: trip substitution, modal shift, distance reduction and technological innovation. A content analysis of policy documents shows that the municipality of Amsterdam has the most extensive approach, tackling issues in most categories (modal shift, distance reduction and technological innovation). Delft and Leiden have been mostly addressing challenges of the categories modal shift and technological innovation. These large differences between the approaches of the studied cities could be coherent with the differences in budget. None of the cities have considered the category trip substitution. This could possibly be explained by the difficult position of municipalities to implement measures in this category. Policy recommendations are the stimulation of working from home policies using subsidy arrangements (trip substitution), the development of eHubs (modal shift), setting requirements for concentrations in to build areas within city boundaries (distance reduction), and the development of MaaS tools (technological innovation).

Key words Sustainable mobility, urban mobility, sustainable development, urban sustainability

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1. Introduction

1.1 Background

In 2015 all United Nation member states adopted seventeen Sustainable Development Goals as part of the 2030 Agenda for Sustainable Development. One of these goals is to make urban areas "*inclusive, safe, resilient and sustainable*" (Inter-Agency and Expert Group on Sustainable Development Goal Indicators, 2016, p.14). This includes providing sustainable transport systems for all (Auclair et al., 2013). According to Mihyeon Jeon and Amekudzi (2005), there is no standard definition of sustainable transport. However, they argue that the consensus seems to be that progress for developing sustainable transport systems is needed on at least economic development, environmental preservation and social development.

On a continental scale, this goal has partly been translated in the European Green Deal. As part of this deal, the European Commission initially expressed its ambition to reduce greenhouse gas emissions with at least 40% in 2030 compared to 1990, with the final aim to become climate neutral in 2050 (European Commission, 2020). However, recently this ambition has been raised to a reduction of 55% (European Commission, 2021). The Dutch national government has not adjusted its ambitions to this change yet and strives for a reduction of 49% (Ministerie van Economische Zaken en Klimaat, 2020). According to CROW (2020b), the share of the traffic and transport sector in total CO_2 emissions in the Netherlands has fluctuated around 29% over the past years. Since this sector is one of the largest sources of CO_2 emissions in the Netherlands, drastic changes need to be made in order to achieve the goal of sustainable mobility in the upcoming decade.

In the Netherlands, many people have access to public transport. The average distance to a train station in the Netherlands is 5.1 kilometres in 2019 (CBS, 2020), which is within cycling distance (7.5 kilometres) (CROW, 2020a). However, the dominant mode of transport still remains the car (Wiersma et al., 2017). In order to reverse the process of car-dependence, and thus to reduce the greenhouse gas emissions, it is essential for Dutch institutions to use an appropriate combination of measures to encourage sustainable mobility. This is not only necessary to reduce the effects of global warming, but this will also increase the liveability for the citizens (e.g. air quality and health concerns).

1.2 Research Problem

1.2.1 Research Gap

While there are plenty of universal (United Nations New Urban Agenda, United Nations Sustainable Development Goals), continental (European Green Deal) and national visions (Green Deal), it remains unclear how these visions are translated in urban policies. This because there currently is little known about how mobility policies address sustainability challenges in practice and what is missing from these practices. Specifically, in the Netherlands there is no overall masterplan and the implementation of sustainability measures is decentralised to the municipal level. This entails that every municipality has to draw up their own plan and it is therefore unclear how sustainable mobility policies are adopted (Planbureau voor de Leefomgeving, 2013). It is unknown what the differences between the approaches of cities are, and literature suggests that the current approaches are not ideal yet (Batty et al., 2015; Berger et al., 2014; Kauf, 2019). Therefore, the aim of this research is to compare policies of several Dutch cities, and to determine what lessons these cities can learn from each other's approach.

1.2.2 Research Question

From this aim the primary research question is defined as followed:

> *To what extent are current mobility policies in the cities Amsterdam, Delft and Leiden addressing challenges and opportunities around sustainable mobility, and what lessons can be derived from these policies?*

In order to answer this question, this research will address the following secondary research questions:

1. *What are the general challenges and opportunities regarding sustainable mobility?*
2. *How are the cities Amsterdam, Delft and Leiden dealing with the challenges and opportunities regarding sustainable mobility?*
3. *What are the differences and similarities between sustainable mobility approaches in the cities Amsterdam, Delft and Leiden?*
4. *How extensive are sustainable mobility policies in the cities Amsterdam, Delft and Leiden (compared to each other)?*

1.3 Thesis structure

The remainder of this thesis is structured as follows. Chapter 2 contains the main concepts and ideas in the theoretical framework. Chapter 3 elaborates upon the methodology and data that have been used to answer the research questions, and the results of this are presented in chapter 4 together with a comparison. The research question is answered and discussed in chapter 5 and recommendations for further research and policies are given. Lastly, the list of references and the appendices are found in chapter 6 and chapter 7 respectively.

2. Theoretical Framework

2.1 Types of sustainability

Many different definitions of sustainable development and its different aspects are used in the literature. Science for Environmental Policy (2018) distinguishes between three types of sustainability that are interrelated: environmental, economic and social sustainability, also known as the three pillars of sustainable development. Tanguay et al. (2010) argue that development must be equitable, liveable and viable. They regard each of these three features as interactions between multiple dimensions of sustainability and they visualize this in the diagram below (Figure 1).

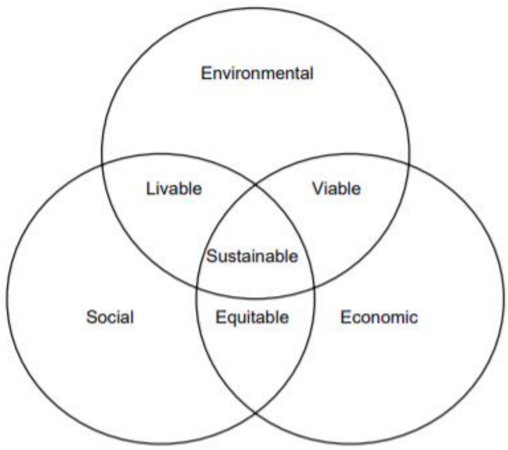

Figure 1 Classic Dimensions of Sustainable Development (Tanguay et al., 2010)

Sustainable mobility is concerned with all of these three types of sustainability. It is concerned with environmental sustainability as the needs of both current and future generations cannot exceed the capacity of their environment and ecosystem (Kennedy et al., 2007; Morelli, 2011). Next to that sustainable mobility is also concerned with economic sustainability as it is focused on using resources (such as gasoline) as efficient as possible (Kammerlander et al., 2015). Lastly, it is concerned with social sustainability as well, e.g. the mode choice behaviour of individuals (Tyrinopoulos & Antoniou, 2013). This means that sometimes sustainable mobility issues are environmental, social, economic or a combination of these. Thus, to become fully sustainable in terms of mobility, the city's environment needs to be protected while using available resources as efficient as possible and adjusting the mode choice behaviour of its residents.

2.2 Definition sustainable city

On a global scale, more people live in urban areas (55% in 2018) compared to rural areas. Cities are accountable for around 70% of the global carbon emissions and over 60% of the total resource use (United Nations, 2018). The United Nations (n.d.) argue that rapid urbanisation results in "*inadequate and overburdened infrastructure and services, worsening air pollution and unplanned urban sprawl*". Because of these effects and relatively high numbers compared to rural areas, most focus is on urban areas to become more sustainable.

According to Cohen (2017), there is no single definition of a sustainable city agreed-upon in literature. Definitions of the sustainable city often include environmental, social, economic, political, demographic, institutional and cultural goals (Satterthwaite, 1997). Cohen (2017) defines the goal of a sustainable city to build human settlements that have the least possible impact on the environment. Here impact refers to the ensuring that natural systems that are central to the well-being of people are maintained and damaged as little as possible.

This definition is useful, however, this definition is mainly focused on environmental sustainability, while leaving out other relevant social and economic aspects of mobility. The different types of sustainability and the many different aspects of sustainability make it complex to sufficiently capture the definition of the sustainable city concept.

2.3 Indicators for sustainable mobility

Banister (2008) distinguishes between four types of approaches towards sustainable mobility: trip substitution, modal shift, distance reduction and technological innovation. These are focused on increasing human well-being and ecological protection in the form of emission reduction. According to Mokhtarian (2009) and Sarkady et al. (2021), trip substitution is the reducing need to travel. In this case the trip will be replaced by a non-travel activity, for instance working from home rather than working from the office. For the second approach, modal shift, transport policy measures can be used to initiate a shift from relatively unsustainable modes (e.g. gasoline-fuelled car) to more sustainable modes (e.g. walking, cycling, public transport, electric/hybrid car) (Batty et al., 2015). Another approach is distance reduction. Banister (2008) argues that land-use policy measures on urban form and layout can lead to a shift towards more sustainable modes of transport. The final approach is technological innovation that leads to an efficiency increase, for instance in engine design or the generation of renewable energy sources.

Gallo and Marinelli (2020) and Banister (2008) provide a range of general actions a governmental organisation can include in policies. These actions have been taken as indicators for sustainable mobility within the framework displayed in Table 1. These general actions have been linked to the four approaches mentioned earlier. Besides this, each indicator is provided with multiple examples of how the indicators can be recognized or identified in policy documents. This table will later be used to assess the presence of the indicators in sustainable mobility policies of several cities.

Table 1 Indicator framework sustainable mobility

Approach	Indicator	Examples of how to identify indicators in policy documents	Presence in objectives: goals, targets, principles	Presence in implementation
Substitution	Stimulating working from home	Reducing travel allowance, working-from-home reward		
Modal shift	Discouraging private car ownership	Limited parking spots, expensive parking costs, car-sharing		
	Stimulating electric/hybrid vehicles	Providing charging spots, special parking spots		
	Stimulating slow modes (walking/cycling)	Development of safe bicycle lanes/ sidewalks		
	Stimulating public transport	High accessibility, reliable schedules, frequency		
Distance reduction	Increasing densities and concentration	No expansion of the city towards rural area, infringement projects		
	Mixed-use developments	Neighbourhoods with multiple functions besides residential		
	Public transport oriented developments	Development of a strong public transport network with high accessibility in a close proximity		
	Car-free developments	Car-free zones, limited parking spots		
Technological innovation	Smart mobility	Smart mobility labs		
	Renewable energy	Solar panel subsidies, wind/solar park development		

2.4 Conceptual Model

The conceptual model in Figure 2 shows how the main concepts and theories within this thesis are related. It first shows the interrelation of economic, social and environmental sustainability. To determine the extensiveness of a sustainable mobility policy document, four strategies can be specified: travel substitution, modal shift, distance reduction and technological innovation. Each of these with their respective indicators.

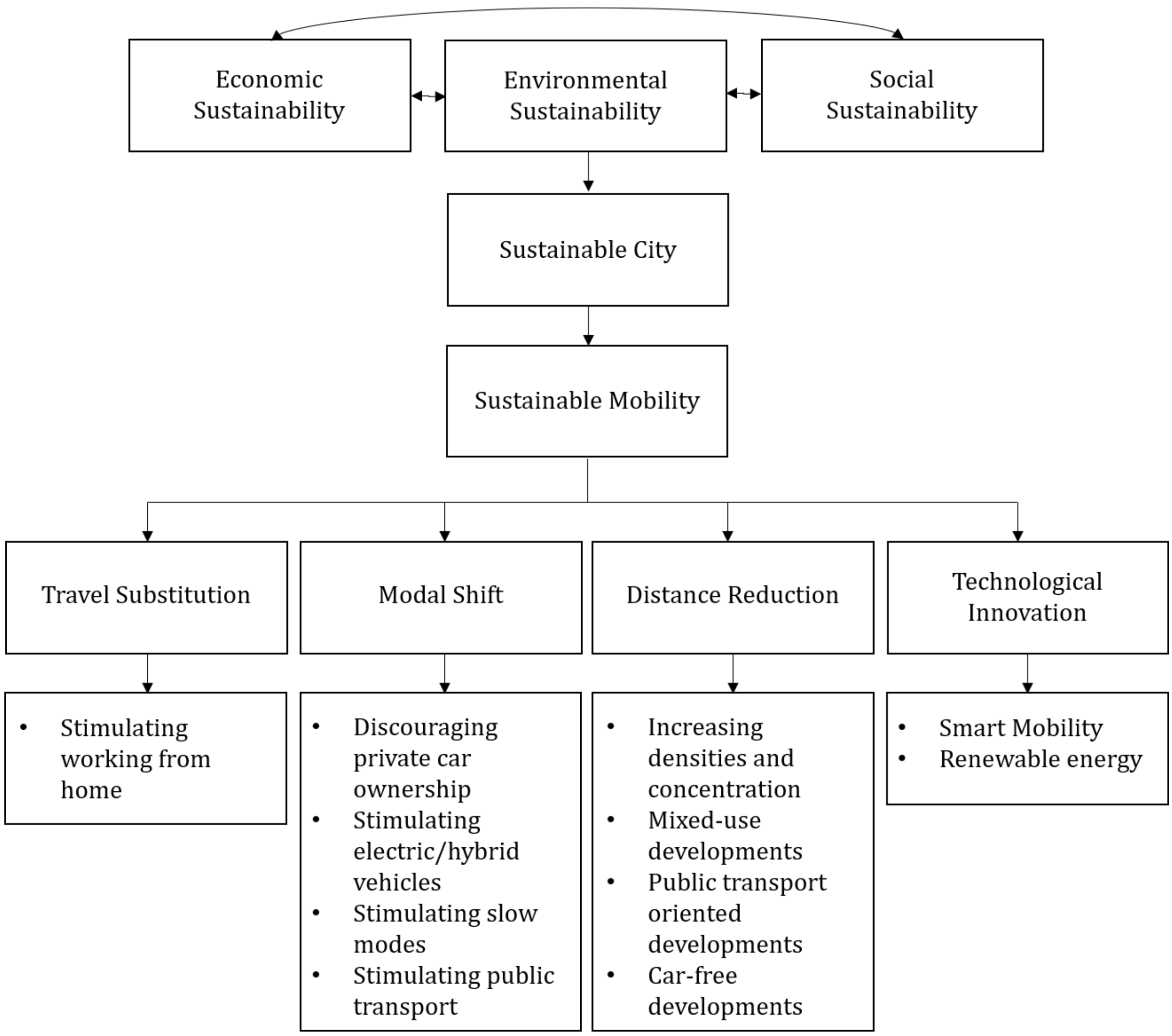

Figure 2 Conceptual model

3. Methodology

3.1 Case selection

As the Netherlands offers its residents access to a good variety of transport modes (e.g. good cycling infrastructure and overall access to public transport), three Dutch cities have been selected to be analysed, compared and drawn general lessons from. The cities have been selected by using the key parameters of the sustainable city as empirically researched by Banister (2005, 2006). He argues that sustainable cities should be:

1. Over 25.000 population, and preferably over 50.000,
2. with medium densities of over 4.000 persons per km^2,
3. with mixed use developments, and
4. with preference for developments in public transport corridors and near highly public transport accessible interchanges.

Of the cities that satisfy the criteria relatively the best, three have been chosen based on the availability of data. These remaining three cities are Amsterdam, Delft and Leiden. For a more detailed description of the selection of the cities and the data used for this, see Appendix 1.

3.2 Data collection and analysis

3.2.1 Literature review

To answer the primary research question "*To what extent are current mobility policies in Dutch cities addressing challenges and opportunities around sustainable mobility?",* two complementary qualitative methods have been used. The first method being a semi-systematic literature review to determine both the general challenges and opportunities of sustainable mobility based on academic literature. This method is used to answer secondary question 1, that focuses on the theoretical component of challenges and opportunities regarding sustainable mobility policies. Tranfield et al. (2003) define a literature review as the collecting and synthesizing of previously done research in a systematic manner. According to Snyder (2019), an effective and well-conducted literature review creates a solid basis for advancing knowledge and facilitating theory development. The challenges and opportunities found in the literature review are therefore used as a basis for identifying the challenges and opportunities in sustainable mobility policy documents of three cities.

The framework in Appendix 2 has been used to conduct literature searches. This framework offers a step-by-step guide to conduct a literature search. The search terms used for this literature review are "challenges" OR "opportunities" AND "sustainable mobility". These search terms produced an extensive amount of literature. In order to reduce the list of references to manageable proportion, the references have been evaluated using the criteria in the table in Appendix 2 (Clifford et al., 2016). The literature used has been collected using the search engines *Scopus* and *Smartcat*.

3.1.2 Content analysis

As most information on the sustainable mobility policies was expected to be found in policy documents (as these represent current choices), a content analysis of policy documents is a suitable method. A content analysis is a detailed reading and a classification of (policy) texts (Clifford et al., 2016). The documents used and a description can be found in Appendix 3. After the literature review, this content analysis of cities' policies has been conducted to determine in which manner cities deal with the challenges and opportunities identified in the literature review (secondary question 2). This has been done by using the indicators in the evaluation framework defined in the Theoretical Framework (Section 2.3) as codes in ATLAS.ti (for coding scheme see Appendix 4). The codes and the indicators used are the same and have been developed beforehand to serve as a guide to help identify each indicator. Therefore, the type of coding used is deductive (Punch, 2014). For two indicators little was known on how they would emerge in policy documents and therefore these two codes have been marked as inductive in the coding scheme in Appendix 4.

Each indicator's level of presence has been determined for both the objectives of the policy and the implementation of the policy. The different degrees of presence have been colour coded as follows: (red) not present in the policy document, (orange) only mentioned in the policy document, and (green) actively elaborated upon in detail in the policy document.

Table 3 Colour coding degree of presence in objectives and implementation

	Not present in policy document
	Passively present: only mentioned in the policy document
	Actively present: elaborated upon in detail in the policy document

The different approaches have been compared, determining the differences and similarities between the cities (secondary question 3). Eventually, the evaluation framework has been used to evaluate on the extensiveness of cities' sustainable mobility policies compared to each other (secondary question 4). This entails an approach that tackles the issues on all four types of indicators.

Based on the evaluation frameworks developed for each city, the colour codes have been transformed into five numerical categories. The colours used have been assigned the following scores: the colour code green is worth 2 points, orange is worth 1 point and red is worth 0 points. For each indicator, the points given for the objectives and the implementation have been summed. This allows for a total of 0 to 4 points per indicator or five degrees of presence.

In order to understand the context of policies, other documents (such as newspaper articles) have been analysed as well. This is necessary in order to avoid deprivation of the real meaning of a text or document (Punch, 2014). The policy documents used in the content analysis, have been collected from the websites of Amsterdam, Delft and Leiden. Newspaper articles have been gathered using the *Nexis Uni* database (formerly called *LexisNexis*). The analysis of the gathered data is visually resembled in Figure 4.

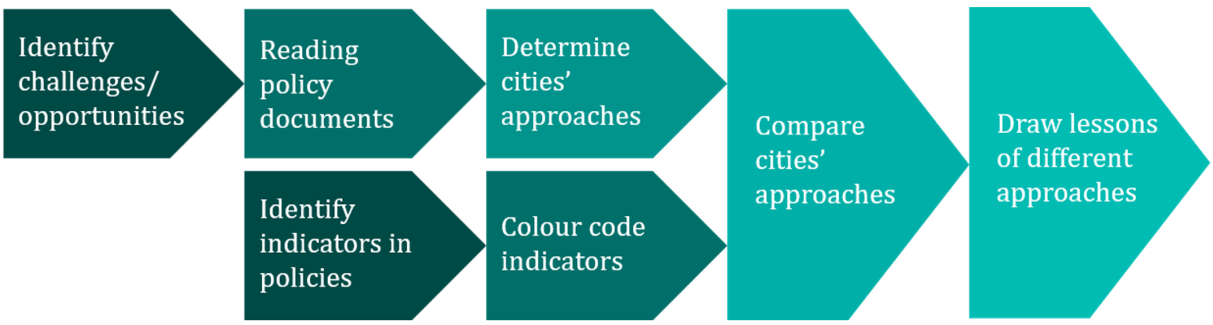

Figure 4 Data analysis scheme

4. Results

In this chapter first the general challenges and opportunities of sustainable mobility policies have been identified using academic literature in section 4.1. After that, each indicator's level of presence is determined using colour codes for each city's policy documents. A list of the used policy documents and context of the cities is added in Appendix 3. Finally, section 4.5 draws a comparison between the cities' approaches.

4.1 Challenges and Opportunities

4.1.1 Trip Substitution

Trip substitution is often linked to information and communications technology. It is argued that the use of telecommunication tools would reduce the amount of face-to-face interactions between people (Mokhtarian, 2009). In the past, this has happened for instance with the invention of telephones, as people did not need to travel to another person to pass on information any longer. However, reducing the travel demand by use of ICT is not as easy as often thought (Mokhtarian, 2009). Municipalities are often not in the right position to implement measures to substitute trips. For instance, they do not have the power to decide that their citizens have to work from home on certain days to reduce commuting. This power lays with companies themselves, and thus municipalities can only implement such a measure through collaboration or only for their own employees.

However, there are opportunities to stimulate working from home in order to reduce travel demands regarding commuting. During the COVID-19 pandemic, many employees are forced to work from their homes instead of the office, leading to less trips (Sarkady et al., 2021). Municipalities could use this temporary development to continue stimulating working-from-home policies in collaboration with local companies post-pandemic. An example is the Province of Overijssel, which has made €500.000,- available to support employers in stimulating their employees to work from home through a subsidy arrangement (RTV Oost, 2020). With this budget companies hire an external advisor that will help them to compose plans for working from home post-pandemic (Provincie Overijssel, n.d.). These companies also could stimulate their employees by offering working-from-home subsidies instead of travel cost subsidies. When stimulating employees to work from home, less workspaces on location are needed. Therefore, the employer could reduce the amount of office spaces for their company and thus reduce their costs (Kelly, n.d.; Messenger, 2019).

Thus, the literature suggests that to substitute trips, municipalities need to collaborate with local companies and together decide on suitable working-from-home policies, for instance through subsidiary arrangements.

4.1.2 Modal Shift

The use of private cars is generally regarded as an essential part of life for many citizens (Batty et al., 2015). The convenience, flexibility and personal space are considered of significant importance in people's modal choice for private cars (Beirão & Sarsfield Cabral, 2007; Vredin Johansson et al., 2006). Next to these characteristics, private car usage is often also perceived as a social status symbol (Pojani et al., 2018), and the personal benefits outweigh the environmental costs (Becker et al., 2012). According to Batty et al. (2015), these factors can be challenging in the mission to initiate a shift from private transportation towards slow modes and public transportation.

Cities can address such challenges by composing the right policies and plans. To overcome the barriers of modal shift, the externalities of cars need to be internalized, both public support (or at least acceptance) and political commitment are necessary, just as investments and research in the matter (Batty et al., 2015). Batty et al. (2015) and Straatemeier and Bertolini (2020) propose different push and pull measures to initiate such a modal shift. Pull measures include an increase in safety and security, sufficient provision of travel information, a high frequency and reliability, and multimodality to increase the ease of use. The push factors mentioned by Banister (2007) and Batty et al. (2015) are congestion charging, parking regulations and urban planning. This last measure, the efficient and compact planning of cities, can be of use to combine multiple functions on a closer proximity. Next to this, cities could be planned in a manner that is unsatisfactory for car, think about car-free areas of bicycle streets. Compact planning does not only lead to a shift towards the use slow modes, but also to distance reductions for the remaining use of motorized vehicles.

Therefore, the key challenges are a shift from private to public modes and a shift from relatively unsustainable to relatively more sustainable modes of transport.

4.1.3 Distance Reduction

It is argued that transport has a clear impact on both land-use and urban form. Land-use and the urban form are factors that affect people's modal choice, trip lengths and speeds (Banister, 2007b). This can be shown with use of the land-use transportation feedback cycle displayed in Figure 5. This figure shows the interaction between transport and land-use. The distribution of land-uses partly determines where certain activities take place (e.g. residential, recreational). The distribution of activities over space creates the need for a sufficient transportation system to move from one activity to another. In turn the distribution of infrastructure partly determines where opportunities for spatial interaction lie (Straatemeier & Bertolini, 2020). Therefore, Banister (2007) argues that higher density developments are more probable to be clustered around a public transport network than lower density developments.

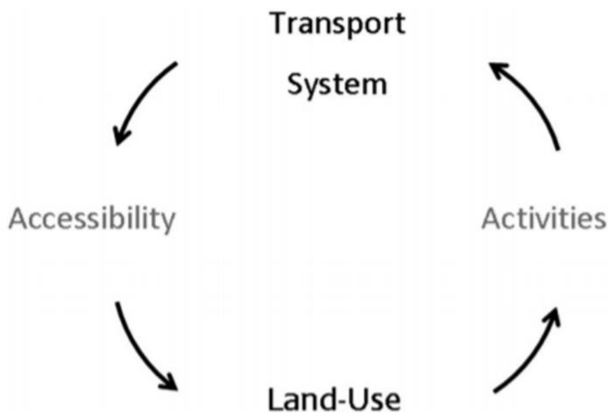

Figure 5 Transport and land-use feedback cycle (Giuliano, 2004; Meyer & Miller, 2001; Wegener & Fürst, 1999)

For this reason, Banister (2007) pleads for an intensification of functions within existing settlements. As more functions are developed in a closer proximity to each other, trips become shorter and the proportion of trips by public transport increases. Litman (2010) argues that vehicle travel is usually 5% to 15% lower in mixed-use areas compared to single-use areas. Banister (2005) shows that an increase in density leads to a decrease in the proportion of car-usage. Therefore, mixed-use developments reduce both trip lengths and car dependency (Banister, 2007b).

In short, according to the literature this entails that cities need to be planned with a high density, and thus to densify and mix functions to reduce the distance that is needed to travel.

4.1.4 Technological Innovation

Currently, many motorized vehicles run on non-renewable energy sources, such as gasoline and diesel. To reduce emissions from these vehicles, it is of importance to use the best technologies available (Banister, 2008). Some measures Banister (2007) proposes (for governments) to tackle sustainable mobility issues, are "*investments in technology in transport modes, in information systems and in the transport system itself*" (Banister, 2007, p.95). These measures are aimed at achieving smart mobility within cities. Examples of this are investments in Mobility as a Service tools, developments of smart tools to monitor and analyse traffic, or the development of eHubs. Another (complementary) approach would be technological innovation in the field of energy. The last two steps of the *Trias Energetica* highlight the importance of both the use of renewable energy (instead of non-renewables) and the use of energy supplies as efficient as possible (Lenhart et al., 2015).

Thus, a typical challenge for technological innovation is resource efficiency and the use of renewable resources.

4.2 Amsterdam

For the city of Amsterdam, not all indicators are present in the policy and plan documents (Table 4). In order to gain the most in terms of sustainable mobility in all categories, gains are to be made in the categories trip substitution (stimulating working from home), modal shift (stimulating electric/hybrid vehicles) and distance reduction (mixed-use developments).

Overall, the municipality of Amsterdam has a rather complete approach. Most of the measures can be found in the policy and plan documents. Even though the municipality of Amsterdam aims to discourage car-usage within the city and aims to keep developments within the current city boundaries, they still allow for controlled expansion of car facilities at the edges of the city. Their main plan to reduce cars in the inner-city is by providing underground parking facilities to ensure the cars do not cause hindrance on the streets. Thus, the parking of cars in the inner-city is not actively discouraged by this measure, but provided with facilities to keep cars at the edge of the city. The municipality does discourage the use of the most polluting vehicles by maintaining environmental zones where these vehicles are not allowed (Gemeente Amsterdam, n.d.-b).

4.3 Delft

In the case of Delft, not all indicators are present in the policy and plan documents (Table 5). In order to gain the most in terms of sustainable mobility in all categories, gains are to be made mostly in the categories trip substitution and distance reduction.

Remarkable is the amount of red marked cells in Table 5 in the category distance reduction. None of the above-listed documents mention anything about the potential of these measures regarding the development of more sustainable mobility plans and policies. The category trip substitution has been marked red as well. Certain goals and targets that have been announced in policy documents do not return in any actual plans of the municipality. This may be due to the fact that the documents reviewed in this study are not all final yet, and they have been published rather recently. The document '*Mobiliteitsprogramma Delft 2040'* has been approved by the municipal council in January 2021 (Gemeente Delft, 2021). Therefore, the implementation of the mentioned measures has not been fully incorporated into plans yet.

Surprisingly, none of the documents mentions a potential collaboration with the Technical University of Delft. The TU Delft is researching future challenges regarding smart mobility in its Smart Mobility Lab (TU Delft, n.d.). Results of the studies done could not only be of importance for the city of Delft, but as well for other cities. A newspaper article from 2019 mentions the intensification of the collaboration between the municipality and the university (Delftse Post, 2019), however little to no signs of this are to be found back in their policy and plan documents. The better use of this collaboration could perhaps help the municipality of Delft in providing a more detailed plan regarding smart mobility and to seek the situation-specific opportunities for Delft's future.

4.4 Leiden

For Leiden, not all indicators are present in the policy and plan documents (Table 6). In order to gain the most in terms of sustainable mobility in all categories, gains are to be made in all categories: trip substitution (stimulating working from home), modal shift (stimulating electric/hybrid vehicles), distance reduction (increasing densities and concentrations, mixed-use developments, public transport-oriented developments) and technological innovation (renewable energy).

Several indicators in the category distance reduction are notably absent within the policies and plans of the city of Leiden. Only the indicator car-free development has been actively present within the policy documents. Even though Leiden has mentioned itself as a compact city, it has not been discussed more in-depth showing any measures on how to maintain Leiden compact and how to regulate that in the future anticipating for the predicted urbanisation. Therefore, in order to have a more extensive approach towards handling sustainable mobility issues, more measures are needed.

In terms of technological innovation it is remarkable that ambitions are actively mentioned, but when it comes to implementation the municipality takes a passive role. The municipality of Leiden would like to cooperate with companies to develop tools for smart mobility, but does not aim to take an active role and develop tools themselves. With regards to the measure renewable energy in this indicator category there are yet no measures, since the policy is still in development. After approval of the policy it is expected more measures will be implemented.

Table 4 Evaluation framework sustainable mobility Amsterdam

Approach	Indicator	Presence in objectives: goals, targets, principles	Presence in implementation
Substitution	Stimulating working from home		
Modal shift	Discouraging private car ownership	AMS1: Parking policy (higher costs, less parking spots), prioritizing slow modes and PT over car-usage	AMS1: Parking policy (higher costs, less parking spots) AMS3: Promoting car-sharing, prioritizing slow modes and PT over car-usage (traffic lights, green wave for cyclists)
	Stimulating electric/hybrid vehicles	AMS1: Stimulating electric scooters	
	Stimulating slow modes (walking/cycling)	AMS1: Prioritizing slow modes over car-usage, increasing quality of bicycle lanes (widening, lighting) AMS2: Developing parking facilities for bicycles	AMS2: Development of 38.000 parking spots for bicycles at specified locations, the widening of 15 kms of bicycle lanes, increasing flow capacity, developing new connections AMS3: Creating more space for walking and cycling, prioritizing slow modes over car-usage (traffic lights, green wave for cyclists), (re)developing currently missing/weak connections
	Stimulating public transport	AMS1: Stimulating multi-modality, prioritizing PT over car-usage, increasing comfort of PT (higher frequency, better connections)	AMS1: Development of P+R's, development of Noord/Zuidlijn and Zuidas AMS3: Car parking outside of the city to stimulate the use of PT to the centre of the city (P+R), prioritizing PT over car-usage, fastened implementation of investment agenda PT, expansion and increasing quality of PT network
Distance reduction	Increasing densities and concentration	AMS1: Keeping developments within the current urban areas (not expanding outwards)	AMS2: Controlled small-scale expansion of car usage outside the Ring road
	Mixed-use developments	AMS1: Intensifying land-use through combining service, residential and labour functions	

	Public transport oriented developments	AMS1: Development of more nodes to distribute passengers over multiple large stations (thus not all passengers over Amsterdam Centraal)	AMS1: Development of Noord/Zuidlijn and Zuidas
	Car-free developments	AMS1: Less cars inner-city, stimulating use of P+R's, parking policy (higher costs, less parking spots)	AMS1: Less cars inner-city, stimulating use of P+R's, parking policy (higher costs, less parking spots)
Technological innovation	Smart mobility	AMS4: (1) Optimizing digital tools and instruments and (2) developing innovative solutions for mobility-related issues	AMS4: (1) Use of platform MobiLab to manage, analyse and predict traffic flows, and research through Mobility Urban Values app, and (2) use of eHubs, Smart Mobility Labs and driverless-car pilot
	Renewable energy	AMS1: Generate energy locally through district heating, solar energy, wind energy and biomass, and developing underground energy storage according to the principle *Trias Energetica*	Not present in mobility plans, but present in energy plans (see *Concept RES Amsterdam* (Gemeenteraad Amsterdam, 2020))

Table 5 Evaluation framework sustainable mobility Delft

Approach	Indicator	Presence in objectives: goals, targets, principles	Presence in implementation
Substitution	Stimulating working from home		
Modal shift	Discouraging private car ownership	DEL2: Prioritizing slow modes and PT over car-usage, decreasing speed limits for most roads, no free parking, stimulating car-sharing, stimulating MaaS, campaigning for alternatives for private car ownership	OS*: Increasing parking costs, campaigning for alternatives for private car ownership (development of shared mobility hub)
	Stimulating electric/hybrid vehicles	DEL2: Stimulating electric vehicles, set environmental zones (limit non-electric vehicles), campaigning for alternatives for private car ownership	OS*: Campaigning for alternatives for private car ownership (development of shared mobility hub including electric vehicles)
	Stimulating slow modes (walking/cycling)	DEL2: Prioritizing slow modes over car-usage, main walking routes are being made free of obstacles, expansion of walking zone, improving walking routes towards station, centres and university, prioritizing cyclists at potential conflicting situations, increasing the amount of bicycle parking spots, campaigning for alternatives for private car ownership	DEL2: Expansion of walking zones at Campus and inner-city, increasing the amount of bicycle parking
	Stimulating public transport	DEL2: Prioritizing PT over car-usage, improve services by improving the through-flow, campaigning for alternatives for private car ownership	OS*: Provide input for transport plans Metropole region Rotterdam Den Haag, campaigning for alternatives for private car ownership (development of shared mobility hub)
Distance reduction	Increasing densities and concentration		
	Mixed-use developments		
	Public transport oriented developments		

	Car-free developments		
Technological innovation	Smart mobility	DEL2: Stimulating MaaS, using Intelligent Traffic Systems	
	Renewable energy	DEL2: 25% of energy is renewable by 2030, all electric charging stations use renewable energy by 2020, development of district heating	Not present in mobility plans, but present in energy plans (see *Concept Warmteplan* (Gemeente Delft, 2020))

*OS = other source (Gemeente Delft, n.d.)

Table 6 Evaluation framework sustainable mobility Leiden

Approach	Indicator	Present in objectives: goals, targets, principles	Present in implementation
Substitution	Stimulating working from home		
Modal shift	Discouraging private car ownership	LEI1/LEI2/LEI4: Expansion of car-free zones LEI2: Supporting vehicle-sharing concepts LEI2/LEI5: Increasing price of car-parking LEI4: Developments of P+R's	LEI1/LEI2/LEI4: Expansion of car-free zones LEI5: Increase in prices car-parking LEI4: Reduction of speed limits, research about shared-mobility and hubs, developments of P+R's
	Stimulating electric/hybrid vehicles		
	Stimulating slow modes (walking/cycling)	LEI1/LEI2: Improvement and expansion of walking and cycling paths LEI1/LEI2/LEI5: Development of more bicycle parking LEI2: Improvement of quality and experiences along walking routes, specific attention to different types of walkers/cyclers (children, fast-bikers, elderly) LEI2/LEI4: Invest in services for cyclists	LEI2: Adaptation of fast cycling routes (*snelfietsroutes*) at specified locations LEI2/LEI4: Expansion of walking and cycling paths: giving more space to slow modes LEI5: Development of more bicycle parking (including the replacement of car-parking with bicycle-parking)
	Stimulating public transport	LEI1: Improvement and expansion of public transport network LEI2: Improve availability, frequency, comfort, destinations and flexibility (to compete with car)	LEI1: Developing connections of all neighbourhoods to the inner-city and to the new PT terminal LEI2: Realisation of HOV corridors at specified locations e.g. *R-netlijn 400* and Leiden-Katwijk
Distance reduction	Increasing densities and concentration	LEI1: Leiden is mentioned as a compact city	
	Mixed-use developments		
	Public transport oriented developments		
	Car-free developments	LEI1/LEI2/LEI4: Expansion of car-free zones	LEI1/LEI2/LEI4: Expansion of car-free zones e.g. Stationsgebied Leiden and Turfmarkt

Technological innovation	Smart mobility	LEI2: Stimulating MaaS with an emphasis on vehicle-sharing, walking and cycling	LEI2: Collaborate with partners to let them develop MaaS tools (no active action for municipality itself)
	Renewable energy	Reduce energy consumption, generate own renewable energy, Leiden natural gas free (not mentioned in mobility-related policies, see '*Energietransitie in Leiden*' (policy in development) (Gemeente Leiden, n.d.)	

4.5 Comparison

Based on the evaluation frameworks developed in Table 4, 5 and 6, the colour codes have been transformed into five numerical categories as explained in section 3.1.2. The results of this are displayed in Table 7 (for the full calculation see Appendix 5).

Table 7 Sum of degrees of presence in objectives and implementation per indicator per city

Indicator	Amsterdam	Delft	Leiden
Stimulating working from home	0	0	0
Discouraging private car ownership	4	4	4
Stimulating electric/ hybrid vehicles	1	4	0
Stimulating slow modes (walking/ cycling)	4	4	4
Stimulating public transport	4	4	4
Increasing densities and concentration	4	0	1
Mixed-use developments	2	0	0
Public transport oriented developments	4	0	0
Car-free developments	4	0	4
Smart mobility	4	2	3
Renewable energy	4	4	2

Based on these calculations the extensiveness webs in Figure 6 have been composed. This figure displays the degree of presence in both objectives and implementation per indicator for the cities Amsterdam, Delft and Leiden respectively. The outer hendecagon indicating the measure in question is actively present in both objectives and implementation (highest score possible = 4 points), to the inner hendecagon indicating that the measure is not present in objectives nor in implementation (lowest score possible = 0 points).

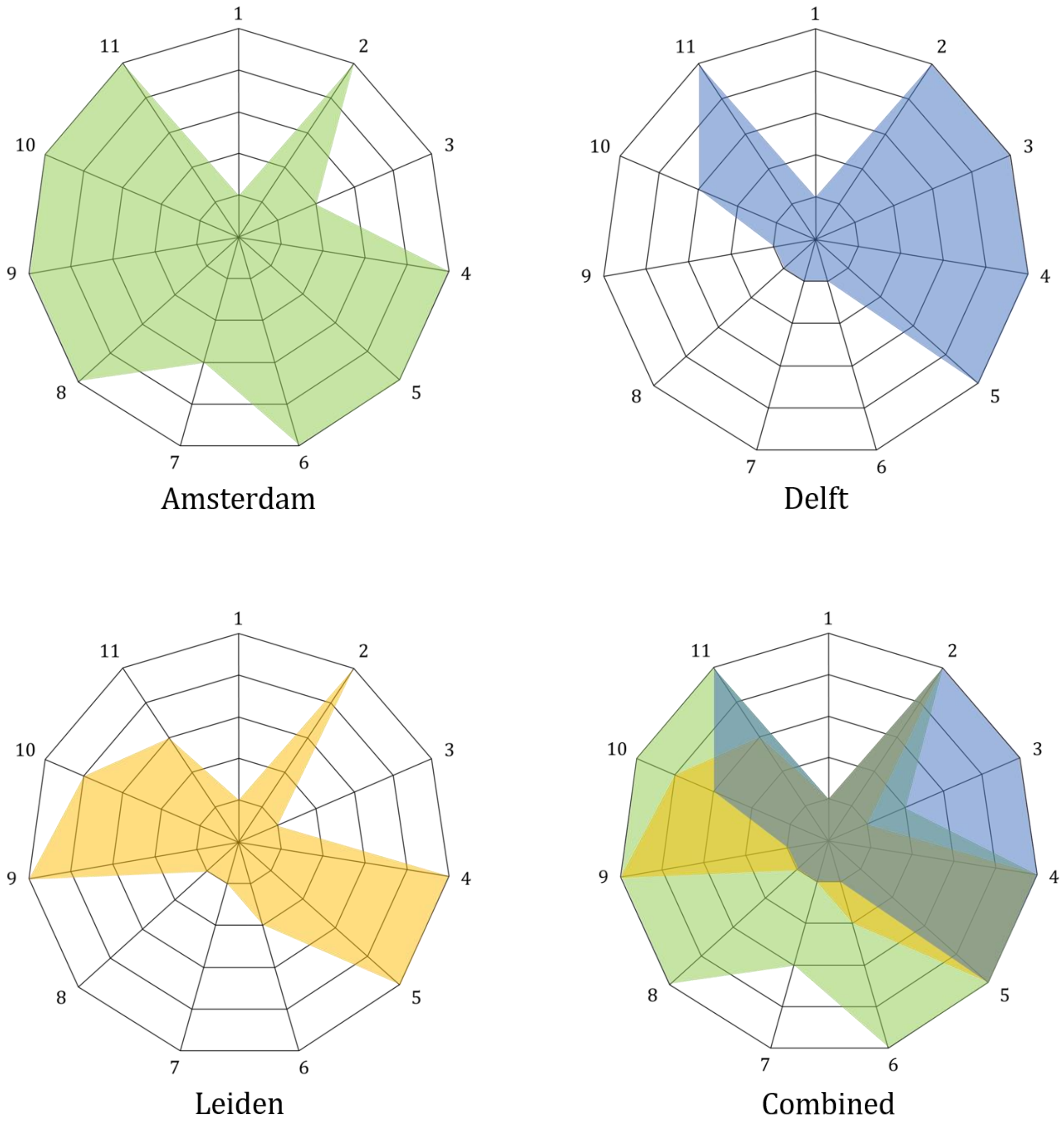

Figure 6 The extensiveness of sustainable mobility policies based on the evaluation frameworks for Amsterdam (Table 4), Delft (Table 5) and Leiden (Table 6) using the colour coding for degree of presence in policy documents (Table 3). Indicators: 1. Stimulating working from home, 2. Discouraging private car ownership, 3. Stimulating electric/hybrid vehicles, 4. Stimulating slow modes, 5. Stimulating public transport, 6. Increasing densities and concentrations, 7. Mixed-use developments, 8. Public transport oriented developments, 9. Car-free developments, 10. Smart mobility, 11. Renewable energy. Indicator categories: 1: Trip substitution, 2-5: Modal shift, 6-9: Distance reduction, 10-11: Technological Innovation.

4.5.1 Trip Substitution

All three cities are dealing with rapid urbanization and keeping up to those developments. Strikingly, Delft's and Leiden's main focus seems to be on modal shift and technological innovation. This contrasts to the more extensive ambitions of the city of Amsterdam, that also develops measures for the category distance reduction. Though, it is remarkable that none of the studied cities is concerned with the category trip substitution. As indicated in section 4.1.1, municipalities are often not in the right position to implement measures in this indicator category. However, the current COVID-19 pandemic measure, that only allows people with certain essential occupations to work on location, offers an opportunity to partially continue this trend in post-pandemic times.

4.5.2 Modal shift

The indicator category modal shift is by far the most present in policy and plan documents in all three cities. This is due to the clear tangible effect these measures have to obtain sustainable mobility (e.g. reduction of parking spot capacity) in contrast to the often less tangible effects of the other categories (e.g. intensification of land-use functions). Of the measures, the indicator stimulating electric/hybrid vehicles scores the lowest overall. The other three indicators are simply more interesting and have more potential to create a large effect. In their policies, the city of Delft mentions their goals and ambitions for the future, but does not name concrete plans to implement the measures yet as the policy has been approved only recently.

Regarding the indicator discouraging private-car ownership, it is remarkable that parking policies in both Amsterdam and Leiden are aimed at reducing the number of parked cars on and along streets, but that the cities do provide more parking space in parking garages or at the edge of the cities. The city of Leiden has recently, in 2019, realised two new parking garages. The approach here seems to be to park the cars out of eyesight, instead of tackling the issue and discouraging car-usage as the city of Delft aims to do. Therefore, this measure seems to be aimed more at increasing liveability than at increasing sustainability.

4.5.3 Distance reduction

As displayed in Figure 5, Amsterdam currently has the best scores for level of presence regarding policies and plans for sustainable mobility. Delft and Leiden both score relatively low compared to Amsterdam. The white areas in the web diagrams show for which indicators gains are to be made. For the cities Delft and Leiden most gains are to be made in this category. In this category Delft has not included any measures at all in objectives, nor in implementation. Leiden looks similar to Delft in this case, with a small difference for the indicator increasing densities and concentrations which scores a bit higher, but this score is still rather low. Leiden does have the same level of presence for the indicator car-free developments as Amsterdam.

4.5.4 Technological innovation

The last two indicators are concerned with the category technological innovation. Regarding the indicator smart mobility, all three cities have ambitions to use mobility as a service (MaaS). Amsterdam has a very active approach, not only do they use platforms such as MobiLab and Mobility Urban Values to manage, analyse and predict traffic flows, they also make use of eHubs, have developed a Smart Mobility Lab, and even started a driverless-car pilot. Delft and Leiden, on the contrary, have fewer visionary ambitions, but also take a more passive approach. Delft has no concrete plans on how to make use of Maas, and Leiden only wants to collaborate with other companies so they can develop tools for MaaS.

One of the projects regarding technological innovation, that could serve as an example to the other cities, is the eHub project of the municipality of Amsterdam. These eHubs are specified locations where shared electric vehicles are stationed for everyone to use. The vehicles stationed here are for instance electric cargo bikes and electric scooters, but also charging facilities for electric cars. This project is called BuurtHubs and is part of the European eHUBS project. Therefore, the municipality receives subsidies of Interreg North-West Europe to develop these eHubs. Within this project the municipality collaborates with several universities and mobility-related companies. The Dutch cities Nijmegen and Arnhem are both also working on this project (Gemeente Amsterdam, n.d.).

4.5.5 Budget

Besides the above-mentioned differences within the indicator categories, another difference was found during the analysis. This concerns the municipality's budget available per resident. Table 8 shows the significantly higher budget available to the municipality Amsterdam compared to the municipalities Delft and Leiden.

Table 8 Total budget and expenditure in 2019 per municipality (Rijksoverheid, 2019, 2020)

Municipality	Budget (€ million)	Expenditure (€ million)	Budget per resident (€)
Amsterdam	585,6	591,7	685,68
Delft	51,0	44,7	498,76
Leiden	50,4	48,4	405,45

5. Discussion and Conclusion

5.1 Discussion

5.1.1 Interpretation of the results

The aim of this research has been to compare the extensiveness of sustainable mobility policies between the cities Amsterdam, Delft and Leiden, and to draw lessons from their varying approaches. As the previous section showed, the city of Amsterdam has the most extensive approach towards handling sustainable mobility challenges. The other two cities have been mainly concerned with handling challenges in the categories modal shift and technological innovation, and thus placing less emphasis on challenges regarding the category distance reduction. This difference in approach between on the one hand Amsterdam and on the other hand Delft and Leiden could be explained through the budget available to these cities (Table 8). According to Rijksoverheid (2020), the budget of the municipality of Amsterdam is ten times higher than the budget of Delft or Leiden. This much higher budget of the municipality of Amsterdam could offer a potential explanation for the city's broader and more extensive approach. They simply can afford to initiate more measures and thus to tackle issues in all categories of sustainable mobility. On the other hand, it must be taken into account that the costs of the municipality of Amsterdam are also higher (Rijksoverheid, 2020). The lower budget of Delft and Leiden could possibly explain why these municipalities have focused on modal shift and technological innovation alone, instead of addressing measures in all categories (Trip substitution, modal shift, distance reduction, technological innovation). The municipality of Amsterdam has the budget to implement measures in most categories all at once, while Delft and Leiden have to implement the same measures in phases, starting with modal shift and technological innovation. The reason to start with modal shift, instead of the other categories (trip substitution, distance reduction, technological innovation), could be because the measures in this category offer larger effects than measures in other categories (considering the technologies currently available) (Banister, 2007b). Further research is needed to determine if there is coherency between the approach per city and their budget available.

5.1.2 Reflection on the research

This research consisted of the study of three cities regarding their approach towards sustainable mobility. The three cases selected have sufficient variation, however, they do not offer a complete overview of all types of cities. The policies of the cities Amsterdam, Delft and Leiden have been looked into in high detail. The findings from these policies have been linked to some contextual aspects such as the available budget per inhabitant per municipality. Perhaps there are more contextual aspects that could be taken into account.

When selecting the cities, four criteria of Banister (2005, 2006) have been used to select cities that are in certain way comparable. However, Amsterdam's budget per resident has shown to be higher compared to the other two cities. This makes a comparison between the cities not entirely reasonable. However, incorporating the municipality with the highest budget in the Netherlands (Rijksoverheid, 2020), does make the comparison more interesting. As the municipality of Amsterdam has most monetary resources, it intuitively follows that their practice should also be one of the best within the Netherlands. Whether this actually is the case, would be an interesting theory to test in further research. If one would wish to repeat this study, the budget per municipality should be considered when selecting cities on similar criteria.

A second point of attention during the research process has been a certain aspect of the research strategy. The content analysis consisted of the reading and coding of hundreds of pages of policy documents. One of the risks of coding everything by hand is that the researcher can unfortunately miss certain relevant information, which leads to less positive results when determining the extensiveness per city. This problem has been encountered and has caused spending a substantial amount of time rereading all policy documents and finding additional sources to determine the extensiveness. This study has focused on the most extensive approach. However, the extensiveness of an approach does not say anything about the quality of an approach and the quality of its implementation. To determine the effectiveness of an approach further research is needed.

5.2 Conclusion

The research question this study aimed to answer is:

> *To what extent are current mobility policies in the cities Amsterdam, Delft and Leiden addressing challenges and opportunities around sustainable mobility, and what lessons can be derived from these policies?*

This research question is a multiple question that can be split in two: challenges and opportunities, and policy recommendations.

5.2.1 Challenges and opportunities

The first part of the research question concerns the extent of which the three cities have addressed the challenges and opportunities. The challenges and opportunities are divided over the categories trip substitution, modal shift, distance reduction and technological innovation (Table 9).

Table 9 Overview of the challenges and opportunities

Category	Challenges	Opportunities
Trip Substitution	- Unsuitable position of municipalities	- Stimulating working from home
Modal Shift	- Convenience, flexibility, personal space of private cars and the lack thereof for other modes (public transport) - Private car as a social status symbol - Disproportionate costs of cars	- Discouraging private car ownership - Stimulating electric/hybrid vehicles - Stimulating slow modes (walking/cycling) - Stimulating public transport
Distance Reduction	- Urban growth - Urban sprawl - Edge city developments	- Increasing densities and concentrations - Mixed-use developments - Public-transport oriented developments - Car-free developments
Technological innovation	- Use of non-renewable energy sources (gasoline, diesel)	- Smart mobility - Renewable energy

Figure 6 shows the extent in which every measure was present in policy objectives and implementation plans per municipality. The municipality of Amsterdam has the most extensive approach, tackling issues in most categories (modal shift, distance reduction and technological innovation). Delft and Leiden have been mostly addressing challenges of the categories modal shift and technological innovation. These large differences between the approaches of the studied cities could be coherent with the differences in budget.

Strikingly, none of the municipalities has been concerned with the category trip substitution. This could possibly be explained by the fact that municipalities often are not in the right position to implement measures in this category, although there are opportunities.

5.2.2 Policy recommendations

The second part of the research question is concerned with the lessons that can be derived from the policies studied to guide the cities on their way to initiate sustainable mobility.

Since none of the three studied cities have incorporated the category trip substitution in their approach, incorporating this would be recommended. As elaborated upon in section 4.1.1 there are opportunities to do this. Stimulating working-from-home can be done by reducing travel allowance or by rewarding working-from-home.

The least gains are to be made in the category modal shift, as all three cities have an overall good score for the three out of four measures concerned with modal shift. The least successful measure, stimulating electric/hybrid vehicles, could be given more attention within policy documents. This measure can be combined with technological innovation as the municipality of Amsterdam does by developing eHubs.

Regarding the category distance reduction, the cities Delft and Leiden still have gains to be made. Measures in this category do not necessarily require high expenses. Instead of high-cost urban renewal projects, focus could be placed on the intensification of new developments and the implementation of mixed-use development. For instance, set requirements for certain concentrations in to build areas within city boundaries.

Technological innovation offers many possibilities and opportunities. An opportunity could be tools to better monitor, analyse and evaluate traffic flows e.g. MobiLab or Mobility Urban Values (Gemeenteraad Amsterdam, 2019, 2020). Another opportunity is the development of Mobility as a Service tools or MaaS tools. Such a tool could be an application to download on smartphones where all mobility services are combined within in one application. This makes it easier for people to see all their modal options (public transport, shared transport), the costs connected to each option and thus makes the choice for more sustainable modes easier. The development of such tools contributes to the stimulation of shared vehicle use, electrical vehicle use and public transport use (Gemeenteraad Amsterdam, 2013).

5.2.3 Final remark

Overall, the Dutch cities that have been analysed do not perform well yet. There is a lot more profit to be made for cities' mobility to become sustainable and achieve the Dutch government's aim to reduce greenhouse gas emissions with 49% by 2030 (compared to 1990). Amsterdam currently has the best practice of the three cities, but is far from the ideal situation. Delft and Leiden have made a decent start, but also still have left many challenges unaddressed. To successfully become sustainable, Banister (2005, 2006, 2007a) argues that a paradigm shift towards sustainable development is needed, and that this is not difficult to achieve in cities under the assumption that there is provided enough political and public support or acceptability. Banister (2008) regards acceptability as an essential but often neglected element of sustainable mobility. The studied cities have shown to be on their way to shift towards sustainable development. However, this is still difficult. As sustainable mobility will only succeed through the understanding and acceptance by the people, clearly targeted personal information is recommended. This includes social pressure, awareness raising, demonstration, persuasion and individual marketing (Banister, 2008).

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7. Appendices

7.1 Appendix 1 – Case selection data

As the Netherlands offers its residents access to a good variety of transport modes (e.g. good cycling infrastructure and overall access to public transport), and is thus innovative, three Dutch cities have been selected to be analysed, compared and drawn general lessons from. The cities that have been analysed in this study have been selected by using the key parameters of the sustainable city as empirically researched by Banister (2005, 2006). He argues that sustainable cities should be:

1. Over 25.000 population, and preferably over 50.000,
2. with medium densities of over 4.000 persons per km^2,
3. with mixed use developments, and
4. with preference for developments in public transport corridors and near highly public transport accessible interchanges.

One of the datasets used for the selection of the cities that has been researched in this study is the *Regional Key Figures Netherlands* dataset composed by the Central Bureau for Statistics (2020). This table contains a large amount of subjects covering the most important statistical data for diverse regional classifications. However, because this data is not available for only cities, the data for municipalities has been used under the assumption that the cities Banister (2005, 2006) has described, are situated within the municipalities selected by the stated criteria. The variables used from this large dataset are the population according to the population composition on January 1st 2021 and the population density per km^2 for the year 2020 (most recent data). Besides this, a filter has been applied to view the data per municipality. The data has been downloaded and analysed using Microsoft Excel, and has been used to determine which cities are suitable for this study in terms of population size and density.

For the first criterium, a population of over preferably 50.000, the list of municipalities has been reduced from 722 to 88 municipalities (population according to the population composition on January 1st 2020). After this, the second criterium, population density of over 4.000 persons per km^2, reduced the list of suitable municipalities to eight municipalities. These remaining municipalities are displayed in Table 9.

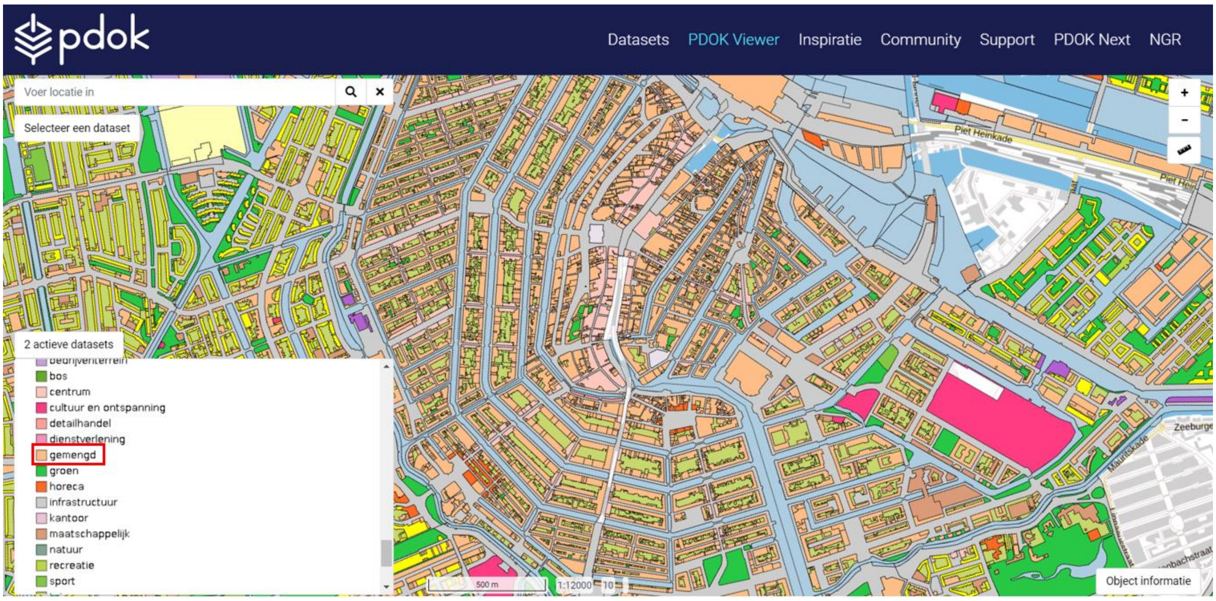
Table 10 Selection of cities based on criteria 1 and 2 of Banister (2005, 2006) selected with use of data of Regional Key Figure Netherlands by CBS Statline (2020)

Municipalities	Period	Population	Density per km^2
's-Gravenhage	2020	545838	6620
Leiden	2020	125099	5710
Haarlem	2020	162902	5585
Amsterdam	2020	872757	5273
Capelle aan den IJssel	2020	67122	4747
Delft	2020	103595	4573
Gouda	2020	73427	4449
Schiedam	2020	78730	4417

The second dataset used for the selection of cities is the tool *PDOK viewer*. This online tool allows to view different geographical datasets. The specific dataset used within this tool is the *Dataset Spatial Plans* based on data of Kadaster (PDOK, 2021). This dataset contains officially published spatial plans in accordance with Spatial Planning Act (Wet ruimtelijke ordening) and the

Decision Spatial Planning (Besluit ruimtelijke ordening) (PDOK, n.d.). The variables used from this dataset are single function (enkelbestemming) and double function (dubbelbestemming), and have been used to research which cities are suitable for this study considering mixed-use developments (criterium 3). After examination of the variables single function (enkelbestemming) and double function (dubbelbestemming) it is clear that each of the cities has the different functions blended. An example of what this looks like in the PDOK viewer is shown in the figure below for the city of Amsterdam. In this figure the functions of spaces have been indicated. Examples of functions are residential or leisure. As to be seen in the figure there are many areas indicated with the pink colour that has been marked in the legend on the left. This function is called “gemengd”, which translates to mixed-functions. The other seven cities have shown similar patterns.

Figure 7 Map of mixed functions in Amsterdam composed by PDOK.



As indicated in section 1.1 most people in the Netherlands have access to public transport. The average distance to a train station in the Netherlands is 5.1 kilometres in 2019 (CBS, 2020), which is within cycling distance (7.5 kilometres) (CROW, 2020a). Based on this information it is assumed that all of the remaining eight cities offer sufficient developments in public transport corridors and near highly public transport accessible interchanges (criterium 4).

Of the cities that satisfy all criteria of Banister (2005, 2006), three have been chosen based on the availability of data. These remaining three cities are Amsterdam, Delft and Leiden. The location of these three cities within the Netherlands is displayed in the map on the left.

Figure 8 Reference map Amsterdam, Delft and Leiden

List of secondary datasets for case selection:

1. Regional Key Figures Netherlands by Central Bureau for Statistics available through the CBS open data portal.
2. Spatial Plans by Kadaster available through the PDOK viewer.

7.2 Appendix 2 – Semi-systematic literature review

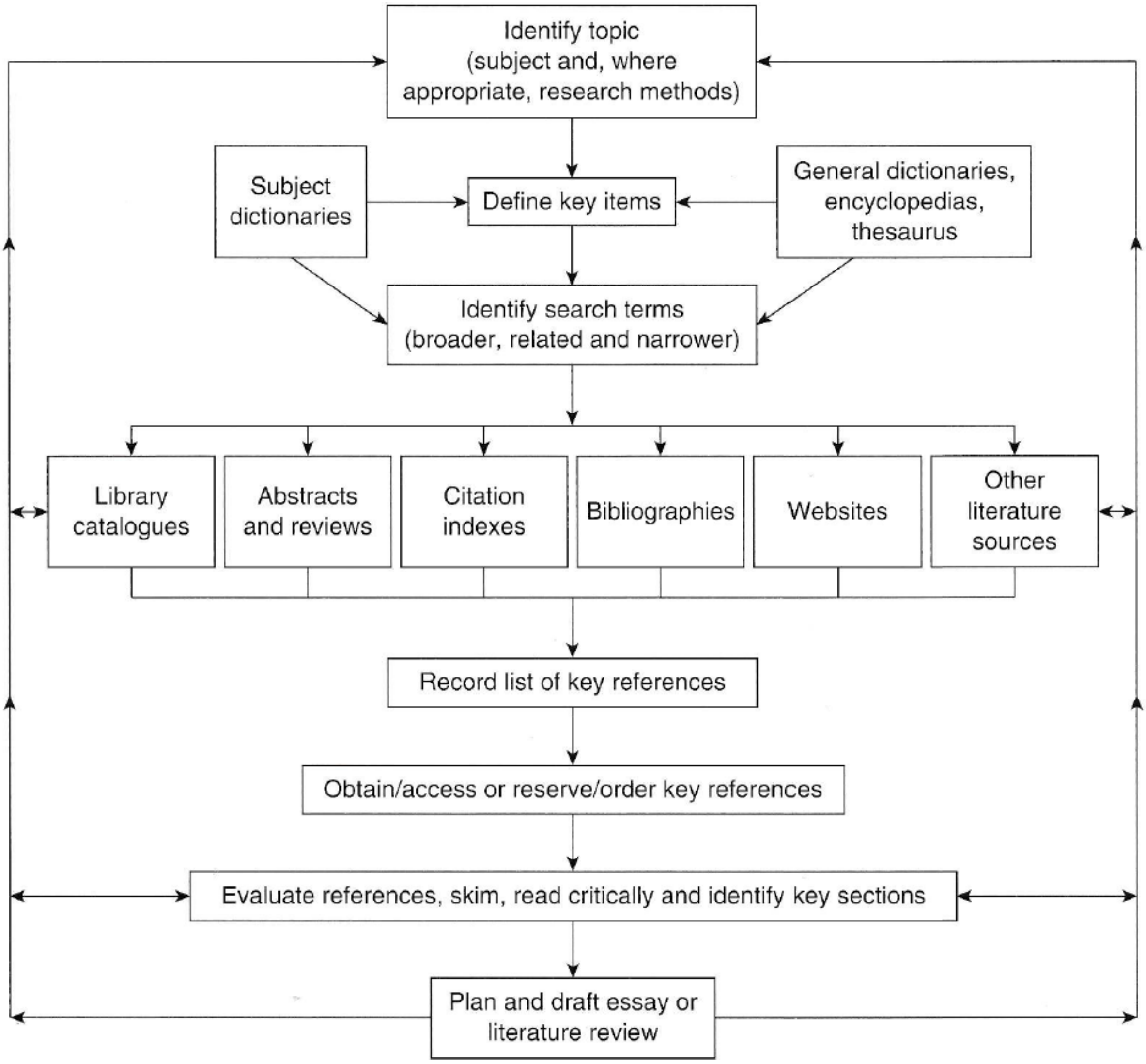


Figure 9 Framework for undertaking literature search (Clifford et al., 2016)

Table 11 Reducing your list of references to manageable proportions (Clifford et al., 2016)

Criterion	Possible (Score 4 points)	More doubtful (Score 2 points)	Probably forget it (Score 0 points)
Relevance to my topic – judged by title and/or abstract (double the score for this criterion)	High	Moderate	Tangential
Up-to-date	Last 5 years	6–15 years old	Over 15 years old
Authority – the author or paper is cited in the references I have already read	Extensively cited	Recent paper not yet had time to be cited extensively	Older paper cited infrequently or not at all
Respectability and reliability of source publication	Published in major geographical publication or that of sister subject or something very close to my topic	Publication is not in geography or an allied field	Informal publication or unreliable Internet source
Nature of publication	Peer-reviewed academic journal or monograph	Textbook or conference proceedings	Popular magazine
Originality	Primary source of information – the authors generated this information using reliable and recognized methods	The authors take their information from clearly identified and reliable secondary sources	The authors assert facts and produce information without providing appropriate supporting evidence
Accessible	Instant – by download or short walk to library	Obtainable with effort – reserve, interlibrary loan	Unobtainable

7.3 Appendix 3 – Policy documents content analysis

7.3.1 Amsterdam

For the analysis of sustainable mobility in the city of Amsterdam, the following policy documents have been used to compose the evaluation framework for the city in Table 4:

1. Structuurvisie Amsterdam 2040: Economisch sterk en duurzaam (AMS1) (Gemeenteraad Amsterdam, 2011)
2. Mobiliteitsaanpak 2030: Amsterdam Aantrekkelijk Bereikbaar (AMS2) (Gemeenteraad Amsterdam, 2013)
3. Uitvoeringsagenda Mobiliteit (AMS3) (Gemeenteraad Amsterdam, 2015)
4. Programma Smart Mobility 2019-2025 (AMS4) (Gemeenteraad Amsterdam, 2019)

The four above mentioned documents are policies from the municipal council of Amsterdam. The first document is the general vision for Amsterdam up and until the year 2040. This policy is aimed at making Amsterdam a strong economic and sustainable city. One of the main points of attention is the regional public transport (Gemeenteraad Amsterdam, 2011). From this document it becomes clear that Amsterdam's vision is aimed at developing the city and its surroundings as a European metropole with a focus on a strong international position in terms of economic competition and sustainable development.

The second policy document further specifies the role of mobility within this broad vision. The goal of the mobility approach is to create better mobility services with less resources and less space. This by focusing on walkability and cyclability and to prioritize these two modes together with public transport. Not only because the city's population keeps rapidly increasing, but also to keep up with the demands of the recreational and tourism sector (Gemeenteraad Amsterdam, 2013). The main focus of this policy document seems to be a modal shift from car usage towards walking, cycling and the use of public transport, but is not limited to this category alone. The third document is more practical, and provides an overview of the implementation of the previous two policies. Here the spatial plans and the exact measures for specific locations are exemplified (Gemeenteraad Amsterdam, 2015). The fourth document is a specification of the aims and ambitions regarding smart mobility in Amsterdam.

7.3.2 Delft

For the analysis of sustainable mobility in the city of Delft, the following policy documents have been used to compose the evaluation framework for the city in Table 5:

1. Concept Structuurvisie: Ontmoetingen met Delft 2030 (DEL1) (Gemeente Delft, 2020b)
2. Mobiliteitsprogramma Delft 2040: Ons Delft, duurzaam bereikbaar (DEL2) (Gemeente Delft, 2020a)

The first policy document for Delft is the general vision for the municipality until the year 2030 (note that this is not the final version). The main missions are Delft as a connected city, a dynamic city and a sustainable city. Delft is aiming to become an important node in the economic network of the Randstad Zuidvleugel with its own identity (Gemeente Delft, 2020b). The municipality of Delft is thus concerned with its position within the Randstad area. Even though the '*Structuurvisie*' mentions its mission to become a sustainable city, not much focus is placed on this within the document. This policy document is rather general and does not include a vision per theme as the city of Amsterdam has done in their '*Structuurvisie*'. It does not contain any information about Delft's aims and ambitions for the future for separate themes such as energy, mobility or water. Therefore, from this document it is unclear what the municipality of Delft is aiming for in terms of sustainable mobility.

The second document, on the contrary, does emphasize the importance of sustainable mobility in the transition towards a sustainable city. In this document emphasis is being placed mostly on the indicator category modal shift. Within this development the city aims to include citizens in the planning process, and considers policies to change car-user behaviour (Gemeente Delft, 2020a). Even though the main aims and objectives of this document are focused on modal shift, it remains unclear how the municipality is planning on realising these aims. Therefore, the budget plans of the municipality have been accessed (OS in Table 5). From this document the implementation of the goals and targets mentioned in the two policy documents regarding the category modal shift became clear. For this category, all cells have been therefore marked green.

7.3.3 Leiden

For the analysis of sustainable mobility in the city of Leiden, the following policy documents have been used to compose the evaluation framework for the city in Table 6:

1. Omgevingsvisie Leiden 2040: versie 1.0 (LEI1) (Gemeente Leiden, 2019b)
2. Mobiliteitsnota: Leiden duurzaam bereikbaar (LEI2) (Gemeente Leiden, 2020b)
3. Kijk op mobiliteit (LEI3) (Gemeente Leiden, 2019a)
4. Agenda autoluwe binnenstad (LEI4) (Gemeente Leiden, 2020a)
5. Parkeervisie (LEI5) (Gemeente Leiden, 2020c)

The first document concerns the vision of the city Leiden (note that this is not the final version). Leiden is spatially connected with nine other municipalities, together known as “Hart van Holland” or “Heart of Holland”. These ten municipalities aim to collaborate to handle both the national and international trends, for instance the trends concerning climate change and mobility (Gemeente Leiden, 2019b). The focus of the municipality of Leiden is thus on collaboration with surrounding municipalities to together form a stronger position within the Netherlands.

The second document concerns the approach towards sustainable mobility. The municipality of Leiden strongly emphasizes the concept of modal shift (Gemeente Leiden, 2020b). In this document the municipality states their nine ambitions for the future. These ambitions are to make Leiden a cycling city, to give more space to walking, to stimulate public transport, to strengthen the main road structure, to expand the car-free zones, to develop an emission-free city logistics system, to discourage car-usage by adjusting the parking policy, to support share-vehicle concepts, and to make use of new technologies.

The document “*Kijk op mobiliteit*” describes the involvement of citizens in the plans and policies for more sustainable transport in Leiden (Gemeente Leiden, 2019a). This shows the value of citizen involvement and gives more insight in the public acceptability of the policies and plans. The fourth document is specifically concerned with the reduction of car usage in the inner city of Leiden to create space for a green and vital city (Gemeente Leiden, 2020a). This policy document has a strong focus on modal shift. The last document has a specific concern, namely the parking regulations. The goals and ambitions of this document are intertwined with the previous one. The “*Parkeervisie*” is also aimed at a reduction of car-usage (Gemeente Leiden, 2020c). The last two documents include measures that are aimed at reducing car movements specifically.

7.4 Appendix 4 – Coding scheme

Table 12 Coding scheme used for qualitative coding in Atlas.TI

Code	Sub-code	Examples	Type
Trip Substitution	Stimulating working from home	Reducing travel allowance, working-from-home reward	Inductive
Modal Shift	Discouraging private car ownership	Car-sharing, congestion charging, parking regulations	Deductive
	Stimulating electric/ hybrid vehicles	Providing charging spots, special parking spots	Deductive
	Stimulating slow modes (walking/ cycling)	Development of safe bicycle lanes/ sidewalks	Deductive
	Stimulating public transport	High accessibility, reliable schedules, frequency	Deductive
Distance Reduction	Increasing densities and concentration	No expansion of the city towards rural area	Deductive
	Mixed-use developments	Neighbourhoods with multiple functions besides residential	Deductive
	Public transport-oriented developments	Development of a strong public transport network with high accessibility in a close proximity	Deductive
	Car-free developments	Car-free zones, limited parking spots	Deductive
Technological Innovation	Smart mobility	Smart mobility labs	Inductive
	Renewable energy	Solar panel subsidies, wind/solar park development	Deductive

7.5 Appendix 5 – Calculation web diagrams

The web diagrams in Figure 6 have been based on the three levels of presence presented in Table 4, 5 and 6 for the cities Amsterdam, Delft and Leiden respectively. Each of the colour codes has received a numerical score: green counts for 2 points, orange counts for 1 points and red counts for 0 points. After assigning these numerical values to each indicator for both objectives and implementation, the sum per indicator has been calculated. In the tables below the calculation of these number can be found.

Table 13 (left) Colour coding degree of presence in objectives and implementation
Table 14 (right) Colour coding sum objectives and implementation

	Not present in policy document
	Passively present: only mentioned in the policy document
	Actively present: elaborated upon in detail in the policy document

	0
	1
	2
	3
	4

Table 15 Calculation Amsterdam

Approach	Indicator	Score objectives	Score implementation	Sum
Substitution	Stimulating working from home	0	0	0
Modal shift	Discouraging private car ownership	2	2	4
	Stimulating electric/hybrid vehicles	1	0	1
	Stimulating slow modes (walking/cycling)	2	2	4
	Stimulating public transport	2	2	4
Distance reduction	Increasing densities and concentration	2	2	4
	Mixed-use developments	2	0	2
	Public transport oriented developments	2	2	4
	Car-free developments	2	2	4
Technological innovation	Smart mobility	2	2	4
	Renewable energy	2	2	4

Table 16 Calculation Delft

Approach	Indicator	Score objectives	Score implementation	Sum
Substitution	Stimulating working from home	0	0	0
Modal shift	Discouraging private car ownership	2	2	4
	Stimulating electric/hybrid vehicles	2	2	4
	Stimulating slow modes (walking/cycling)	2	2	4
	Stimulating public transport	2	2	4
Distance reduction	Increasing densities and concentration	0	0	0
	Mixed-use developments	0	0	0
	Public transport oriented developments	0	0	0
	Car-free developments	0	0	0
Technological innovation	Smart mobility	2	0	2
	Renewable energy	2	2	4

Table 17 Calculation Leiden

Approach	Indicator	Score objectives	Score implementation	Sum
Substitution	Stimulating working from home	0	0	0
Modal shift	Discouraging private car ownership	2	2	4
	Stimulating electric/hybrid vehicles	0	0	0
	Stimulating slow modes (walking/cycling)	2	2	4
	Stimulating public transport	2	2	4
Distance reduction	Increasing densities and concentration	1	0	1

	Mixed-use developments	0	0	0
	Public transport oriented developments	0	0	0
	Car-free developments	2	2	4
Technological innovation	Smart mobility	2	1	3
	Renewable energy	2	0	2

The total score per indicator per city displayed in the tables above, have been used in Table 7 and have been used to create the web diagrams in Figure 6. The scoring within these web diagrams is displayed in the figure below.

Figure 10 Colour coding and numerical values used in web diagrams