How Ready a Municipality is for Zero-Emission City Logistics? Development and Application of Maturity Model for Dutch Municipalities

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Word Count: 4748 words + 5 table (250 words per table) + 5 Figures (250 words per figure) = 7498 words

Submitted [December, 2023]

ABSTRACT

The number of activities in city logistics is growing rapidly causing an increase in emissions, and a decline in accessibility and safety in cities. Therefore, the Dutch government has introduced GreenDeal Zero-emission city logistics. The goal of this deal is to have 30-40 of the biggest municipalities in the Netherlands have zero-emission city logistics in 2025. The goal for 2025 is clear, but it lacks a way for municipalities to see their progress and a way to find improvements in their city logistics. This research is focused on developing a maturity model as a tool to assess the maturity level of a municipality for its performance-related city logistics process management to achieve its aim of reaching zero emissions. The City Logistics Maturity Model for Municipality (CL3M) requires a domain-specific, multidimensional model to assess city logistics from a municipal point of view. The model includes six levels (0-5) and a PCDA cycle is embedded throughout the levels. The model is populated through three focus fields (Technical, Social and Corporate, and Policy), branching out into six areas of development: Information and communication technology, urban logistics planning, Stakeholder communication, Public-Private Partnerships, Subsidization and incentivization, and Regulations. The CL3M model was tested for three municipalities, namely, the municipality of Deventer, Zwolle, and Nijmegen. The assessment pointed out that CL3M is yet in its juvenile stage and with further development, the model can reach its full potential in usefulness, reliability, and adaptation.

Keywords: City logistics, maturity model, municipality, CO2 emission, climate agreement

INTRODUCTION

City logistics is an important and challenging process for logistics companies and organizations. During the pandemic, when people could not go out, city logistics provided goods at their doorsteps. Although not alien to such a service, people appreciated the possibility of getting goods without venturing out into the street. Around a 25% rise is noted in consumer e-commerce deliveries in 2020, with some of the increased demand expected to last well beyond the pandemic [1]. The ease of access to goods has hurt cities. According to the report of the World Economic Forum, growing demand for e-commerce delivery will result in 36% more delivery vehicles in inner cities by 2030, leading to a rise in both emissions and traffic congestion without effective intervention. With no action taken, urban last-mile delivery emissions and traffic congestion are on track to increase by more than 30% in the top 100 cities globally [2].

As of November 2015, the Netherlands is a part of the Paris Climate Arrangement which is an international treaty to keep the rise in mean global temperature below 2°C. The agreement has the main goal to reduce emissions by 50% by 2030 and wants to reach net-zero emissions by the middle of the 21st century. Acknowledging the importance of the problem of climate change, the EU introduced the European Green Deal in July 2019. The most important goal of this deal is to reach a decrease of 55% in emissions compared to 1990 and become the first climate-neutral continent in 2050 [3].

On a national level, the Netherlands introduced the so-called "klimaatakkoord" (translated as climate arrangement) in June 2019. Within this arrangement, there are more than 600 agreements to reduce the number of CO_2 emissions. The agreement's goals align with the Paris climate arrangement by establishing a 49% reduction by 2030 and climate neutrality by 2050 [4]. The Dutch government is working with organizations, local and regional governments, and interest groups on the so-called 'Dutch green deals'. Within these deals, the government supports the stakeholders to stimulate sustainable economic growth. In the deals, the initiative, the actions, and the input by participants are described as clearly as possible, all to reach the goal of the deal within 2-3 years [5].

One of those deals, 'Green Deal 173' will handle the zero-emission city logistics. The main goal of this deal is to have 30-40 participants reach a zero-emission zone by 2025. As of now, 62 participants have joined the Green Deal differing from companies, foundations, and municipalities. The main goal of the deal is to reduce the amount of emissions with the growth in city logistics [6]. Figure 1 puts this green deal into perspective.

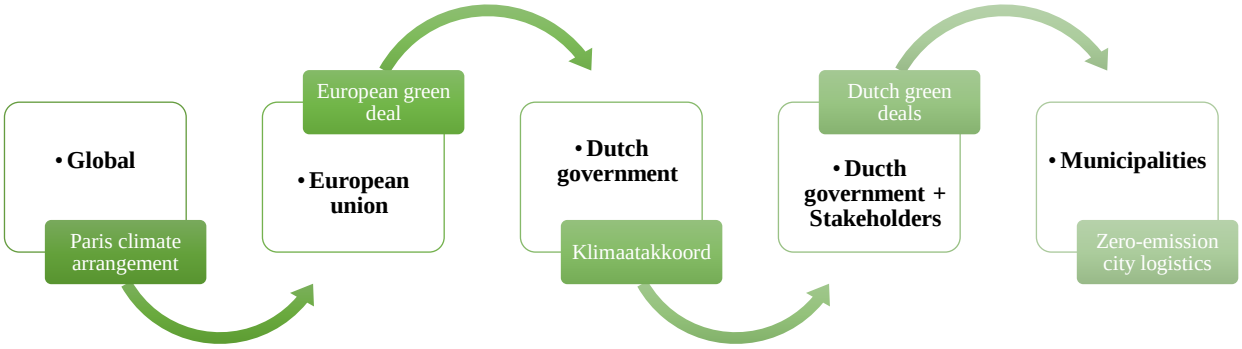

Figure 1 Motivation for zero-emission city logistics initiatives by Dutch municipalities

There is an urgent need for government intervention so that mobility in city areas (including city logistics) can be performed sustainable. To gain broad societal acceptance for necessary transition measures, public actors need to prioritize their time and resources on issues that are credible means to achieve a future sustainable transport system [7]. Municipalities play a great role in tackling city logistics matters, having many instruments at hand. However, it is not self-evident that all municipalities use these instruments to their full potential. The goal for 2025 is clear, but it lacks a way for municipalities to see their progress and a way to find improvements in their city logistics. A maturity model can provide the government as status of overview insight of the zero-emission progress in the individual cities. Also it can help the individual

cities to benchmark their performances with other cities and learn from their best practices. This innovative approach goes far beyond the traditional project control tools where monitoring only can be done for a simple city. The objective of this research is to develop a maturity model to measure the readiness of municipalities for zero-emission city logistics (ZECL). The research starts with finding key criteria for sustainable city logistics (henceforth also SCL), the role of the municipality in creating SCL and finally creating a uniform method of assessing the maturity of the municipality to support SCL. The outcome of the research will be a conceptual maturity model framework. The rest of the paper is organized as follows: Next, the section explored literature related to criteria for evaluating measures related to SCL. Afterwards, the development process of the City Logistics Maturity Model for Municipality (henceforth also CL3M) is described. Finally, the paper ends with testing and evaluating the model in three Dutch cities and provides insights to conclude the usefulness of the model and directions for further development.

LITERATURE REVIEW ON MEASURING PERFORMANCE OF CITY LOGISTICS POLICIES

To start with, the review focuses on studies and meta-studies evaluating various criteria for measuring the performance of city logistics schemes and initiatives. It is important to identify the most common and suitable criteria and factors for evaluating sustainable city logistics initiatives which could be applied for evaluating initiatives in different cities. It requires defining a large number of criteria to be applicable in all cities by taking into account all the requirements of stakeholders and the factors that cover different aspects of city characteristics [8]. This part of the review aims to create an inventory of criteria, based on which the most suitable categories for the maturity model will be identified.

During a congress held by the City Logistics Italia association in Rome in 2006, the association determined that separate and regional measures do not lead to a sustainable and competitive urban logistics system. The association stated that the integration of four criteria was needed to progress towards a sustainable urban logistics system on a national level: Regulatory policies (restrictions or incentivized), information and communication tools, contributions in infrastructure, technology or civil engineering, and partnerships between public and private enterprises [9].

Another important source of knowledge comes from project SUGAR. To enhance capabilities within urban logistics, 17 partners from 10 different European countries have together created a public association called Sustainable Urban Goods Logistics Achieved by Regional and Local Policies, known as SUGAR. SUGAR states there are four categorized policy leverages: transport, environment, space and territory, and harmonization [10]. Under SUGAR, 44 best practice initiatives taken by public authorities were analysed and categorized into nine criteria of measures.

Awasthi and Chauhan [11] evaluated four initiatives (namely, vehicle sizing restrictions, congestion charging schemes, urban distribution centres and access timing restrictions) using a multi-criteria multi-stakeholder approach under a fuzzy environment. They used the analytic hierarchy process (AHP) method to analyse the structure of the sustainable city logistics measure problem and applied the fuzzy TOPSIS method to determine weights of criteria to obtain the final ranking. This study concludes economic, environmental, societal and technical as four criteria for evaluating city logistics measures using the Affinity diagram.

A French study focusing on the evaluation of local public urban freight policies looked at case studies to determine strengths, weaknesses, threats and opportunities. In total, 18 different French cities were part of the research. After conducting the case studies, the researchers found there were eight criteria to be key for the evaluation of public urban freight policy [12].

Smart Freight Centre [13], an organization that, among other activities, works on catalysing sector-wide proven cost-effective technologies and solutions on urban freight conducted a review of worldwide good policy practices taken by municipalities. The research included case studies from a global perspective, including London, New York, Tokyo, Paris and California. In this study, eleven criteria of urban freight development were listed.

A study conducted by the Department of Enterprise Engineering of the University of Rome investigated the effect of city logistics measures on the economy. Managing the various stakeholders with different

objectives and constraints related to the urban landscape is challenging in a city logistics environment [14]. The paper concluded that seven criteria of measures could be applied to achieve objectives in city logistics.

In the context of planning and evaluation of city logistics Gonzalez-Feliu [15] states that sustainable development is essentially an organizational matter and generally can be categorized into three spheres that require cohesion: economic, environmental and social. The research further used a co-constructive consensus method to establish indicators and a dashboard for the evaluation of sustainable urban logistics. Overall, a group of 25 field experts listed 95 different indicators. The research finally gives a list of 16 indicators spreading out over three categories: economic, environmental and social.

A meta-analysis from the University of Hull identified the results of multiple studies on applied criteria and sub-criteria for sustainable city logistics initiatives and combined these results into common criteria [8]. The combined results include eleven research papers conducted in eight different countries from the year 2000 until 2017. The outcome of the research shows that there are five common criteria used in sustainable city logistics initiatives: economic, technical, environmental, social, and services.

It is clear from the literature review that there are two types of criteria found in the literature 1) Focusing on details of measures and 2) Focusing on an overview of measures. Table 1 shows a list of criteria found in the literature for both types.

TABLE 1 List of criteria for evaluating city logistics measures

Criteria focusing on details of measures				
(Gonzalez-Feliu, 2008) [9]	**(SUGAR, 2011) [10]**	**(Ducret, Diziain, & Plantier, 2015) [12]**	**(Smart Freight Centre, 2017) [13]**	**(Russo & Comi, 2020) [14]**
Regulatory policies	Administrative	Formalisation of the freight policy	Vision	Supply management measures
	Urban Planning	Quantitative diagnosis	Emission targets	Demand management
Information and communicatio n tools	Governance	Public-private consultation or partnership	Infrastructure	Infrastructure
	Awareness	Political support and commitment	Restrictions on freight mobility	Technology (ICT/ITS)
Contributions to infrastructure, technology or civil engineering	Infrastructural	Traffic and parking regulations and the efficiency of the control system	Trucks	Environment-friendly vehicles
	It's Technical	Urban planning regulations	Operations	Public-private collaboration
Partnerships between public and private enterprises	Modelling Tools	Delivery bays' number, location and design	Technology	Reverse logistics
	Supply Chain Management	Human and financial resources allocated to the policy	Freight Partnerships	
	Information		Data	
			Finance	

			Recognition schemes	
	Criteria focusing on an overview of measures			
(Awasthi & Chauhan, 2011) [11, 16]	**(Parezanovic, Tarle, and Perovic, 2014) [16]**	**(Gonzalez-Feliu, 2018) [15]**	**(Jamshidia, Jamshidia, Ait-Kadi, & Ramudhin, 2018) [8]**	
Economic	Economic	Economic	Economic	
Environmental	Environmental	Environmental	Environmental	
Social	Social	Social	Social	
Technical	Technical		Technical	
			Service	

The four main entities of the city logistics domain are the shipper, transporter, receiver and local authorities [17]. Traditionally, the role of public authority in city logistics is seen as an enforcement authority – a reactive role. Accordingly, the municipality has been mainly responsible for infrastructure (e.g. parking and loading zone) and introducing fines for vehicles violating restrictions [18]. However, with a change in governance strategies, the role of government is more becoming of a leader – with a more proactive role. In the case of sustainability (in general and mobility in specific), government intervention has been deemed important. Without government proactive effort sustainability is not possible [19]. In the section "populating maturity model", we will use learning from this literature review as a base to identify criteria for evaluating maturity of local government/municipality.

DEVELOPING CITY LOGISTICS MATURITY MODEL FOR MUNICIPALITIES (CL3M)

The research follows the existing methodology for maturity model development guidelines provided by [20]. Figure 2 shows a six-step approach for maturity model development.

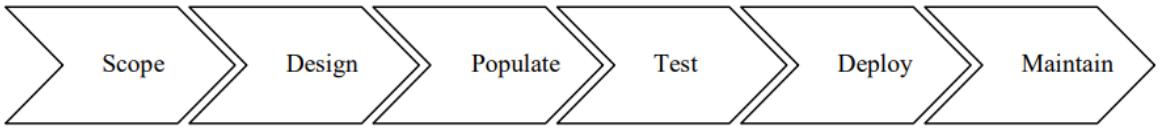

Figure 2 Phases of model development. Source: [20]

Scoping and design of CL3M

The scoping and design of CL3M include decisions about the focus of the model, stakeholders involved in the development, the audience for which the maturity model is used, model application method, motivation (driver) for application, respondents (who will provide information for evaluation) and application entities. Table 2 shows these criteria, choices made for city logistics maturity model for municipalities and respective explanations.

TABLE 2. Criteria and respective choice for CL3M characteristics

Criterion	Characteristics of CL3M	Reasoning
The focus of the model	Domain-specific	Focused only on the city logistics domain
Development stakeholders	Combination of academia, practitioners and government	Development initiative by academic researcher (primary) but input is taken from practitioners and government (secondary)
Audience	External	Applied to an external audience that is not the primary developer of the model
Method of application	The third-party assisted	Assisted by municipality employee
Respondent(s)	Municipality employee	The employee working closely with city logistics-related activity will be consulted
Application	Multiple entities/regions	The model can be applied to single or multiple municipalities

Lastly, before moving to the populating phase of the maturity model, it is important to pre-determine the stages of maturity within the model. It includes decisions about several stages of the maturity model, name and definition of each stage. The number of stages used in the model can vary, however, a common practice is to establish five stages ranging from 1 to 5, with the addition of a stage, where there is no awareness of the topic or process [20]. Since many municipalities are still not incorporating city logistics in their urban planning, they are unaware of specific city logistics initiatives and thus fall under the "Oblivious" level. It is self-evident that levels 2 to 5 are closely connected with stages of the PDCA cycle and thus a closed plan-do-check-act (PDCA) cycle is associated with these levels. With this logic, a total of 6 levels are considered for CL3M as shown in Table 3.

TABLE 3 Levels and explanation for city logistics maturity model for the municipality

Level	Label	Explanation of level
0	Oblivious	Municipality, typically, in this category has no awareness of the role it plays regarding city logistics.
1	Awareness	Municipality in this category has a sense of knowledge about CL initiatives, but does not have an interest in actively taking part in increasing the sustainability of city logistics.
2	Interest	The municipality is aware of the value it can add towards sustainable city logistics and has plans to take action. However, no measurements are currently in place. In the PDCA cycle, this level could be considered the 'plan' phase.
3	Managed	Municipality has started taking measurements towards sustainable city logistics; however, the steps are in the initial stages. In the PDCA cycle, this level could be considered the 'do' phase
4	Established	Municipality measures in place are developed to a degree where there is a clear positive impact and stakeholders are satisfied. In the PDCA cycle, this level could be considered the 'Check' phase. The municipality is checking the results of its measurements and thus knows the impact exactly.

5	Optimized	Municipality is at the forefront of development and all activities around city logistics are continuously improving. There is a closed PDCA cycle. This level also includes having detailed strategic planning, anticipating future needs and playing a leading role in sustainable city logistics development for all stakeholders involved.

Populating CL3M

Populating the maturity model answers the question 'what' needs to be measured. It is important that the elements used to measure maturity need to be mutually exclusive and collectively exhaustive, meaning there is no overlap and that the model includes all aspects to determine maturity in city logistics. As mentioned in the review, there are two types of criteria found in the literature: 1) Focusing on details of measures and 2) Focusing on an overview of measures. The criteria focusing overview of measure shows quite unanimity with economic, environmental, technical, and social occurring in each literature source. Let's call these overview criteria a focus field since they are not at the detail level.

Since technology implemented by a private or a public stakeholder can be termed as technological advancement, the 'technical' criteria can be readily adopted from the literature as a focus field of the maturity model. The social criteria focus on creating awareness about city logistics among different stakeholders. This awareness could be for citizens who bear the consequences of the city logistics but is also important for the carriers, the receivers and the transport companies. Therefore, it is logical to include the corporate side in this focus field naming it 'Social and corporate'. From a private stakeholder perspective, economic criteria are reduction of cost, higher profit etc., however, the government perspective focuses on policymaking based on subsidies or monetary incentives. Similarly, the environmental criteria are also related to policy making such as the introduction of environmental zones. Thus, economic and environmental criteria should be presented by criteria 'Policy' as a focus field. As a conclusion, three focus fields have been established to continue the process of determining the specific areas of development. To clarify further, below a description of each of these focus fields is given in Table 4.

TABLE 4 Focus fields and description for city logistics maturity model for the municipality

Technical	Under the technical aspect falls any measurement that is related to either technology (ICT) or anything physical in the public atmosphere, such as transport hubs, loading/unloading areas or road signs.
Social and Corporate	The social and corporate focus field in the context of this research is aimed at measurements that are based on external involvement such as: creating awareness, education or entering a public-private partnership.
Policy	The policy field includes any measurements such as rules and regulations to guide or enforce processes. Examples are vehicle restrictions or incentivisation schemes.

Six areas of development

Based on established the focus fields, the 38 criteria gathered from the literature review focusing on the detail of measurement can be divided into six categories. These criteria have been analysed and clustered together based on their similarities to establish these categories: Information and communication technology, urban logistics planning, Stakeholder communication, Public-Private Partnerships, Subsidisation and incentivisation, and Regulations. Figure 3 shows how the measures found in the literature are distributed across the six areas of development.

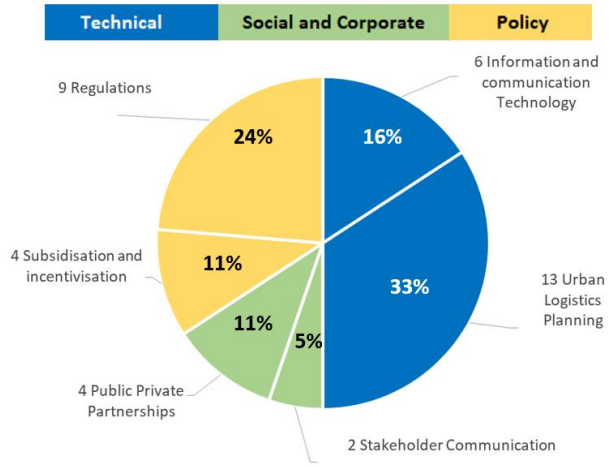

Figure 3 Categorizing the measures found in the literature

What is important to consider when developing this specific maturity model is that a public entity like a municipality has a very different role compared to a business entity. A municipality does not have operations to run as shippers and carriers do. Based on empirical research with Dutch municipalities and experts, it was found that a municipality has the following five roles: regulating and enforcing, facilitating, stimulating, coordinating, and experimenting. To put this into perspective the correlation between the six areas of development and the five municipal roles are shown in Figure 4. It shows that there is a strong connection between developing a model that measures maturity on sustainable city logistics for municipalities and the general role municipalities have, as each of the roles is connected to one or more areas of development.

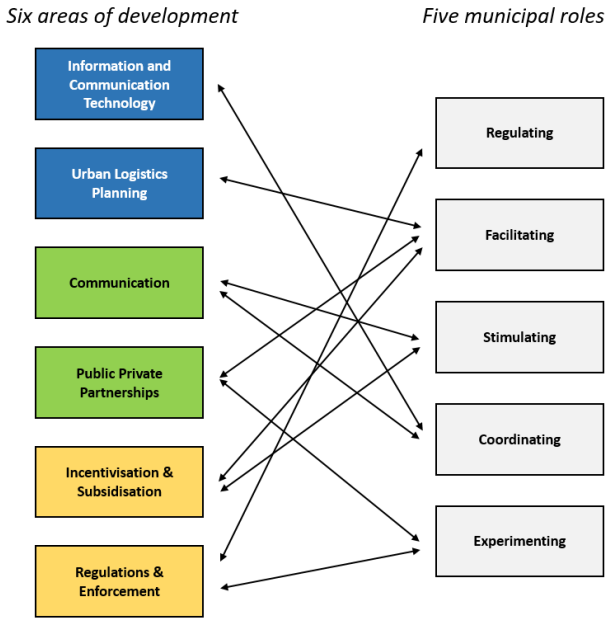

Figure 4 The relation between performance measurements areas and the role of municipalities

Taking into account the measurements found in the literature and the five municipal roles, the following definition can be given:

Information and Communication Technology

ICT within city logistics is about traffic management, where traffic is regulated to create less congestion and increase safety [21]. Besides this ICT can also be used to enforce regulations by gathering traffic data that allows officials to see which vehicles enter a restricted area within the city. Another area where ICT is used by measuring progress on emission or congestion goals, where sensors could detect the amount and type of vehicles. The key here is to coordinate.

Urban logistics planning

This category is focused on the integration of city logistics into urban planning implies that sufficient research and planning have been done on the exact needs of specific areas in/around the city. These needs could be city hubs, loading or unloading areas, and electric charging stations [15]. The role of the municipality here is to facilitate logistics activities by including it in all urban planning

Communication

The communication category entails the communication of developments within city logistics, which could be the (re)designing of urban space or the introduction of new policies [10]. This category is mostly linked to the coordination role; however, communication can also be used to stimulate by sharing best practices and connecting stakeholders through a communication community.

Public-private partnerships

Public-private partnerships are linked to facilitating city logistics activities. These partnerships can occur in the form of pilot concepts [22], but also through signing a covenant [23], which brings together multiple stakeholders and thus facilitates the interaction created. Through these partnerships, municipalities can also experiment with new concepts.

Subsidization and incentivization

This category also is related to facilitating as urban logistics planning and public-private partnerships also are, although subsidizing and creating incentives do this more directly. By creating recognition schemes [13] municipalities can both facilitate and stimulate the development of sustainable city logistics practices.

Regulations and enforcement

Regulations have no basis if there is no enforcement policy. This category focuses on putting in place the needed regulations and enforcements, which could be restrictions on vehicles or allocating time frames for logistical traffic in specific streets [12]. Besides this category falling in line with the regulatory role of municipalities, regulations could also act as a form of experimentation.

After the developing first version of CL3M, practitioners and municipality authorities were contacted to provide their feedback on the model. Suggestions and feedback from two external advisors to different municipalities and one municipality employee were incorporated into the model to prepare the current final version of the city logistics maturity model for the municipality. Table 5 shows the final version of CL3M.

TABLE 5 City logistics maturity model for municipalities (CL3M)

Focus Field		Technical		Social & Corporate		Policy	
Area of Development		**Information and communication Technology**	**Urban Logistics Planning**	**Stakeholder Communication**	**Public Private Partnerships**	**Subsidisation & incentivisation**	**Regulations & Enforcement**
Definition		**The development of ICT to support traffic management**	**The planning of city hubs, Infrastructure, loading and unloading areas, roadway use, public charging stations, etc.**	**Communication on new policies, planning, infrastructure, etc.**	**Partnerships between public and private entities to promote and run pilots with new technologies and concpets.**	**The subsidisation and incentivisation of sustainible urban logisites operations**	**Regulations to minimize congestion and pollution, and increase safety**
Level							
0	**Oblivious**	There is no awareness or knowledge about ICT systems used in city logistics	There is no awareness on integrating logistics activities into urban planning	There is no communication channel for city logistics	There is no awareness of the added value of public private partnerships	There is no awareness of the concept of incentivisation or subsidisation	There is no awareness of urban logisitics regulatory policies
1	**Awareness**	There is some knowledge about ICT however there are no plans to implement a system	There is awareness on urban logistics planning although little thought is given to the topic as it is not a part of urban planning	The municipality is aware of the need to share information, although there currently is insignificant communication	There is awareness of public private partnerships although no action has taken place	There is awareness of the concept of subsidisation and incentivisation but possibilities are not explored	There is awareness of regulatory polocies, although none are officially in place or enforced
2	**Interest**	There is a good knowledge on ICT and means/systems are currently being investigated and/or are part of future plans	Logistics are a part of urban planning. There is no strong link between planning and doing, as different actors express their own will regarding urban planning	Newsletters and surveys are send out to some concerning stakeholders	One or more pilots have taken place with public private partnerships, although with little to no actual benefits	There is knowledge on what subsidies and incentives are proven effective and there are plans to roll out these measures	The municipality has a plan on how to regulate congestion, pollution and safety to an acceptable level for all stakeholders
3	**Managed**	ICT is in place and some data is gathered, but this data does not consistantly loop back into the process of managing traffic flow. Traffic management is still mostly an ad-hoc activity	Urban logistics planning is realized according to a plan. Decision making actors are alligned within this process. However the 'check' is missing, there is a lack of measuring improvements or stakeholder satisfaction.	The municapality communicates if possible through branch organisations as much as possible. However there are multiple windows through which communication on city logistics takes place	A few (1-3) pilots have been successful and are now permanent operations. Public private parnerships are still mostly an ad-hoc activity	A few (1-3) local subsidisation and incentivisation schemes are in place. However, the exact result these measurements have on social, economic or environmental levels for the city is not known.	The regulations mentioned in the plan are in place, but there is a lack of enforement policy. The municipality is unaware if regulatory policies are well functioning
4	**Established**	ICT is used to a greater extend. Traffic management is an established process with the gathered data being integrated into the decision making process on a tactical level (1-5 years)	Measurements sush as loading/unloading areas and city hubs used with high satisfaction levels from stakeholders, who are involved in continuous improvement and tactical planning (1-5 years)	A community for news regarding city logistics is setup, which is active in organizing congresses or similar events. The municipality shares best practices and new methods/technologies which could help businesses	The municiality has a taskforce established to manage public private partnerships. Multiple (3+) public private partnerships are in place and have proven positive impact on social, economic or environmental levels	Multiple (3+) subsidisation and incentivisation schemes are active and have proven to contribute positively towards the goals for which they were established	Regulations and enforcement is established to a point where the policy plan is 'checked'. Results are proven to positively impact congestion, pollution and safety
5	**Optimized**	ICT is continuously improved with a closed plan-do-check-act cycle. The data gathered is used to plan traffic management on a strategic level (5+ years)	Future needs are already anticipated. City hubs are the standard for deliveries. The grid is sufficient and all public EV charging needs are fulfilled. There is a continuous plan-do-check-act cycle with strategic planning (5+ years)	All concerning stakeholders are active in the city logistics community and the municipality has a clear one-single-window through which communication on city logistics takes place	Public private partnerships are a go-to solution and a task force is permanently active to evaluate existing operations and research future possibilities	The plan-do-check-act cycle is complete. At the end of subsidisation and incentivisation scheme periods the results are analyzed and new ittirations of schemes are continuously improved	Regulations and enforement measures are continuously improved by analyzing results and adjusting policy so goals towards sustainible city logistics are reached. There is a full plan-do-check-act cycle

TEST & VALIDATION: APPLICATION OF CL3M FOR DUTCH MUNICIPALITIES

The goal of the testing is to ensure validity and reliability in data collection. This involves engaging a selected group of domain experts from the municipality. The method used is a maturity assessment interview, providing a comprehensive understanding of the municipalities. The interview aims to gather ample data and knowledge from the domain experts. To avoid bias, an open interview format was chosen, letting experts freely express insights and opinions. Six specific questions were used to guide the discussion and cover relevant aspects of the municipalities.

1. How does the municipality use technology/ ICT in its traffic management (especially for city logistics)?
2. How does the municipality integrate city logistics in its urban logistic planning (e.g., city hub, infrastructure, loading- and unloading areas)?
3. How does the municipality communicate with stakeholders regarding new policies and changes?
4. How does the municipality collaborate and cooperate with CL stakeholders (e.g., pilot case)?
5. How does subsidization from the municipality stimulate CL stakeholders to become more sustainable?
6. How does the municipality work with the regulation of the upcoming zero-emission zones and how does it plan to enforce them?

With the use of information gathered from these open questions, discussion on different maturity criteria and feedback from interviews, a maturity score is given to the municipality for each criterion. Figure 5 shows a radar chart showing the maturity score of three municipalities and Table 6 explains the results. The researcher calculates the maturity score using municipality data. The interviewee is informed of the score using a model or framework. When the researcher and interviewee disagree, both scores are included. Considering all sides' perspectives, the purpose is to agree on the maturity score and having a fruitful discussion. This provides a collaborative and balanced maturity evaluation of the municipality.

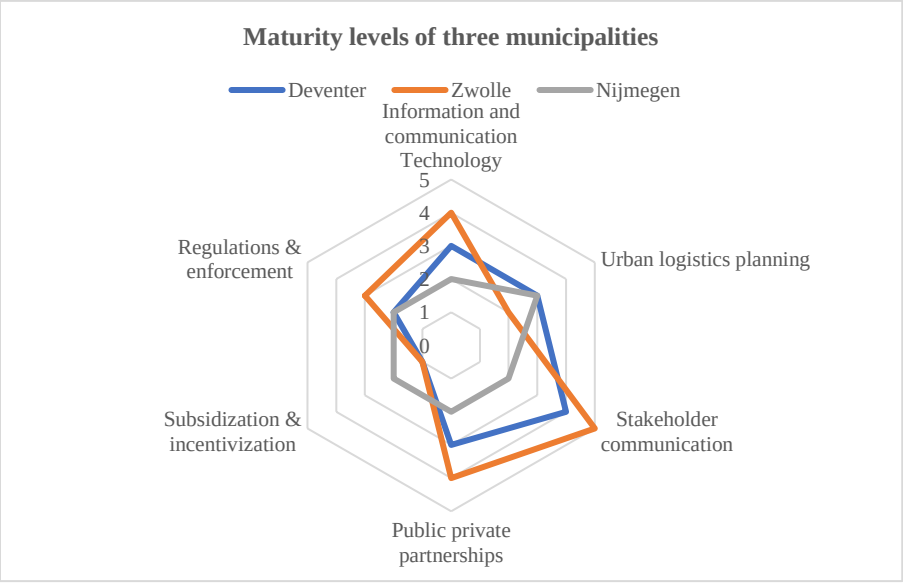

Figure 5 The relation between performance measurements areas and the role of municipalities

TABLE 6 Explanation about scoring the maturity level of three municipalities

Information and Communication Technology			**Urban logistics planning**		
Municipality	**Findings**	**Score**	**Municipality**	**Findings**	**Score**
Deventer	Frontrunner in the use of iTCI (intelligent traffic control installation) in the Netherlands	3	Deventer	Currently has a bike courier hub and other facilitating private consolidation centres. Researching the need for electrical charging infra for commercial vehicles	3
Zwolle	Along with iCTI, this municipality also uses number plate recognition	4	Zwolle	Close monitoring of current CL flows integrated into mobility planning. The vision is to facilitate private actors and then build any hub and other infra.	2
Nijmegen	Uses TCI for traffic management, exploring the use of it	2	Nijmegen	A city hub is implemented in partnership with CL stakeholders	3
Stakeholder communication			**Public-private partnerships**		
Municipality	**Findings**	**Score**	**Municipality**	**Findings**	**Score**
Deventer	Actively communicating with CL stakeholders but not on a regular base. Still working on creating a dedicated website/page for putting all information for stakeholders	4	Deventer	Two pilots are planned and a few are already finished. The most important PPP project is iTCI, which is implemented and running.	3
Zwolle	Weekly meeting with CL stakeholders, All information is available on the website. Regular newsletter kind of communication for un-coming changes in CL policy	5	Zwolle	Multiple PPP projects are going on (e.g., Pilot is running to stimulate the use of electric bicycles and vans by providing vehicles at the cost of the municipality for a week.). In the process to introduce shared freight bikes.	4
Nijmegen	In the process of creating regular communication with CL stakeholders. More reliance on the national government for providing	2	Nijmegen	A city hub is implemented in partnership with CL stakeholders. No other partnership yet. Exploring opportunities.	2

	communication guidelines				
Subsidization & incentivization			**Regulations & enforcement**		
Municipality	**Findings**	**Score**	**Municipality**	**Findings**	**Score**
Deventer	No subsidization. CL stakeholders are referred to the subsidy at the provincial and national levels	1	Deventer	Zero-emission zone signs will be put at all entry points and will be monitored by police. Exploring the possibility of using the special camera for monitoring.	2
Zwolle	No subsidization. CL stakeholders are referred to the subsidy at the provincial and national levels	1	Zwolle	Zero-emission zone signs will be put at all entry points and will be monitored by police. Already started testing using the special camera for monitoring.	3
Nijmegen	A subsidization project is in process and will be implemented in the coming 2-3 years	2	Nijmegen	Zero-emission zone signs will be put at all entry points and will be monitored by police. Exploring the possibility of using the special camera for monitoring.	2

DISCUSSION

Validating and testing a maturity model can take months if not years. In the case of CL3M also, this is true. By applying this model to three Dutch municipalities, we started with the process of validating the model. The initial idea was to use a questionnaire for collecting data about the maturity level of municipalities. However, it was deemed not feasible due to the complexity of the criteria, the knowledge level of the respondent (it was observed that not always an employee working in the municipality is an expert in city logistics) and the perception towards questions. Therefore, an open interview is deemed a suitable option. However, there are still challenges experienced with open interviews. As we can see, each criterion is discussed with the municipality based on what is being done or what the municipality thinks should be done. For instance, in the case of ICT, there are many different possibilities from the CL perspective (e.g., smart loading/unloading zone, sensors, smart routing...), however, in the application to three municipalities, the focus was solely on ITS. Similarly, in urban logistics planning, only city hubs and charging infrastructure are focused on. Here too, topics such as integration of logistics in mobility planning, dedicated freight policies etc. could be part of urban logistics planning. Thus, on one hand, the maturity model is developed on a solid base of main six balanced criteria without flooding the model. On the other hand, the list of initiatives must be clear within six criteria to evaluate a municipality. An alternative approach could be to send a quick scan questionnaire (comprising of eclectic measures) followed by an in-depth interview. The quick-scan step will prepare municipality representatives with information about different initiatives. Along with that, the discussion will include all the different possible measures listed in a quick scan. Interpreting the scores should not be seen as absolute score, however they should be seen in comparison with other cities. It helps each municipality to define new measures to make a next step to a

higher level of maturity. Overall it gives the provinces and the national government quantitative insight what the current state of reaching zero emission zones in their cities.

During the first application of the model, most feedback given was related to specificity. During the maturity assessment, it became evident that cases can vary and needs in terms of city logistics measurements can differ between municipalities. A report from Topsector logistiek also states that requirements differ widely between segments of city logistics and also solutions to the same problem can be handled differently [24]. To meet audience needs, a balance must be created between a complex reality and model simplicity [20]. As such, integrating all feedback into the model would create an overly complex model, creating confusion and a lack of interest. To tackle the issue of creating a balance between a generalized and overly complex model, a SWOT analysis can assist. Combining the output of a maturity model with creating a SWOT analysis is a promising option to build an effective roadmap for implementation with actionable insights [25]. For the City Logistics Maturity Model for Municipality established in this research this means the output of the assessment would be both the score (0-5) and a SWOT per each area of development, and thus create a tool that is both generalized and tailored to individual cases.

CONCLUSION

The landscape of city logistics is changing at a fast pace, with a need for a more sustainable approach to city logistics being unavoidable as logistical traffic in cities keeps increasing, resulting in unsafe, congested, and environmentally polluted city centres. In the same line of development, the number of activities in city logistics is growing rapidly in the Netherlands causing an increase in emissions, and the decline in accessibility and safety in cities. Therefore, the Dutch government has introduced GreenDeal Zero-emission city logistics. The goal of this deal is to have 30-40 of the biggest municipalities in the Netherlands have zero-emission city logistics in 2025. Municipalities play a great role in tackling this matter, having many instruments at hand. However, it is not self-evident that all municipalities use these instruments to their full potential. The goal for 2025 is clear, but it lacks a way for municipalities to see their progress and a way to find improvements in their city logistics. A method to measure city logistics performance of municipalities can help in creating awareness and guidance, to ultimately lead to a more sustainable environment for inhabitants and businesses. Subsequently, this research is focused on developing a maturity model as a tool to assess the maturity level of a municipality for its performance-related city logistics process management.

After conducting a literature study, the first step was to scope and design the maturity model. The review revealed that to measure performance within city logistics the most used criteria are based on technical, economic, environmental, social, and service aspects. The City Logistics Maturity Model for Municipality (CL3M) requires a domain-specific, multidimensional model to assess city logistics from a municipal point of view. The model includes six levels (0-5) and a PCDA cycle is embedded throughout the levels. The model is populated through three focus fields (Technical, Social and Corporate, and Policy), branching out into six areas of development: Information and communication technology, urban logistics planning, Stakeholder communication, Public-Private Partnerships, Subsidization and incentivization, and Regulations. Furthermore, a strong correlation between the six areas of development and the five municipal roles was found, adding to the validity of the model. To furthermore validate the model, expert interviews were conducted to ensure the completeness of the model.

The CL3M model was tested for three municipalities, namely, the municipality of Deventer, Zwolle and Nijmegen. The assessment pointed out that CL3M is yet in its juvenile stage and with further development, the model can reach its full potential in usefulness, reliability and adaptation. Through these maturity assessments, it became evident the model required specificity complementary to the existing assessment interview, and thus a SWOT analysis option should be explored be added as a conclusion during the maturity assessment. Another first point of improvement would be the assessment method. Currently, an expert is required to interview the interpretation of the question must be further clarified. Also, a quick scan including eclectic measures should be sent to the respondent before the interview to assess the holistic performance. Finally, the goal is to develop a more general and quantitative method, perhaps in the form of self-

assessment, to increase the ease of using the model, and to measure the effectiveness of the policy reaching zero-emission target.

ACKNOWLEDGMENTS

We would like to thank TopSector Logistiek for sponsoring this research. We also thank our graduate students Kasper Mittelmeijer and Rory Brand for their fieldwork.

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