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Rewarding organisations for sustainable mobility of their employees: A multi-criteria assessment model and certification framework☆

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ABSTRACT

The concept of sustainable mobility is aimed at minimising environmental impacts of transportation systems while meeting the needs of individuals and communities. This includes encouraging citizens to choose sustainable modes of transportation: walking, cycling, public transport, carpooling, and telecommuting. We present an approach at rewarding organisations that actively support the sustainable mobility of their employees, and propose a framework for awarding a sustainable mobility certificate to organisations that fulfil sustainable mobility goals and objectives. The assessment is carried out using a qualitative rule-based multi-criteria model, which considers 50 indicators. Other elements of the certification process include methods for assessing the mobility structure of employees in the organisation and its potential for improvement. In this paper, we present the main components of the proposed certification framework and illustrate its application for assessing the status of sustainable mobility of employees at a Slovenian research institute.

1. Introduction

The mobility of people and goods is one of the cornerstones of modern society. However, ever increasing traffic has various adverse effects on individuals, communities and the environment: congestion, air and noise pollution, infrastructure strain, social isolation and inequality, economic costs and others (Bıyık et al., 2021).

Ljubljana, the capital city of Slovenia, is no exception. With approximately 300,000 inhabitants, Ljubljana is one of the smallest European capital cities. Nevertheless, it is faced with severe traffic problems (SURS 2023a and 2023b; Petelin et al., 2023). There are over 220,000 jobs in the city, which account for over 25 % of all jobs in Slovenia. As a result, over 120,000 people commute to Ljubljana daily from elsewhere. This means approximately 100,000 vehicles entering and exiting Ljubljana on a daily basis. The majority of those are private cars; the estimated average occupancy on a working day in 2021 was 1.26 persons per vehicle (SURS 2021). Thus, it is essential to employ the concepts of sustainable mobility (Gallo and Marinelli, 2020; Morfoulaki and Papathanasiou, 2021a), particularly to reduce the number of cars in favour of public transportation and other more sustainable means of transportation, such as walking, cycling and car sharing.

SmartMOVE (2022–2024) was a project aimed at preparation of strategies and mobility plans, in order to justify the need for systematic development of sustainable mobility in the Ljubljana Urban Region. The main goal was to limit the negative environmental impacts resulting from unsustainable forms of mobility and the long-term development of sustainable mobility.

In this paper, we address one of SmartMOVE activities: development of a *certificate* for organisations that actively work on reaching the principles of *sustainable mobility* of their *employees* (the so-called *SmartMOVE Certificate*). The idea is that an organisation that monitors, actively supports, evaluates and, in the long term, improves the mobility

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of their employees towards sustainability is encouraged and awarded by an officially and publicly recognised certificate. In perspective, the certificate may bring advantages to such organisations, e.g., in positive public recognition and in obtaining governmental projects and funds.

The central component of the analytical process as part of the certification framework consists of *a multi-criteria evaluation model* that prescribes the necessary conditions and evaluation criteria for awarding the certificate. The model considers 50 indicators, with which it assesses important aspects of sustainable mobility, including the current situation in the organisation, its vision and management, performance in terms of general and specific measures/activities for improvement, and their monitoring and evaluation. Technically, the model is qualitative and rule-based, developed according to the method DEX (Decision EXpert) (Bohanec, 2022). Another important part of the certificate is the assessment of the current *mobility structure of employees* and *potential* for its improvement, which is aimed at perpetual monitoring and managing of the situation. The certificate proposal also defines the certification process and means of acquiring the necessary data, which includes preliminary self-assessment of organisations, interviews with the organisation's management and surveys of employees' mobility behaviour.

The main contributions of this work are the proposed certification framework together with its main component, the multi-criteria DEX model, as a systematic approach to awarding organisations that successfully manage sustainable mobility of their employees.

In the following sections, we first present the related work considering existing similar certificates, certification criteria and the role of multi-criteria decision-modelling (MCDM) in this context. In Section 3, the key concepts of the proposed certification framework are defined in terms of its purpose, requirements, and stages of the certification process. The methodological approach is presented in Section 4, justifying the selection of DEX method and describing the process of DEX model development. This is followed by a presentation of certificate concepts and components: the DEX model in Section 5, and assessment of the current and potential mobility status in Section 6. In Section 7, the approach is illustrated by a real-world application at a Slovenian research institute. Section 8 concludes the paper.

2. Literature and related work review

As the first stage of certificate development, we conducted a thorough state-of-the-art and related-work analysis (Bohanec et al., 2022). In this section, we overview the main results of that study that are relevant for the certification of organisations: state-of-the-art of similar certificates, certification criteria, and the role of MCDM in the process.

The two main findings, which considerably shaped our further work, were:

1. We could not find any existing certificate framework that would fully meet the goals and requirements for the sustainable mobility certificate, as detailed further in Section 3.
2. MCDM methods (Greco et al., 2016; Kulkarni, 2022) are well established and widely used in the area of sustainable urban mobility planning (SUMP) (Yannis et al., 2020; Garcia-Ayllon et al., 2021; Lindfors, 2021).

Actually, there exist several certificates that in some way address the aspects of mobility and sustainability. In Slovenia, there are three well-established certificates: Green Star (2024); Cyclists-Friendly Employer Certificate (2024) and Pedestrian-Friendly Organization (2024). The former addresses general aspects of green transformation and climate action, and only barely touches upon sustainable mobility. The latter two are specific and address only cycling and walking, respectively, as sustainable means of mobility. Some comparable certificates are used in Norway (Bohanec et al., 2022), too, such as "Eco-lighthouse" and "Bicycle-Friendly Workspace". Overall, it is surprising that employers- and employees-related topics are relatively poorly covered in the scientific literature. On the other hand, this topic was much better covered in research projects, such as CIVITAS (2002–2024), ENDURANCE (2013–2016), CH4LLENGE (2013–2016), ICARUS (2016–2020), and ELTIS (2024), where we found a number of useful recommendations and tips for evaluating sustainable mobility of organizations and their employees. The principles advocated there have been meticulously translated into the development of the SmartMOVE Certificate framework (see Section 4.2).

Among the scientific papers in this domain, some have a general and review focus. Singh et al. (2012) presented sustainability indicators across environmental, economic, social, and institutional domains, but did not specifically address urban mobility. Rudolph et al. (2015) compared MCDM to cost-benefit analysis (CBA), highlighting MCDM's advantages in supporting mobility planning decisions. Additionally, Yannis et al. (2020) and Lindfors (2021) confirmed the growing use of MCDM methods in transportation and mobility-related realms.

A large number of studies have applied MCDM in the context of SUMP, addressing specific decision problems like project prioritization, urban infrastructure evaluation, and spatial and location planning. Several publications proposed detailed and structured systems of criteria for evaluating urban mobility. Awasthi et al. (2013, 2018) offered two frameworks categorizing 19 and 31 variables, respectively, into economic, environmental, social, and technical domains. Similarly, Oliveira Cavalcanti et al. (2017) proposed a hierarchical breakdown of criteria, emphasizing qualitative evaluation. These frameworks served as the foundation for the SmartMOVE project's preliminary criteria pool. Damidavičius et al. (2020) introduced 46 descriptive variables for urban logistics, while Morfoulaki and Papathanasiou (2021a, 2021b) suggested six thematic groups of criteria (e.g., Accessibility, Environment, Economy), using the PROMETHEE (preference ranking organization method for enrichment evaluations) method—also applied by Kiba-Janiak and Witkowski (2019) and Manzolli et al. (2021).

Many studies focused on city- or region-wide SUMP assessments, such as those by Garcia-Ayllon et al. (2021) and Kiba-Janiak and Witkowski (2019), who evaluated multiple cities using a wide range of criteria. Other studies tackled localized decision problems, such as Cieśla et al. (2020) and Ortega et al. (2021), who evaluated shared mobility programs and park-and-ride facility locations.

The SUMI (Sustainable Urban Mobility Indicators) framework developed by the European Commission (SUMI, 2020; Rutka et al., 2024) is another key resource in terms of providing criteria to be considered in decision making about sustainable mobility. It includes 18 indicators, categorized into core and non-core groups. While these indicators are rigorously defined, past studies (e.g., Finger and Serafimova, 2020) suggest that some SUMI indicators may be too complex or data-intensive for practical use, leading us to adapt simplified versions of these indicators for more practical application. As a more practical alternative, the self-assessment questionnaire developed within the project CH4LLENGE (2013–2016) was identified as a relevant and applicable reference. This tool offers a structured yet accessible approach by employing a series of clearly formulated yes/no questions designed to assess key dimensions of sustainable urban mobility. These dimensions include organisational structures, resource allocation, implementation of sustainable mobility measures, and processes for monitoring and evaluation. Compared to the more data-intensive SUMI framework, the CH4LLENGE approach provides a more feasible and scalable option for employer organisations seeking to evaluate their mobility practices in a systematic but manageable way.

Additionally, the PSUM (Policies for Sustainable Urban Mobility) methodology proposed by Marletto and Mameli (2012) promotes

stakeholder engagement in selecting evaluation criteria collaboratively. This participatory approach aligns with SmartMOVE's emphasis on building context-sensitive, inclusive evaluation frameworks.

Regarding specific MCDM methods, it seems that a wide variety of methods is suitable and actually used in sustainable urban mobility planning. According to Yannis et al. (2020), typical MCDM methods include simple additive weighting (SAW), multi-attribute utility/value theory (MAUT/MAVT), elimination and choice translating reality (ELECTRE), preference ranking organization method for enrichment evaluations (PROMETHEE), and analytic hierarchy process (AHP). Lindfors (2021) also identifies a similar, but somewhat wider, list of methods, including MAUT/MAVT, MIVES (Spanish acronym for integral evaluation model for sustainability), WSM (weighted sum method), WAM (weighted average method), OWA (ordered weighted averaging), ELECTRE, PROMETHEE, DEXi/MASC (multi-attribute assessment of the sustainability of cropping systems using DEXi), AHP, ANP (analytic network process), TOPSIS (technique for order of preference by similarity to ideal solution), and VIKOR (Serbian acronym for multi-criteria optimization and compromise solution). All this indicates that MCDM is a common and valid approach to addressing sustainable mobility issues, and that our route is in line with the state-of-the-art. Also, a great variety of MCDM methods involved indicates the absence of a commonly accepted approach, which is likely caused by the diversity and specific needs of sustainability-related decision-making tasks. Among the MCDM methods mentioned above, only DEX(i) has been used in this study. For information about other MCDM methods, the interested reader is referred to Ishizaka and Nemery (2013), Greco et al. (2016) and Kulkarni (2022).

One of the most significant findings of the literature review was the widespread application and maturation of MCDM methods in evaluating sustainable urban mobility. These methods are especially valuable for certifying organizations because they offer a systematic, transparent, and consistent approach for assessing whether organizations meet sustainability requirements. MCDM models help standardize data collection, facilitate the comparison of alternatives, and support informed decision-making—key elements for certifying compliance with sustainable mobility goals. MCDM methods are applicable in contexts where decision-making involves multiple, often conflicting, criteria, as is common in the sustainability domain. MCDM methods are well-established, flexible, and effective tools for supporting decision-making in sustainable mobility. They accommodate both qualitative and quantitative data, integrate expert judgment, and are adaptable to a wide range of decision problems. These characteristics make MCDM methods a robust foundation for the development of a decision-support model for the SmartMOVE certification, ensuring that the model is both methodologically sound and contextually relevant.

In addition to academic contributions, European research and demonstration projects have significantly influenced the development and operationalization of the SUMP concept. The CIVITAS (2002–2024) initiative, launched by the European Commission in 2002, has played a key role in advancing SUMP practices. Through collaborative networks of European cities, CIVITAS has tested and implemented innovative mobility measures, focusing on areas such as active mobility, energy-efficient vehicles, shared transport modes, smart mobility, and integrated planning. Several CIVITAS projects, such as SUMPs-Up, Park4SUMP, Handshake, SUMP-PLUS, MUV, and MOMENTUM, have contributed to the integration of sustainability indicators and the improvement of decision-making processes. Many of these projects implicitly or explicitly employ MCDM approaches, reinforcing the relevance of these methods for the SmartMOVE framework.

Through this literature and related work review, we systematically collected a vast array of sustainabile mobility indicators and criteria that could be used – directly or adapted – for our purpose. Ultimately, we made a collection of more than 100 criteria (Bohanec et al., 2022). Most of them address Economic, Environmental and Social aspects of SUMP. Somewhat less frequently mentioned criteria address also Technical, Security, Political, Implementation, Promotional, Institutional, Infrastructure, and Management aspects. While this collection turned out too wide for the sole purpose of certification, it gave us a good starting point and a number of criteria to choose from. Among the reviewed studies, the most useful were those that addressed specific decision problems, for example introducing shared transport resources in cities (Cieśla et al., 2020), and sustainable urban mobility evaluation at specific locations or organizations (Zapolskytė et al., 2020; Ortega et al., 2021). The work of Awasthi et al. (2018) stands out for a very clear structure of SUMP-assessment criteria.

Among the approaches suggested by various projects, we found the SUMP self-assessment questionnaires developed in the CH4LLENGE project the most relevant and operational. They consist of series of carefully designed and as-simple-as-possible yes-no questions. We chose to follow their general approach, but formulated a tailored set of questions/criteria that specifically address sustainable mobility of employees in organizations relevant for awarding the SmartMOVE certificate..

3. The SmartMOVE certificate

3.1. Purpose

The SmartMOVE certificate is intended to raise awareness and promote the sustainable mobility of employees in organizations. It can be rewarded to any organization that:

- continuously monitors travel habits and mobility structure of its employees,
- designs and implements activities to improve mobility towards the use of sustainable means of transport, and monitors and evaluates their results,
- shows a good state and/or sufficient improvement related to sustainable mobility.

The certificate explicitly addresses only the mobility of *employees* and excludes other purposes of transportation, for instance logistics, which would require a different approach.

3.2. Requirements

The basic requirements for the certification process and corresponding criteria are:

- *Minimality*: The certification methodology should include as few relevant criteria as possible.
- *Operability*: All used criteria must be measurable and obtainable relatively easily through surveys and interviews with the organisation's representatives.
- *Simplicity*: The approach should be effective and simple enough for its users.

The simplicity requirement clearly distinguishes this certificate from *mobility plans*, which are commonly developed in relation to sustainable mobility (Kiba-Janiak and Witkowski, 2019; Rupprecht et al., 2019). Although both require a fairly detailed insight into the organization's mobility structure and its relationship to sustainable mobility, the certificate is intended to be a significantly simpler (and cheaper) instrument. The certification process could be roughly described as a subset that corresponds to the initial steps of creating mobility plans; it excludes a detailed consideration of specific activities, which are an

integral part of mobility plans and require substantial effort. Having a mobility plan is not required for obtaining the certificate.

The certification process should be performed by a reputable organization with properly trained auditors. The procedure must be clear and have clear objectives, equal for all – thus the need for an explicit evaluation model. Also, the certification process must be self-sustaining: the foreseen procedures and instruments must provide all the data necessary for the certificate awarding decision.

Regardless of the final decision – whether the organization receives the certificate or not – the process is also expected to show a clear picture of the state of sustainable mobility in the organization, its strengths and weaknesses, and above all, suggest possibilities for future improvements.

3.3. Certification process

The proposed certification framework consists of three steps:

1. *Preliminary self-evaluation*: Unsupervised and free of charge, performed by the candidate organizations themselves using a simple and publicly available questionnaire (Certificate, 2025), consisting of ten questions. The aim is to determine whether the organization meets the essential requirements for obtaining the certificate.
2. *First certification*: Carried out in collaboration with the organisation and certification auditor. The aim is to assess the state of sustainable mobility in the organization. This includes two major categories: (1) general assessment from various aspects, such as organization, vision, plans, implementation and monitoring of activities, and (2) travel habits of employees, their mobility structure and potential for further improvement. The category (1) is assessed by the multi-criteria model, further detailed in Section 5. The category (2) is assessed through surveys conducted among employees and through numeric models, as presented in Section 6.
3. *Renewal of the certificate*: Carried out after the certificate expires. The process incudes the main step, which is equal to the step 2 above, and an additional step: reviewing the changes and results of the previous period, in order to determine whether sustainable mobility in the organization improved, worsened or remained at approximately the same level. The certificate is not renewed if the status has worsened to the unacceptable level ("unacc" in the DEX model in Section 5). The renewal provisionally takes place each five years, in order to give enough time to organisations to implement changes suggested in the previous certification round.

This certification process is designed to be carried out by a designated certification agency and involves a trained auditor. While not considered a commercial for-profit activity, it is expected that the costs involved in stages 2 and 3 are reimbursed by the organization being certified.

4. Methods

4.1. Selection of the MCDM method

In order to be eligible for receiving a sustainability certificate, an organisation has to satisfy a number of criteria. This justifies using the general MCDM approach (Section 2). However, there is a multitude of available MCDM methods that have different characteristics and are suitable for different decision-making contexts (Wątróbski et al., 2019; Cinelli et al., 2022). Therefore, the question is which method to use for the SmartMOVE certification. Our selection was based on the following lines of thought.

First, decision alternatives (i.e., organisations being certified) are not known in advance. They are assessed when they decide to step in the certification process. This requires using *full-aggregation* (Ishizaka and Nemery, 2013) MCDM methods, which proceed by first developing an explicit multi-criteria model, which is then used to evaluate alternatives as they enter the process. This requirement effectively excludes all methods that begin with a set of alternatives and proceed to evaluate and/or rank them. Specifically, this excludes outranking methods, such as PROMETHEE, and methods employing pairwise comparison of alternatives, such as the basic variation of AHP.

Second, alternatives are in principle independent of each other. There is no need to rank organisations or to choose the best one; we only need to establish whether or not an organisation is eligible for receiving the certificate. This qualifies the task as a "*sorting problem*" (Roy, 2016), defined as assigning each decision alternative to one category among a family of predefined preferentially-ordered categories. In principle, two such categories (such as "no" and "yes") would be sufficient for the certification. In order to distinguish between different levels of eligibility, we actually opted for four, as indicated in Sections 4.2 and 5. There are MCDM methods specifically designed for sorting (Greco et al., 2016; López et al. 2023). Examples include UTADIS (French acronym for discriminant additive utilities), DRSA (dominance-based rough set approach), DEX, and specialized variations of already mentioned methods AHP, ELECTRE, TOPSIS, and VIKOR.

Third, the number of criteria to be considered is large (50, as shown in Section 5). This gives a strong priority to *hierarchical* MCDM methods, which facilitate structuring criteria in a tree or hierarchy, constructing smaller sub-groups of related criteria, which are possibly more comprehensible and easier to handle than the whole criteria set at once. Methods using a single decision matrix, which consist of a linear list of criteria on one dimension and alternatives on the second, are unsuitable for the task at hand. There are not that many hierarchical methods; possible candidates include MAUT/MAVT, AHP, ANP, MACBETH (measuring attractiveness by a categorical based evaluation technique), MCHP (multi-criteria hierarchy process), and DEX.

Last but not least, the certification is a *non-compensatory* (Bouyssou and Marchant, 2007; Dieckmann et al., 2009) decision task: an organisation is required to meet at least the minimal requirements on a substantial subset of criteria. It is generally not possible to compensate an unsatisfactory performance according to one criterion with an excellent performance on the other. This calls into question the use of scoring methods and methods using linear evaluation functions based on criteria weights, which are inherently compensatory. None of these methods can be used without adaptations, such as defining minimal thresholds for non-compensatory criteria. On the other hand, rule-based methods, such as DEX, do not need such adaptations and can handle both compensatory and non-compensatory cases, depending on the local context in the hierarchy of criteria.

On this basis, we eventually selected the method DEX (Bohanec, 2022), which fulfils all the mentioned criteria: it is a full-aggregation MCDM method, well suited for sorting problems, and facilitates using both criteria hierarchies and decision rules.

4.2. Selection and formulation of criteria

Fifty criteria were selected based on the concepts of SUMP for employers (e.g., companies, organisations). These were first addressed in the ELTIS/CH4LLENGE SUMP Self-Assessment (2016) questionnaire which was aimed at assessing the potential for a successful implementation of a SUMP. The approach was further elaborated in the ICARUS project (ICARUS, 2016–2020; Kontić, 2019) as an aid to assess the feasibility of implementation and operation of sustainable mobility measures. Based on this previous experience in sustainable mobility monitoring and evaluation, the key categories were extended here by

the design of the questions that specifically reflect the goals of sustainable mobility, focusing on potential for success, organization aspects, assessment of situation and scenarios, setting vision, priorities and goals, spatial planning issues, responsibility and financing, and readiness to perform monitoring and evaluation.

Furthermore, we established criteria pertaining to various general and specific measures to improve mobility, including cycling, walking, parking and accessibility for individuals with disabilities.

Within the fifty criteria, we selected eight "foundation criteria" that must be necessarily fulfilled. The basis for this selection came from the aforementioned ELTIS/CH4LLENGE SUMP questionnaire, where not fulfilling these key criteria would most probably result in a failure in terms of reaching the SUMP goals.

4.3. DEX model development

The development of the DEX model (presented in Section 5) has been carried out in three steps that correspond to the three main components of such models (Bohanec, 2022; Section 3):

1. *Development of the tree of criteria*: Here, the task is to structure the criteria, identified in Section 4.2, in a form of a tree. Criteria are gradually grouped in subtrees that connect closely related criteria, and form higher and higher evaluative concepts. For instance (Fig. 1), the criteria that address individual modes of transportation (*Walking, Cycling, Public transportation*) may be grouped in a subtree *Sustainable modes of transport*, which in turn contributes to a higher-level subtree SPECIFIC MEASURES). In this way, we get a tree of variables (called *attributes* in DEX), which are of two types: (i) *basic*, which correspond to criteria from Section 4.2 and represent model inputs, and (ii) *aggregate*, which represent model outputs, i.e., assessments with respect to those attributes. The root of the tree represents the overall mobility assessment of each organisation.
2. *Definition of attribute scales*: Scales determine the set of values that can be assigned to each attribute. In DEX, scales are qualitative; they generally consist of words and are preferentially ordered from 'bad' to 'good' values. According to the recommendation (Bohanec, 2022) to "use the least number of values that is still sufficient to distinguish between importantly different characteristics of alternatives," we chose the scales {no, yes} and {no, partly, yes} for basic criteria that examine whether certification requirements are fulfilled or not. For aggregate criteria we defined the scale {unacceptable, acceptable, good, excellent} that represents various levels of eligibility for receiving the certificate.
3. *Definition of decision tables:* In DEX, the evaluation of decision alternatives proceeds in the direction from basic attributes towards the model's root. Each aggregate attribute has an associated decision table that determines the value of that attribute depending on the values of its subordinate descendants (one level lower) in the tree. Each decision table consists of decision rules where each decision rule determines the outcome corresponding to a particular combination of descendants' values. To illustrate the concepts on a simple decision table, let us take the attribute VISION (see Fig. 5), which depends on two lower-level criteria [15] *Existence of policy, strategy, plan*, and [16] *Long-term vision*. The associated table consists of all nine combinations of values of [15] and [16], and assigns an output VISION value for each combination as shown in Table 1.

Attribute	Scale
CERTIFICATE	unacc;acc;good;*exc*
BASICS	unacc;acc;good;*exc*
POTENTIAL FOR SUCCESS	unacc;acc;good;*exc*
ORGANIZATION	unacc;acc;good;*exc*
Management	no;partly;*yes*
Research and experience	no;partly;*yes*
Adjustment of work	no;partly;*yes*
VISION AND GOALS	unacc;acc;good;*exc*
SITUATION AND SCENARIOS	unacc;acc;good;*exc*
VISION	unacc;acc;good;*exc*
PRIORITIES AND GOALS	unacc;acc;good;*exc*
MEASURES	unacc;acc;good;*exc*
GENERAL MEASURES	unacc;acc;good;*exc*
SPECIFIC MEASURES	unacc;acc;good;*exc*
Sustainable modes of transport	unacc;acc;good;*exc*
Walking	no;partly;*yes*
Cycling	no;partly;*yes*
Public transportation	no;partly;*yes*
Motorised vehicles	no;partly;*yes*
Measures for customers	unacc;acc;good;*exc*
ACTING AND MONITORING	unacc;acc;good;*exc*
SPATIAL PLANNING	no;partly;*yes*
RESPONSIBILITY AND FINANCING	no;partly;*yes*
MONITORING AND EVALUATION	no;partly;*yes*

Fig. 1. Top-level structure of the certificate evaluation DEX model.

As a side note, Table 1 also illustrates the compensatory and non-compensatory aggregation mentioned in Section 4.1. Actually, both of them are combined in this single table. The value "no" of [15] always maps to VISION = "unacc" (rules 1–3) and can thus not be compensated by any value of [16]. Rules 4–9 represent cases of a more compensatory type, where, for instance, the value "no" of [16] can be partly compensated by better values of [15] (rules 4 and 7). Also, this table shows that decision rules indeed depend on the context provided by subordinate criteria; different contexts may require different decision tables. Decision tables do not depend on the auditor or current organisation being assessed by the model, but are formulated once for all, which assures an equal treatment of all candidate organisations.

All the three model development steps were carried out by the six co-authors of this paper, of whom three are sustainable mobility experts and practitioners, and three decision support and decision modelling methodologists. As the development progressed, the model was regularly presented to other SmartMOVE project partners (represented by about 20 members), collecting their suggestions and accordingly improving the model for the next round.

5. Qualitative multi-criteria DEX model

The central component of the SmartMOVE certification method is a qualitative multi-attribute rule-based model, developed according to the DEX method. The model defines criteria for granting the certificate; in total, there are 50 criteria (shown in Appendix 1, Fig. 5) that address various aspects of sustainability, from criteria addressing the management of sustainable mobility in the organisation, to those addressing general activities toward improvement (e.g., education of employees) and specific measures addressing sustainable means of transportation. According to certificate goals (Section 3.1), which aim to reward organizations that are aware and already take good care of sustainable mobility, we formulated eight foundation criteria that must be necessarily fulfilled:

1. Established (planned and regularly addressed) commitments regarding sustainable mobility.
2. Perpetual monitoring of travelling habits and mobility structure of employees.
3. Having a policy, strategy or plan for incorporating the principles of sustainable mobility.
4. Assigned a person or body for the coordination of sustainable mobility activities.
5. Cooperation with research or consulting organisations regarding sustainable mobility.

Table 1
Example decision table that maps criteria [15] and [16] to VISION.

	[15] Existence of policy, strategy, plan	[16] Long-term vision	VISION
1	no	no	unacc
2	no	partly	unacc
3	no	*yes*	unacc
4	partly	no	acc
5	partly	partly	acc
6	partly	*yes*	good
7	*yes*	no	acc
8	*yes*	partly	good
9	*yes*	*yes*	*exc*

6. Having recognized the potential for sustainable mobility transformation.
7. Building awareness and educating employees.
8. Having planned, ongoing or already implemented sustainability measures.

These and the remaining 42 criteria are assessed through the discussion between the organisation's representatives and the auditor. The DEX model is qualitative, thus the fulfilment of individual criteria is expressed in terms of a three-valued scale {no, partly, yes}. These assessments are guided by the *Auditor's Manual* (currently available only in Slovenian language, see an English excerpt in Table 3) that consists of a questionnaire addressing all individual criteria and prescribing conditions for assigning specific criteria values.

The 50 criteria are aggregated according to the model hierarchy. The top-level structure of criteria is shown in Fig. 1 (full structure is shown in Appendix 1, Fig. 5). The root criterion is called CERTIFICATE and represents the overall assessment, using the four-valued scale: {unacceptable, acceptable, good, excellent}. Capital letters denote criteria that correspond to important aspects of sustainable mobility, which are assessed in the process:

- POTENTIAL FOR SUCCESS: Considering the organisation's management and leadership, awareness of the mobility situation, and orientation and commitment towards sustainable mobility.
- ORGANIZATION: Considering the management of sustainable mobility on the organization and collaboration with other organisations, such as research and consulting organizations and neighbouring organizations that might share the same mobility space, issues and policies.
- SITUATION AND SCENARIOS: Knowledge of traveling habits of the employees, identification of relevant stakeholders, and awareness of the mobility structure and potentials.
- VISION: The existence and level of sustainability mobility plans, long-term vision of the organization in the area of sustainable mobility.
- PRIORITIES AND GOALS: The existence and quality level of sustainable mobility priorities and goals, with particular emphasis on monitoring SMART (Specific, Measurable, Achievable, Relevant, Time-bound) targets.
- GENERAL MEASURES TO IMPROVE MOBILITY: Conducted or already implemented general measures/projects, such as education of employees, providing appropriate information (e.g., maps with mobility options and public transport timetables).
- SPECIFIC MEASURES TO IMPROVE MOBILITY: Specific measures regarding various means of sustainable transportation: walking, cycling, public transportation, and reducing the use of individual cars. For instance, cycling incorporates measures: easy access, parking lots and stands, proximity to the entrance, measures against theft, maintenance kits, bikes available at the workplace, awards for cycling to work and discounts for employees for purchasing bike equipment.
- SPATIAL PLANNING: Local arrangement of space, traffic and facilities.
- RESPONSIBILITY AND FINANCING: Action plans and ongoing activities for sustainable mobility.
- MONITORING AND EVALUATION: Perpetual monitoring and evaluation of completed and ongoing sustainable mobility projects and measures.

Regarding the value scales of criteria (Fig. 1 and Fig. 5) it is worth noting that the red colour indicates undesired values that lead to rejection of the certificate. For instance, the red "no" denotes that *Management* is an essential criterion that has to be at least partly fulfilled. The black "no" that occurs with some other criteria tells us that they, while still important, are not essential. The green colour indicates highly advantageous values.

The aggregation of values in the model is governed by decision rules. Table 2 shows decision rules for determining the value of ORGANIZATION with respect to three lower-level criteria: *Management, Research and experience*, and *Adaptation of work*. For all possible combinations of values of these three criteria, the corresponding value of ORGANIZATION is given in the rightmost column. It is easy to see that *Management*

Table 2
Decision rules for assessing ORGANIZATION.'≥' and '≤' mean 'better or equal' and 'worse or equal', respectively.'*' represents any value.

	Management	Research and experience	Adaptation of work	ORGANIZATION
1	no	*	*	unacc
2	partly	no	<=partly	acc
3	partly	<=partly	no	acc
4	>=partly	no	no	acc
5	partly	*	*yes*	good
6	partly	>=partly	>=partly	good
7	partly	*yes*	*	good
8	*yes*	no	partly	good
9	*yes*	partly	no	good
10	*yes*	*	*yes*	*exc*
11	*yes*	>=partly	>=partly	*exc*
12	*yes*	*yes*	*	*exc*

is indeed an essential criterion: whenever its value is "no", ORGANIZATION is "unacceptable", regardless of the remaining two criteria (rule 1). Other value combinations lead to other ("acceptable", "good", or "excellent") values of ORGANIZATION.

Similar decision tables are defined for all aggregate criteria in the model, i.e., those that depend on subordinate criteria. In total, there are 31 such tables. Thanks to automatic verification carried out by the DEXiWin (2024) software, which was used to develop the model, all decision tables are guaranteed to be *complete* (they define outputs for all input values' combinations) and *consistent* (the better input value always leads to a better or the same output assessment).

Notice that DEX is a qualitative MCDM method and there are, in principle, no weights associated with criteria. The certificate result is determined by a bottom-up aggregation of 50 input questionnaire values, according to the structure of the model (Fig. 5) and decision rules (example in Table 2). Decision rules were designed to ensure that the eight required criteria are considered more important than others in the sense that when they are not fulfilled, the final evaluation is "unacc" and the certificate cannot be awarded. The remaining criteria have similar impact with respect to each other, however their "importance" (in the sense of MCDM weights) varies depending on values of other criteria in the same context. Consider, for example, rule 12 in Table 2. When both *Management* and *Research and experience* are "yes", then *Adaptation of work* is not really important (denoted by '*') to assess the ORGANIZATION as "exc". By the same token, rule 10 declares *Research and experience* not important whenever both *Management* and *Adaptation of work* are evaluated as "yes". The extreme non-compensatory case is represented by rule 1: when *Management* is "no", only this criterion matters and the remaining two are unimportant.

6. Assessment of employees' mobility structure and potential for improvement

The second main assessment component of the proposed certification framework addresses travel habits of employees, their mobility structure and potential for further improvement. This component has been previously detailed in Ženko et al. (2024), so we provide only a summary of its key concepts here. The component is aimed to assesses:

- *Mobility structure of employees*: A distribution of employees' means of transportation to work, considering categories: Using Car alone, Car with colleagues, Car with family members, Bike, scooter or skateboard (including electric ones), Public transportation (with subcategories: train, bus, city bus).
- *Mobility potential*: How much room is there to improve sustainable mobility of employees in an organisation. We distinguish between:
  - *Objective potential*: Assessed with respect to the distance of employees to the workplace. It is determined by rules, for instance: If an employee is up to 2 km from the workplace and does not yet use a sustainable mode of transport, (s)he might be able to walk to work. Similarly, the distances of up to 5 km and 10 km might be suitable to using bicycle and e-bicycle, respectively.
  - *Subjective potential:* Assessed from individual employee's answers to questions of the type: "What is the possibility for you to use (one of: walking, public transport, cycling, carpooling) for coming to work?" with possible answers: "Not possible for me", "Possible, but I do not want to", "Feasible".

The data for these assessments is collected using a questionnaire for employees consisting of 12 questions: five addressing the current modes of transportation, distance from work, travelling time, and frequency, four questions for assessing the subjective potential, and three demographic questions. The analysis involves basic statistics and visualization methods.

The results obtained in this way serve as a comprehensible overview of an organisation's current sustainability status and future potential. Results cannot be used *per se* as a criterion (or multiple criteria) for certification; they must be interpreted in the geographical, traffic, operational, etc., context. For example, while an organisation with an excellent mobility structure might be a good candidate for receiving the certificate immediately, it would be unfair to disqualify another organisation with a bad mobility structure (e.g., for geographical reasons), but doing their best to make it better. That is why the conversion of this data to the DEX model is not direct nor automated, but takes place in the form of auditing.

7. An example application

The proposed approach has been verified on a sample of five organisations that collaborated with SmartMOVE. In the following we show an example application at Jožef Stefan Institute (JSI). JSI (2024) is the largest and leading Slovenian scientific research institute, covering a broad spectrum of basic and applied research. The staff of around 1200 specialize in physics, chemistry and biochemistry, electronics and information science, nuclear technology, energy utilization and environmental sciences. JSI has facilities in two locations. The headquarters and main facilities are located in a densely populated part of Ljubljana (Location A), and the other location is the Reactor Centre Podgorica (Location B), located approximately 10 km out of the main city area. Although sustainable mobility is regarded by JSI as an increasingly important concept, it has not been addressed in a systematic and organised manner yet.

The main issue regarding the transport is that personal car remains a predominant mode of transport for arrival to work. There is a limited number of parking facilities on the premises of Location A, even though it is easily accessible by public transport and bicycle as well as other means of active mobility. As a result, cars are parked on non-designated areas, such as walkways, bicycle parking areas or in the nearby neighbourhoods. Location B, on the other hand, offers abundant parking facilities, but is poorly accessible by public transport and lacks the appropriate cycling infrastructure. These were the main reasons for testing the SmartMOVE Certificate awarding mechanism on this very organisation. The goals were to determine whether the certification framework could effectively recognize and identify key sustainable mobility issues. Additionally, we wanted to explore its potential as a screening and assessment tool capable of highlighting challenges and suggesting possible solutions for improving mobility conditions.

The experiment involved two JSI departments (of Knowledge Technology and Environmental Sciences), with collectively about 100 employees working at both locations. The assessments of input criteria in the DEX model were obtained in collaboration with JSI environmental experts, who are experienced in the area of sustainable mobility. The values of all input criteria were determined according to the *Auditor's Manual*. For example, the values of the five input criteria [1–5] in Fig. 3 were determined following the instructions presented in Table 3. Eventually, as none of the requirements according to these criteria were fulfilled, all corresponding input values were set to "no". The same procedure was applied for the remaining 45 input criteria.

Table 3
An excerpt from the *Auditor's Manual* for determining input values of the first five input criteria.

Criterion	Question	Explanation	Values
[1] Management commitment	Has the management officially committed to making sustainable mobility a fundamental part of the institution/company/organization's environmental policy?	Management must publicly announce its commitment to sustainable mobility—either as a document or a policy (which can be published online).	no: not committed partly: committed, but not publicly announced yes: publicly documented
[2] Identification of shareholders	During the process of preparing sustainable mobility measures, have you identified the relevant stakeholders, their influence, and their role? [management, employees, people with mobility impairments and other vulnerable users, cyclists, pedestrians, public transport users]	Was an event (workshop, meeting) organized where stakeholders were identified and their needs/preferences documented?	no: not done partly: done without stakeholders yes: done with stakeholders
[3] Status and objectives	Have you conducted a situational analysis, assessing goals, capacities, and resources for planning?	A sustainable mobility situation analysis is crucial for defining the scope of potential measures to achieve the goals.	no: not done partly: attempted without clear results yes: done and documented
[4] Recognition of opportunities	Have you identified the potential for transformation towards sustainable mobility principles, and what are they? Have you explicitly addressed modes: [a] walking, [b] cycling, [c] public transport?	Recognizing potential is key to shaping measures; for example, if a location is inaccessible by bicycle due to a lack of cycling infrastructure or an unsuitable distance, this is an important factor when deciding on the implementation of measures.	no: not done partly: attempted, but not addressing all modes yes: done and documented for all modes
[5] Management as role model	Does the organisation's management lead by example in sustainable mobility (i.e., willingness to adopt changes—giving up company parking spaces, using bicycles, etc.)?	By setting an example, management demonstrates its seriousness about changing travel habits within the company. Management as a role model is crucial for mobilizing employees to shift their commuting behaviour.	no: not interested at all partly: intended, but not really acted upon yes: the management has already acted as a role model

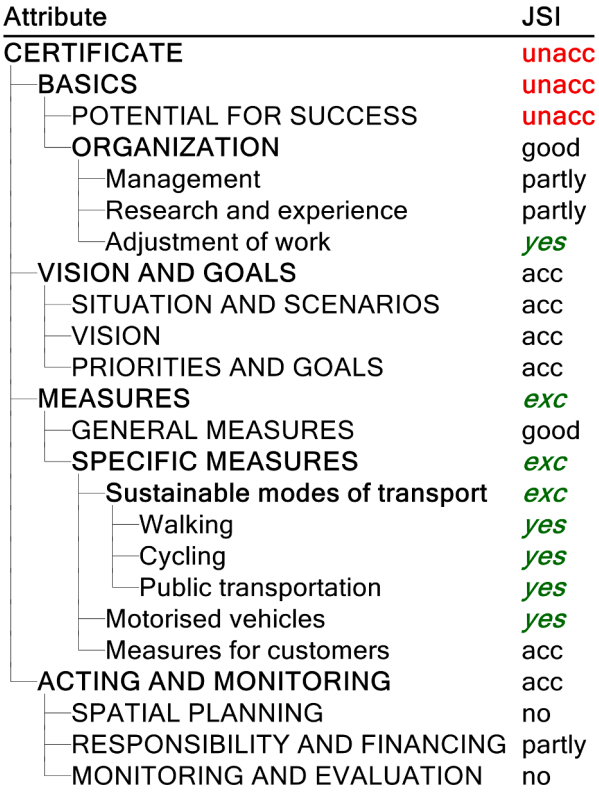

Fig. 2. Assessment of the mobility situation at JSI.

Employing the DEX model on this input data yielded top-level results as shown in Fig. 2.

Overall, the results indicate that JSI is currently not eligible for obtaining the SmartMOVE certificate. The main reason is the unacceptable assessment of POTENTIAL OF SUCCESS. A deeper analysis of the corresponding subtree of criteria (Fig. 3) reveals that such assessment is due to the inactivity of JSI in addressing and managing sustainable mobility issues, and having not assessed the corresponding

Attribute	JSI
CERTIFICATE	unacc
BASICS	unacc
POTENTIAL FOR SUCCESS	unacc
Management	no
[1] Management commitment	no
[5] Management as a role model	no
[2] Stakeholders	no
[3] Status and objectives	no
[4] Recognition of opportunities	no

Fig. 3. Assessment of the JSI POTENTIAL FOR SUCCESS. Numbers in brackets refer to individual questions.

Attribute	JSI	1
CERTIFICATE	unacc	acc
BASICS	unacc	good
POTENTIAL FOR SUCCESS	unacc	acc
Management	no	partly
[1] Management commitment	no	partly
[5] Management as role model	no	
[2] Identification of shareholders	no	
[3] Status and objectives	no	
[4] Recognition of opportunities	no	partly

Fig. 4. Target Analysis of JSI, showing the necessary changes for improving the overall assessment.

opportunities and potentials. On the other hand, the situation regarding general and specific sustainability measures is actually very good.

An important advantage of using assessment models is that they can be used for various decision analysis tasks, such as what-if and sensitivity analysis. With this, the decision maker(s) can explore the situation and find ways for its improvement. In the JSI case, we employed the Target Analysis (Bohanec, 2025) feature of DEXiWin software, which investigates changes of basic criteria values that may eventually lead to the overall improvement of evaluation results. The search is combinatorial and considers changes of multiple attributes. The algorithm considers the internal model structure and decision tables defined at different levels. Given the goal (for instance, "improve the overall score"), the algorithm starts at the root of the model (CERTIFICATE) and recursively searches the underlying decision tables so as to find decision rules and, ultimately, input criteria values that might satisfy the goal. In doing that, it considers the preferential ordering of rules and uses a number of techniques to reduce the combinatorial complexity of the computation. The algorithm outputs combinations of input criteria values that meet the given goal and differ as little as possible from the starting values.

As a result of Target Analysis, Fig. 4 shows the necessary changes to improve the CERTIFICATE evaluation from "unacceptable" to "acceptable": both *Management commitment* and *Recognition of opportunities* have to be improved from "no" to "partly". This would result in the improvement of *Management* (from "no" to "partly"), POTENTIAL FOR SUCCESS (from "unacc" to "acc"), and BASICS (from "unacc" to "good"). Since the criteria *Management commitment* and *Recognition of opportunities* are not really hard to achieve and in principle require only better focus on mobility at the employer's side, this analysis indicates that JSI can relatively easily mitigate the current issues and become an eligible candidate for the certificate.

The mobility structure of JSI employees depends on the location of facilities:

A. *Headquarters and main facilities*, located in a densely populated city area with very limited car parking space. Here, the prevailing mode of transportation is cycling (about 40 %), followed by car (20 % alone and 10 % with family members). Walking and using buses account for about 10 % each, while other modes are negligible.
B. *Reactor Centre*, located approximately 10 km out of the main city area. Here, almost 60 % of employees use cars, about 25 % public transportation and about 15 % bikes.

The analysis of mobility potential revealed that the potential has already been almost fully exploited at both locations, but for different reasons. The limited car parking space on Location A has already forced employees to explore and actually use alternative modes of transportation. While Location B has abundant car parking space, restricting car use would still contribute to sustainable mobility. However, considering the distance from the city centre, which essentially excludes walking and cycling, and infrequent public bus services, it is unrealistic to expect changes of employees' mobility habits without substantial investments in infrastructure and public transportation.

In summary, JSI has a very good potential for obtaining the certificate, subject to improvements that should specifically address the organizational aspects: assigning a sustainable mobility manager, explicitly formulating vision and goals, and, subsequently, monitoring and assessing the effects of activities. Regarding specific actions, only minor improvements of walking pathways and city bike stations might be beneficial. Considering almost fully exploited mobility potential, substantial changes of mobility habits of employees are not expected nor feasible in the near future.

8. Conclusions

We have presented the SmartMOVE certificate, a new mechanism proposed for awarding and encouraging organisations for taking care of sustainable mobility of their employees. This includes a continuous monitoring of employees' travel habits and mobility structure, planning and implementing relevant activities, monitoring and evaluating their effects and impacts, possibly achieving and maintaining a good sustainable mobility standard. The proposed certification framework consists of three elements: (1) preliminary self-evaluation questionnaire for employers, (2) a qualitative multi-criteria DEX model for general

assessment of mobility in an organisation, and (3) assessment of travel habits and mobility potential of employees. The latter two were addressed in this paper. The main novel contributions of this work consist of (a) the proposal and overall design of the certification framework, and (b) the multi-criteria DEX model.

In its current form, the model consists of 50 basic (input) and 31 aggregate (result) criteria. The final assessment, which determines the eligibility of the company to receive the certificate, is located at the very top of the model (called CERTIFICATE). Important aspects of evaluation are also obtained at the first and second levels of the hierarchical model and effectively explain the reasons for the final assessment. The model also facilitates experimentation and can answer the important question: what the organisation needs to change to enhance the evaluation outcomes in subsequent assessments?

The component that assesses employees' mobility structure and potential (Section 6) was designed to be as simple and as efficient as possible – particularly in contrast with mobility plans, which go deeper, but require substantially more resources. Consequently, the approach does not (and cannot) consider all peculiarities due to geographical and other circumstances of an organisation. For instance, the component does not consider altitude differences that may affect cycling. Furthermore, public transportation has been deliberately excluded from consideration, because it would require additional studies in collaboration with public transportation providers. In order to improve the robustness of the model, we included both objective and subjective potential. A substantial difference between the two may indicate issues not detected when assessed independently. For instance, any barriers hindering cyclists to easily reach their destination would very likely yield different outcomes in objective and subjective assessments, and a trained auditor should be able to investigate these inconsistent situations and find the underlying causes.

So far, the approach has been tested on a sample of five organisations and the results are encouraging. The method is indeed operational and in all use cases we were able to obtain the necessary data relatively easily. This typically means conducting an online survey completed by a sample of employees, followed by two to three meetings with representatives of the organisation.

The proposed approach is not necessarily tied to the certificate, but may have a wider applicability. To the best to our knowledge, it is the most detailed assessment system focusing particularly on sustainable mobility of employees. Even if an organization does not apply for the certificate, it can very clearly recognize their positive achievements and challenges. Compared to the development of a mobility plan, the process is easier, faster and cheaper. Even though it cannot provide all the results we expect from a mobility plan (a detailed overview of the situation, a proposal for specific measures and activities, investment planning), it is nevertheless useful as an initial step.

From a wider perspective, this approach is a showcase of human-centric decision support for societal transition. Sustainable mobility and its management are human-centric because they place people and their well-being at the core of transportation systems - in the phase of the design, implementation and operation. The certification process is conducted in an interaction with employers and employees, aimed at identifying their needs and preferences, and making decisions towards achieving more sustainable, accessible and healthier mobility of employees. As such it not only serves as an assessment tool but also as an optimisation tool, which helps identifying the main gaps of each mobility option and simultaneously provides suggestions for improvement, both in terms of infrastructural (the so-called "hard measures") and management aspects ("soft measures"). In this way, it affects societal transitions by reshaping how people move, interact, and live within urban and rural environments, potentially impacting social behaviour, urban planning, and environmental policies.

In the future, we shall continue verifying the approach and improving it along the way. However, the main future concern is the establishment of the SmartMOVE Certificate as an approved and highly respected means for rewarding organisations that contribute to sustainable mobility. Achieving meaningful impact will inevitably require more than just a well-designed assessment approach; it also depends on a broad public recognition of the certificate and the provision of governmental support for those organisations that effectively manage the sustainable mobility of their employees.

CRediT authorship contribution statement

Marko Bohanec: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Davor Kontić:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Bernard Ženko:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Data curation, Conceptualization. **Martin Žnidaršič:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Conceptualization. **Karina Sirk:** Writing – review & editing, Writing – original draft, Validation, Resources, Investigation. **Rok Vodopivec:** Writing – review & editing, Writing – original draft, Validation, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. DEX Model Structure

Fig. 5 shows the complete structure of the DEX evaluation model together with scales. The numbers in brackets indicate criteria assessed through a questionnaire (in the given order) and in discussion involving the certification auditor and the organisation's management. Criteria values printed in red colour indicate conditions that disqualify the organisation from receiving the certificate.

Attribute	Scale
CERTIFICATE	unacc;acc;good;*exc*
BASICS	unacc;acc;good;*exc*
POTENTIAL FOR SUCCESS	unacc;acc;good;*exc*
Management	no;partly;*yes*
[1] Management commitment	no;partly;*yes*
[5] Management as role model	no;partly;*yes*
[2] Identification of shareholders	no;partly;*yes*
[3] Status and objectives	no;partly;*yes*
[4] Recognition of opportunities	no;partly;*yes*
[4a] on foot	no;bad;medium;*good*
[4b] cycling	no;bad;medium;*good*
[4c] public transport	no;bad;medium;*good*
ORGANIZATION	unacc;acc;good;*exc*
Management	no;partly;*yes*
[6] Sustainable mobility manager	no;partly;*yes*
[7] Making a strategy	no;partly;*yes*
[8] Sustainability for work needs	no;partly;*yes*
Research and experience	no;partly;*yes*
[9] Exchange of experience	no;partly;*yes*
[10] Research and consulting	no;partly;*yes*
[11] Adjustment of work	no;partly;*yes*
VISION AND GOALS	unacc;acc;good;*exc*
SITUATION AND SCENARIOS	unacc;acc;good;*exc*
[12] Knowledge of travel habits	no;partly;*yes*
[13] Analysis of the situation	no;partly;*yes*
[14] Discussion with stakeholders	no;partly;*yes*
VISION	unacc;acc;good;*exc*
[15] Existence of policy, strategy, plan	no;partly;*yes*
[15a] idea	no;*yes*
[15b] concept	no;*yes*
[15c] plan	no;*yes*
[15c] mobility plan	no;*yes*
[15d] demonstration	no;*yes*
[15e] execution	no;*yes*
[16] Long-term vision	no;partly;*yes*
PRIORITIES AND GOALS	unacc;acc;good;*exc*
[17] Determination of objectives	no;partly;*yes*
[18] Enabled progress monitoring	no;partly;*yes*
[19] Contribution to achieving the vision	no;partly;*yes*
MEASURES	unacc;acc;good;*exc*
GENERAL MEASURES	unacc;acc;good;*exc*
[20] Raising awareness & informing employees	no;partly;*yes*
[21] Traffic maps	no;partly;*yes*
[22] Premises	no;partly;*yes*
SPECIFIC MEASURES	unacc;acc;good;*exc*
Sustainable modes of transport	unacc;acc;good;*exc*
Walking	no;partly;*yes*
[23] Connecting the entrance to public areas	no;partly;*yes*
[24] Priority for pedestrians	no;partly;*yes*
Cycling	no;partly;*yes*
Access	no;partly;*yes*
[25] Access to the entrance	no;partly;*yes*
[26] Parking lots and stands	no;partly;*yes*
[27] Proximity	no;*yes*
[28] Measures against theft	no;*yes*
[29] Maintenance	no;*yes*
[30] Workplace bikes	no;*yes*
Awards and discounts	no;*yes*
[31] Awards for cycling	no;*yes*
[32] Discounts for employees	no;*yes*
Public transportation	no;partly;*yes*
[33] Access	no;partly;*yes*
[34] Transferable ticket	no;*yes*
[35] Notification-information	no;partly;*yes*
Motorised vehicles	no;partly;*yes*
[36] Sharing incentives	no;*yes*
Restrictions	no;partly;*yes*
[37] Restriction of parking	no;*yes*
[38] Paid access	no;*yes*
[40] Reduction num. company cars	no;*yes*
[39] Changes of purpose	no;*yes*
[41] Cancellation of benefits	no;*yes*
Measures for customers	unacc;acc;good;*exc*
Customers and visitors	no;partly;*yes*
[42] Bicycle parking spaces for guests	no;*yes*
[43] Motivational mobility program	no;*yes*
[44] Bicycle service for customers	no;*yes*
Accessibility for all	no;partly;*yes*
[45] Information for the disabled	no;partly;*yes*
ACTING AND MONITORING	unacc;acc;good;*exc*
SPATIAL PLANNING	no;partly;*yes*
[46] Planning for permanent. mobility	no;partly;*yes*
RESPONSIBILITY AND FINANCING	no;partly;*yes*
[47] Action plan	no;partly;*yes*
[48] Activities/implementation plans	no;partly;*yes*
MONITORING AND EVALUATION	no;partly;*yes*
[49] Regular monitoring and auditing	no;partly;*yes*
[50] Data collection, monitoring, evaluation plan	no;partly;*yes*

Fig. 5. Full DEX model structure with associated value scales.

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