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Article

An Integrated Assessment Method for Sustainable Transport System Planning in a Middle Sized German City

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Abstract: Despite climate change mitigation and sustainability agendas, road transport systems in Germany and the resulting environmental burden are growing. Road transport is a significant source of emissions in urban areas and the infrastructure has a significant impact on the urban form. Nevertheless, mobility is a fundamental requirement for the satisfaction of the human desire to socially and economically engage in society. Considering these realities and the desire for sustainable development in a growing city (Potsdam, Germany), an integrated assessment methodology was co-developed among scientists and practitioners to prioritize a suite of transport-related measures. The methodology reflects the city's qualitative and quantitative goals to improve public transport and promote sustainability, capturing synergies in categories that include environmental considerations as well as road safety, eco-mobility, and quality of life. This approach applies a multi-criteria analysis (MCA) to derive a practically relevant solution for the local traffic and mobility problems that fosters ownership and accountability of all involved. This paper reflects on the process of developing the MCA, and the different aspects that were found important and required consideration during the process. Recommendations on specific traffic-related measures and the assessment of their effectiveness are not given. The aim is that such process information could foster greater collaboration within city departments and similar transdisciplinary efforts.

Keywords: sustainable urban transport; air quality; climate; integrated assessment; multi-criteria analysis; transdisciplinary

1. Introduction

Cityscapes are shaped by road transport infrastructure which is often the single most important element of urban infrastructure [1,2]. Road infrastructure, along with non-road public transport infrastructure, guarantees mobility, and is therefore considered vital for business as well as for quality of life for the individual citizen. Accessibility and mobility are fundamental requirements for the satisfaction of the human desire to socially and economically engage in society [3,4]. Public transport and vehicles, specifically personal vehicles, constitute a significant fraction of personal mobility in Germany—61% of trips were by passenger car in 2002 [5]—and is simultaneously the cause of air and noise pollution and greenhouse gas emissions, as well as the disturbance of habitable spaces and accidental death and injuries. Personal mobility that requires fossil fuel use is often perceived to facilitate an enriched life, but simultaneous adverse effects of road traffic reduce quality of life [6]. Therefore, in order to provide high quality of life in urban areas it is necessary to reduce the negative effects of road traffic while optimizing a variety of mobility options for citizens [3].

Currently, in Germany, road transport infrastructure is becoming denser and the environmental burden is increasing [7]. Car traffic in particular is a significant emission source for nitrogen oxides (NO_x) and particulate matter (PM) in Europe and Germany [8]. These air pollutants have detrimental effects on human health leading to cardiovascular, as well as respiratory diseases [9,10]. European citizens may legally demand air quality action plans in case of actual or potential exceedances of legal air quality limit values such as for NO_x and PM10 (PM with an aerodynamic diameter smaller than 10 µm). This has led to the introduction of so-called low emission zones (German: “Umweltzonen”) in several German cities such as Berlin or Munich [11]. The aforementioned air pollutant and greenhouse gas emissions from road traffic are also responsible for long- and short-lived climate-forcing pollutants that contribute to climate change. Transportation is one of the main challenges for sustainable development as it is mainly dependent on fossil fuel and accounts for a large fraction of energy use, *i.e.*, 25% globally and 30% in EU countries [12]. Altogether car trips are responsible for 46% of the climate impact from German travel activities. Urban trips constitute more than 90% of all trips and make up 22% of the overall traffic climate impact [13].

Developing sustainable city transport, *i.e.*, improving accessibility, minimizing travel times and providing equal mobility options to all while reducing environmental impacts has become a key challenge and priority in urban transport planning [2,14]. Sustainable transport is a complex cross-sectoral topic that links the obligation for legal compliance with air quality and noise standards with a city’s vision for green development and climate strategies, attractiveness, citizens’ satisfaction, and tight city budgets. City authorities are well aware of these challenges and have come up with portfolios of general, as well as locally specific solutions for sustainable transport systems [4,15–17]. Generally, such portfolios include infrastructure projects, car and/or bike sharing initiatives, public relations campaigns to encourage the use of public transport or bikes, and other sustainability-fostering efforts. Such strategic measures combined with those required for legal compliance often create long lists of measures that cannot all be put into practice due to budgetary limitations. In addition, such lists are often opaque in the sense that overlaps, counterproductive measures, or synergies are hardly visible, often owing to the many different departments involved in their planning and implementation.

To structure and prioritize such lists for a sustainable city mobility system that reduces environmental impacts, ensures mobility, makes living in the city attractive, and is financially viable, detailed and diverse information needs to be organized and assessed. Multi-criteria analysis (MCA) or multi-criteria decision making (MCDM) is a type of tool that allows decision makers to go beyond single-criterion approaches that often fall short in environmental and urban planning challenges and to include a wide range of criteria. Multi-criteria techniques have been widely applied to environmental issues e.g., [18] and to urban transport planning where environmental criteria are important, but where additional attributes also play a crucial role. The respective scientific literature from the last three decades comprises over 400 research papers, a review of MCA application in the transport sector can be found in Camargo Perez *et al.* [2]. Many of the studies apply combinations of established MCAs or develop their own purpose specific methods. One example for a purpose tailored MCA is the Dutch Solve initiative focusing on the reduction of the environmental burden from city traffic emissions [19]. Here benefits and trade-offs with respect to several criteria are listed in a performance matrix for individual measures as a decision basis for local governments.

To successfully apply MCAs to urban transport challenges several types of knowledge need to be included. Practical knowledge is important for substantive and instrumental reasons to judge, for example, feasibility and local travel behavior as well as compliance with legal constraints. Scientific knowledge is necessary to estimate the effect on air pollutant concentrations, greenhouse gases emissions, and noise levels from measures. Additionally, next to political motivations normative considerations play a role when it comes to including e.g., social equity and acceptability in urban planning. Solving such a "real-world" optimization problem is ideally tackled with an approach that involves practitioners and scientists to co-design the solution options based on the different knowledge systems required. Although definitions vary in the inclusion of specific methods and components, such approaches are generally known as transdisciplinary research e.g., [20,21], see Section 2.2. A previous application of such an approach specifically to the transport sector is the sustainability oriented transdisciplinary scenario production for leisure traffic in the city of Basel, Switzerland [4].

In this work, we describe the process of developing a multi-criteria assessment jointly between scientists, practitioners, and decision makers for the planning of sustainable and more integrated measures in the passenger transport sector in Potsdam, Germany. The objective is to provide other cities and sectors with a development methodology and tool that they can customize to their specific needs. The integrated assessment approach includes environmental considerations (air pollutants, climate relevant emissions, and noise emissions) as well as considerations for road safety, eco-mobility (*i.e.*, usage of public transport, cycling, and walking), and quality of life. We further present and discuss the result from the application of this approach, as a way to describe more completely the process and method of prioritization of the measures. This serves the primary objective of making the analysis reproducible for other cities and sectors to factor in their specific constraints and values rather than recommending specific measures whose effectiveness might vary from location to location.

The integrated assessment approach developed in this study differs from most established MCAs. While most of the research on urban transport planning has focused on the strategic level and less on the tactical level [2], our method is targeted at the tactical level. This level is crucial to reconcile the various strategic plans for e.g., the environment, infrastructure and economic development of a city and the specific operational measures such as building new transport infrastructure. Bringing in line the diverse objectives from several levels, complying with current legislation and being prepared especially for future environmental legislation, and limited budgets is a common challenge cities are facing.

In addition, the objective of applying an MCA in the case of Potsdam was not to decide between several alternative measures but to prioritize measures in an existing suite of measures that all need to be implemented as part of various plans. This provides the decision makers with a simple tool to tactically redistribute financial resources to already planned efforts under budgetary constraints in line with a consolidated urban transport vision. To assure high acceptability the development of the method involves practitioners and scientists following the idea of transdisciplinary research. Main conclusions from this applied case study are that the joint development of the MCA between different city departments and between practitioners and scientists led to enhanced credibility and acceptability of the outcome and resulted in a change of the budget plan to facilitate the implementation of the planned measures.

2. Materials and Methods

2.1. Background and Problem Description

German cities have to comply with a wide range of regulations that are linked to road transport and other mobility options, and include, for example, monitoring of noise emissions and ambient air pollutant concentrations. Ambient noise and air pollution are both regulated through European guidelines that are translated into national regulations (Federal Ambient Pollution Control Act, BImSchG, ordinances BImSchV 16 for noise and 39 for air quality) that prescribe limit and target values as well as the formulation of action plans in case of exceedances.

Potsdam is a growing middle size German city of about 160,000 inhabitants, located south-west of Berlin. In 2013, the population had increased by approximately 21% compared to 1996. The number of privately owned cars increased by 27% in the same period [22]. The car is the preferred means of transportation for travel including errands (41% of all travel), work or education (35%) and leisure (31%). Citizens bike most often for leisure activities (30%) [23]. For errands and work/education cycling makes up roughly one quarter of all travel and is surpassed by the usage of public transport only for going to work/education (31%). According to survey results, people are most satisfied with the public transport system while they are less satisfied with the cycling infrastructure and least satisfied with driving and car parking options. Compared to average German urban travel behavior in 2008, Potsdam citizens use their cars less and rely more on public transport and cycling. Nevertheless, emissions from traffic contribute significantly to air pollution in Potsdam. 15%–25% of the annual average PM_{10} burden for 2008 and 2010, and >50% of NO_2 emissions originate from traffic [24]. In addition, noise pollution from traffic is so high in some locations that action is required by law [25].

Against this background, Potsdam aimed to improve the accessibility of all parts of the city, increase road safety, establish equal mobility opportunities, increase the attractiveness of the city center, and reduce the environmental and climatic burden resulting from transport. The city developed noise and air quality action plans, both of which recommend minimization of air and noise pollution beyond just achieving target values. In addition, Potsdam had developed a city development concept with a section dedicated specifically to mobility [26] as the guidance document for traffic development and future budget planning. Considering the growing population, thriving local economy and increasing traffic volume, the city development concept aimed to improve the citizens' mobility while simultaneously reducing the environmental burden caused by motorized private transport. Hence all planning and resources were directed towards strengthening public and non-motorized (walking and biking) transport to reduce motorized private transport from 32% to 23% by 2015 following their concept of sustainable mobility [26]. Furthermore, Potsdam developed a climate protection strategy [27] that included a special section on traffic and innovative mobility with an objective to transfer 10% of motorized private transport to public transport and biking by 2020.

Figure 1 illustrates the goals and strategies underlying Potsdam's objective to develop an "urban- and climate-friendly mobility for all in a livable city". The goals and strategies for this initiative were identified based on the above mentioned action plans as well as the mobility and climate strategies in advance of the integrated assessment initiative. To reach the overall goal, the city identified over 75 specific measures that were in the planning stage (pre-implementation) in 2013 relevant to the mobility sector. Some of these measures had multiple sub-measures that were directed at specific streets or areas within the city (only the general measure was assessed, the street-level applications of these measures were not explicitly included). The general categories for the measures were (A) public relations, (B) motorized private transport, (C) public transport, (D) walking, (E) biking, and (F) miscellaneous.

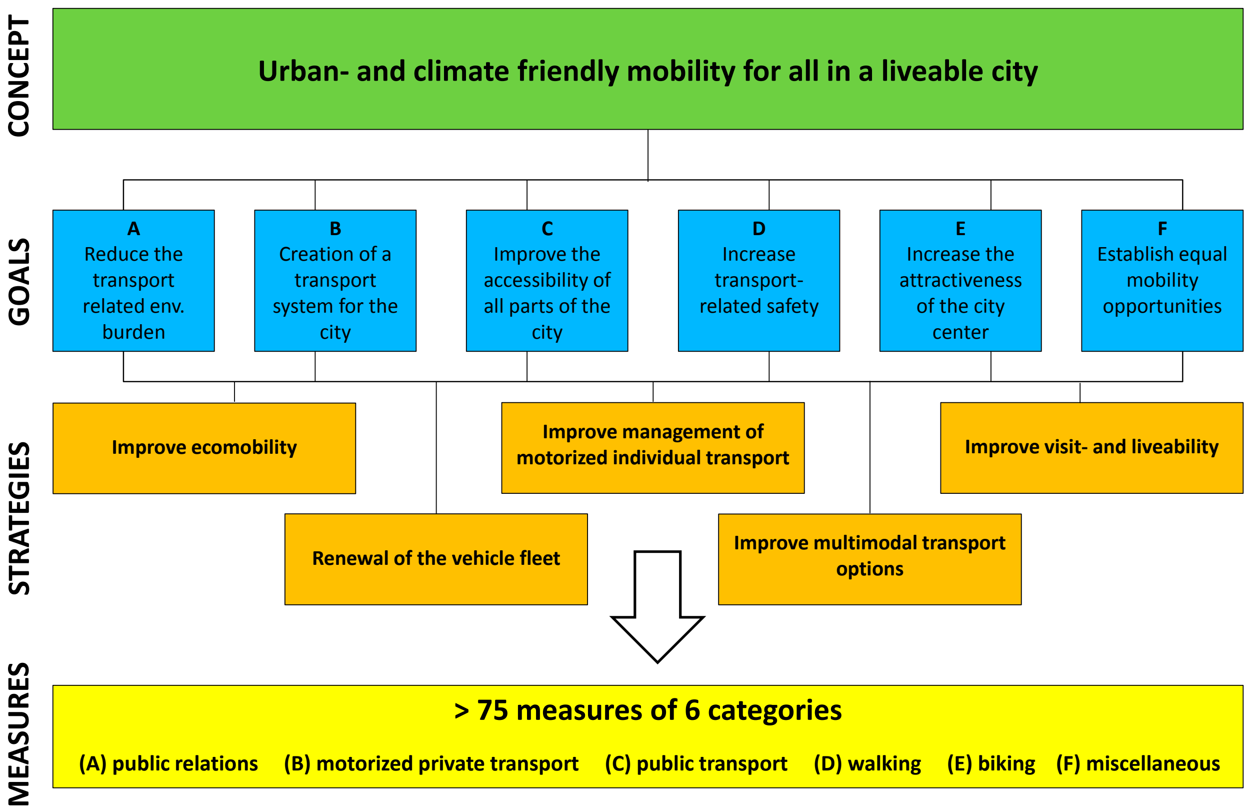

Figure 1. Potsdam's mobility concept including goals and strategies leading to specific implementation measures.

With such a large number of measures it was difficult to maintain an overview for the planning authorities, especially with regard to overlaps, counter-productivity and synergies of measures. Furthermore, a limited budget implied implementation of only a selected number of the measures. While similar situations applied to several other sectors, the city of Potsdam decided to use the transport sector as a pilot project to develop an integrated assessment approach for prioritizing their measures. This sector was chosen because of the large number of domains that it affects, such as air quality, climate change mitigation, quality of life, social equality, and economics. As with the origination of many of these measures in different planning initiatives, different city departments were responsible for their development and implementation, therefore coordination was necessary to determine the most synergistic measures, and plan for their coordinated implementation in any given location throughout the city.

2.2. Working Group Approach

The integrated assessment approach was developed and applied following a transdisciplinary (TD) research approach [21,28–31] and references therein within a one year time frame. We based our method on two key aspects. First, a practically relevant solution for a "real-world" problem had to be found requiring ownership and accountability on the side of the city's project working group. Second, multi-criteria decision analysis, an established instrument in TD research, was to be the basis for the integrated assessment approach.

In the first phase after Lang *et al.* [21] "problem framing and team building" (see Figure 2 stage A) a group leader was appointed from a mandate originating in the city's mayoral office, and a collaborative research team, the working group, was brought together consisting of roughly ten representatives from the various affected departments in the municipality's administration. In addition, one person each from the state province's environmental protection agency and the ministry for environment, as well as two natural scientists (two of the co-authors) joined the working group. The areas of expertise covered road traffic control, city and mobility development, traffic infrastructure, mobility management, air quality, climate change, and public relations.

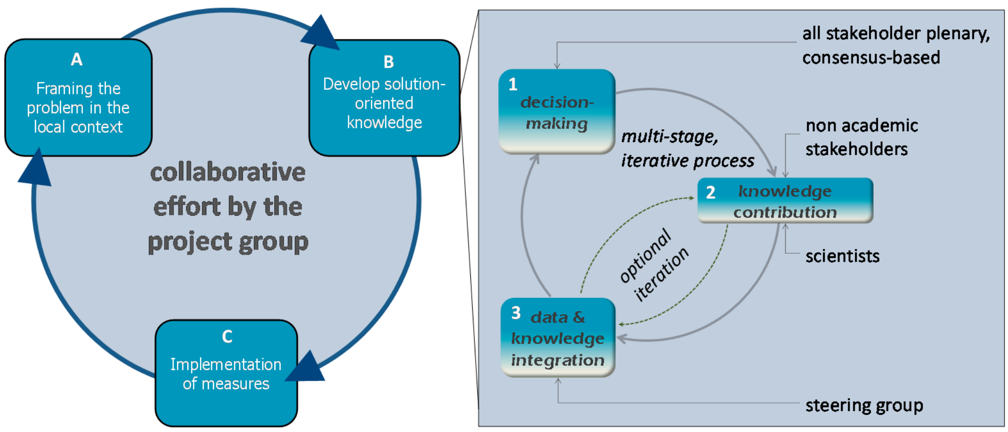

Figure 2. The iterative and multi-stage work cycle. Left: overall cycle. (Step C. Implementation of measures, is represented in the cycle but was in process and has not been completed at the time of the article and therefore not discussed here.) Right: the process applied in this study for the development of solution-oriented knowledge (step B) of the overall cycle.

The problem was collaboratively framed by the group and the to-be-developed integrated assessment approach was identified as the boundary object between science and practice that was both researchable and allowed for implementation in the city's planning process as well as in the scientific body of knowledge [32].

2.3. Development of the Integrated Assessment Approach and Its Application

2.3.1. Co-Development

In the second phase after Lang *et al.* [21] "co-creation of solution oriented transferable knowledge", the purpose-tailored integrated assessment approach was co-developed by all working group members integrating the different available knowledge systems. The iterative and multi-stage process is illustrated in Figure 2. Generally, all decisions were made in the plenary of the working group based on consensus (see box "decision-making" in Figure 2). At each stage of the project, the working group decided on or approved of the next steps. All participants were tasked to gather relevant information and/or conduct targeted research (see box "knowledge contribution") and report this to the steering group consisting of the group leader and the two scientists. The steering group integrated the reported information and knowledge to provide an overview in the following plenary session (see box "data and knowledge integration") for subsequent discussion and revision (box "decision-making"). In cases where information was missing or not understandable and further discussion was not a sufficient solution, the knowledge contribution process was repeated before subsequent plenary working group meetings (dotted arrows). Steering group meetings were twice a month, meetings with the whole working group were monthly. This facilitated continuous engagement and built trust. The process was executed four times for the initial problem definition, the creation of the integrated assessment approach, the evaluation of the results, and final prioritization of measures.

More specifically, for the development of the integrated assessment approach several types of knowledge were required. Scientific knowledge was necessary for information regarding emission changes triggered by the potential implementation of measures as well as their effects on air quality and climate. City-specific systems knowledge was necessary for judgments regarding the interplay between the transport infrastructure and citizens. Much of this was based on results from surveys conducted every five years by the city and long-term experience, such as the likelihood of public acceptance and citizens' behavioral changes due to measures (e.g., what type of cycling lane would be preferred, physically separate from the road or just visible distinction on the same pavement). Furthermore, knowledge of legal constraints or requirements as well as information on current public debates and sensitive issues that might have grown historically was also important.

2.3.2. Design of the Integrated Assessment Approach

Instead of applying an existing MCA method, the group decided to develop a simple, compensatory but purpose-specific MCA technique owing to several factors. Most important for this decision was the given task to deliver a priority list of measures within one year. This type of desired outcome differs from most MCA applications where a decision between a number of alternatives is required. Here, measures did not represent alternatives but a suite of efforts that need to be implemented over time.

Hence, priorities under budget limitations needed to be established. In addition, the number of measures (>75) and their different primary targets were not useful for a pairwise comparison procedure as performed in the most commonly applied MCAs in the urban transport sector, *i.e.*, Analytical Hierarchy Process or Technique for the Order of Prioritization by Similarity to Ideal Solution [2]. Important for the decision was also the type of available data which was very heterogeneous in the sense that the performance of some measures for some criteria could be quantified while scores for criteria such as "quality of life" would be based on qualitative assumptions.

A performance matrix was created where each measure was represented by one row and each criterion by one column. The criteria or assessment categories were determined by the working group based on the above described regulatory demands and city strategies, and recommendations by the German Advisory Council on the Environment and examples from the literature [3,33]. Each measure was evaluated based on its effects in the six criteria categories: air quality, climate change, noise, road safety, eco-mobility, and quality of life.

For the evaluation, the working group chose to assign a score ranging from −3 to +3 for each measure in each category, representing adequately the range of impacts over all measures. A score of −3 would mean strong adverse effects in the category, while 0 would indicate no effect and +3 a strongly beneficial effect. Evaluation metrics for each category are listed in Table 1. The measures excluded the street-specific sub-measures as the level of detail included in the assessment would not have been able to distinguish specific street-level effects.

Often economic considerations constitute a typical additional criterion. In this case, however, the working group deduced the criteria based on the city's mobility policy aims where economic effects were not a high priority. In addition, the results were intended to reflect the six criteria first and foremost (in an idealized way), without constraining the prioritization with the financial cost of implementing the measures, which could have biased the selection based on cost. Economic criteria were applied in the later implementation phase when the proposal was discussed as part of the city administration budget planning (see also Section 2.4). The prioritization of measures was reflected in changes to the budget, whereby finances were reallocated so that the highest priority measures were to be realized in the middle- to near-term.

Table 1. Guiding questions for the application of the integrated assessment approach.

Category	Guiding Questions	Comment	Indicator
Climate	How does this measure change the emissions of greenhouse gases? How relevant is this for Potsdam as a whole?	Focus on local instead of global context since otherwise Potsdam's contributions to emission reductions would be negligible.	estimated change in emissions of CO_2
Air Quality	How does this measure change the emissions of air pollutants? How significant is the contribution of this measure to comply with air quality standards?	Special focus on hot spot areas in the city where currently limit values are exceeded.	ambient concentrations
Noise	How does this measure change the noise burden during the day and at night? How relevant is this measure for the specific location where it might be implemented?	Noise is very local, hence a local focus for this question.	estimated change in noise pollution
Safety	How does this measure contribute to increased safety? How much safer would citizens feels if this measure were implemented?	Taking into account objective facts and subjective perceptions.	estimated change in the number of accidents and change in perception
Increased usage of public transport/walking/biking	How does this measure support the increased usage of public transportation and reduce the volume of motorized private transport? How does this measure influence citizens' decisions regarding mobility options?	Measures exert an influence on the usage of public transport not only if, but also how, they are implemented.	estimated change in the modal-split numbers
Quality of life	How does this measure influence the well-being of citizens given they appreciate a climate-friendly and livable city? How does this measure increase citizens' satisfaction through the available choices of mobility?	Targeted at well-being in general and specifically with respect to sustainable and environmentally friendly, yet convenient, mobility options.	none

2.3.3. Application

In the third phase "(re-)integration and application of integrated knowledge" [21], the integrated assessment approach was applied in a one-day workshop. Three breakout groups, joined by additional experts from the city, were formed, each group representing the broadest possible knowledge base. Each breakout group worked independently and in parallel to evaluate each measure based on the information described above and on consensus during the one-day workshop. All measures were known to all participants in detail as the participants were partly responsible for their creation and all measures had been discussed in a previous working group meeting. To assure that each individual and each group was evaluating the measures from the same contextual reference point, especially regarding the category for quality of life, guiding questions were formulated (see Table 1). This methodology allowed for the integrated consideration of analytical judgment for data and knowledge based effect estimations, as well as intuitive judgment for effects where no data or experience existed and incorporation of desirability of certain measures. The analytical mode is effortful, slow and rule-guided while the intuitive mode is fast and associative, and both modes are activated for uncertain judgment tasks [34,35].

2.4. Data Analysis and Prioritization

The measures with the largest discrepancies in evaluated efficacy between the three breakout groups were double checked and revised if the different scores were due to misunderstandings regarding the nature of the measure (there were 2 cases of this). Subsequently, the total of 1440 scores was statistically analyzed by the scientists and presented and discussed with the working group. Scores for each measure were simply averaged over the three breakout group results for each assessment category, to obtain an average score per assessment category and measure. The standard deviation of this average was used to check for large discrepancies in the evaluation of specific measures. Further discussion, plausibility checks, and decisions on weighting were carried out within the whole working group taking into account the strategic plans, infrastructure development concepts, legal obligations, and the vision to become a climate-friendly and livable city with good mobility options. To establish the final priority list the working group decided to attribute a threefold weight, and thereby greater priority, to the categories air quality and noise because of the associated legal obligations. Climate, safety and eco-mobility were given double weight because they were considered crucial to Potsdam's strategies for a climate-friendly and livable city. Quality of life was counted only once since this category was assumed to be most prone to highly subjective judgments, despite the guiding questions associated with each category (see Table 1). This method will be referred to as the "weighting method" from now on. Threefold and twofold weight means that the score in these categories was multiplied by three and two, respectively (see also Table 2).

Before final prioritization, the results following from this weighting were compared to the results following a method where measures were ranked based on maximized synergies ("synergies method"). A synergistic measure in this context meant that the measure contributed with high scores in several criteria to the overall objective of developing sustainable urban traffic. To identify highly synergistic measures, the measures were ranked within each of the six categories. Then it was counted how often a measure appeared within the top 10 measures for each category. The same procedure was applied to the bottom ten measures in each category.

Table 2. Weighting factors per category.

Category	Weight Assigned
Climate	2
Air Quality	3
Noise	3
(Traffic) Safety	2
Eco-mobility	2
Quality of Life	1

Additional assessment categories like implementation costs, time commitment by city staff, and planning horizons were disregarded for the prioritization step to stay as close as possible to the environmental and social ideal. This avoided higher ranking for low-cost and quick measures that may be less effective otherwise. These factors were considered at a later point in the process focused on implementation. The implementation process, which is far more economically and politically influenced is beyond the scope of this paper.

3. Results

The continuous engagement of all working group members in the four different stages of the process resulted in tight collaboration across several city departments including urban planning and traffic, environment and nature, climate change, safety, green spaces, society and health and public relations together with representatives from the state environment agency, the state ministry for environment and two scientists. The group was able to take all decisions based on consensus and developed a purpose-tailored multi-criteria assessment including the choice of criteria and their weighting factors thereby integrating various kinds of expertise and knowledge into the process. Within one year the working group evaluated all traffic-related measures based on six criteria (air quality, climate, noise, road safety, eco-mobility and quality of life) and created a priority list. This list was presented in the budget determining city assembly where sufficient means were allocated to the measures to be implemented in the following two budgetary periods. In the following, results from the application of the integrated assessment method are described. The results are described so that the process of evaluation and challenges in the process can be discussed, while crystalizing the practical application of the methodology presented. The results are not intended to recommend the implementation of any particular measures, but reflect upon how certain types of measures were evaluated and received the kinds of scores they did, and how context can affect such criteria analyses.

3.1. General Assessment of All Measures

The unweighted results from the integrated assessment approach are presented here first. The development of a park and ride system, falling in (B) motorized private transport measures, was among the most positively rated measures in all assessment categories. This is owing to the assumption that the system would also be combined with other factors (such as highly restricted parking in the town center) so that people would be required to use the park and ride system. Hence, it would reduce the motorized private transport, especially in the city center, while simultaneously increasing the usage of public transportation and thereby reducing overall emissions. Mobility management, part of (A) public relations measures, for the establishment of a city mobility agency promoting the alternatives to car usage, received high scores likely due to the projected positive effects on the mobility choices informed citizens would make.

Measures from the (D) walking sector appeared among the highest and lowest scores as they received many points related to safety and quality of life but in all other categories often 0 points. Measures from the (E) biking sector were assessed only moderately positive and the specific measure for timing traffic lights for bike traffic was ranked last due to producing greater stop and go traffic for cars and the associated higher emissions of pollutants, greenhouse gases, and noise. Generally, the measures received higher ratings in the categories quality of life, noise, and safety than in the categories public transportation, air quality, and climate. These points will be discussed further in Sections 4.2 and 5.

Figure 3 shows the percent of measures that were ranked positive, neutral, and negative in each of the 6 assessment categories. Few measures were ranked negative. Those that did receive negative scores were generally related to a prioritization of driving resulting in decreased usage of public transportation and higher emissions. This general positivity of the rankings however, was not an unexpected result given that the measures originated as part of the air quality or noise plans, or the climate concept document, which were created to reduce emissions and/or consider longer-term sustainability. The highest number of neutral scores was assigned to the climate category because many of the measures were estimated to have very little potential or only incremental effect for greenhouse gas emission reductions.

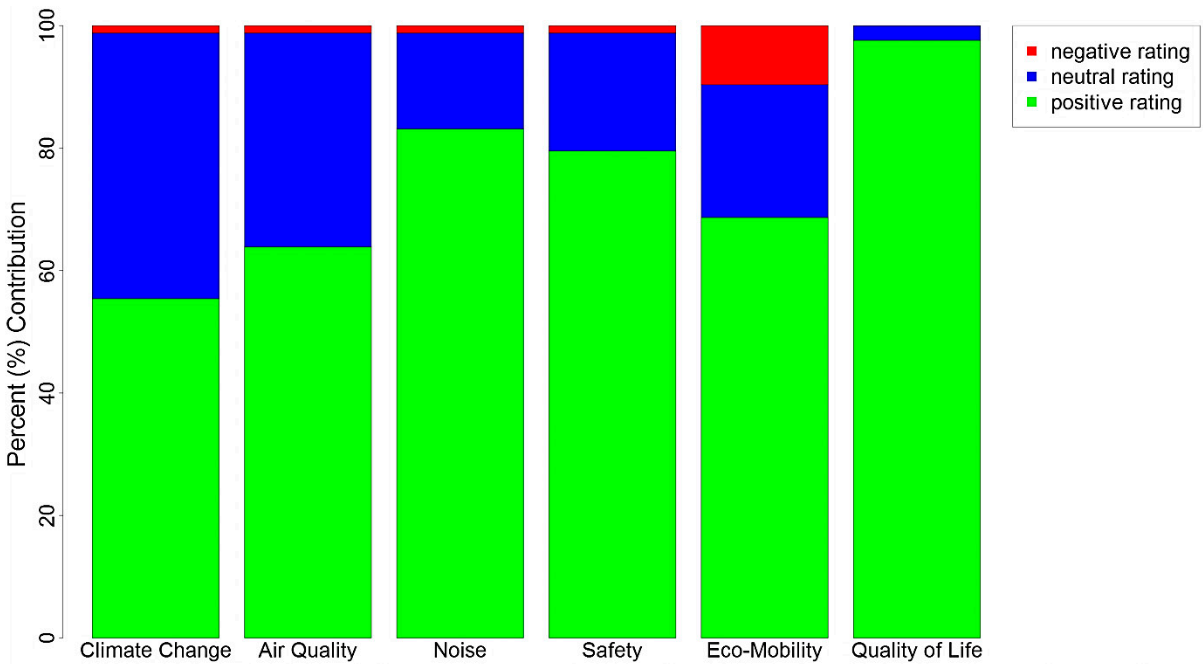

Figure 3. Fraction of positive, neutral and negative scores in each assessment category.

3.2. Ranking of Categories as Function of Sector Category

Figure 4 shows the average score of all measures per sector (A-F) for the 6 different assessment categories. Walking measures (D) were ranked significantly lower than all other sectors for climate, air quality, and noise because no significant change in the number of people choosing the option to walk is expected since this is only a suitable alternative for short distances and hence emissions reductions are minimal. Safety and quality of life, however, were rated highest for walking. The biking measures (E) were ranked second lowest in the emissions categories for similar reasons. However, measures related to electrical bikes received higher scores as more people, and a greater diversity of people, are expected to use them in the future, meaning that in addition to people who already cycle others will use this mode of transport e.g., [36], which is reflected in the high score in category 5, eco-mobility. Park and ride measures were considered part of the (B) motorized private transport sector, despite their being more related to the enhancement of public transport. These measures specifically received relatively high scores in all categories. In order to better understand the influence this had on the rating of the sectors, the park and ride measures were moved to sector (C), see grey columns, and the results compared. A more positive evaluation of sector (C) public transport was the result, including the highest score in category 5 (eco-mobility).

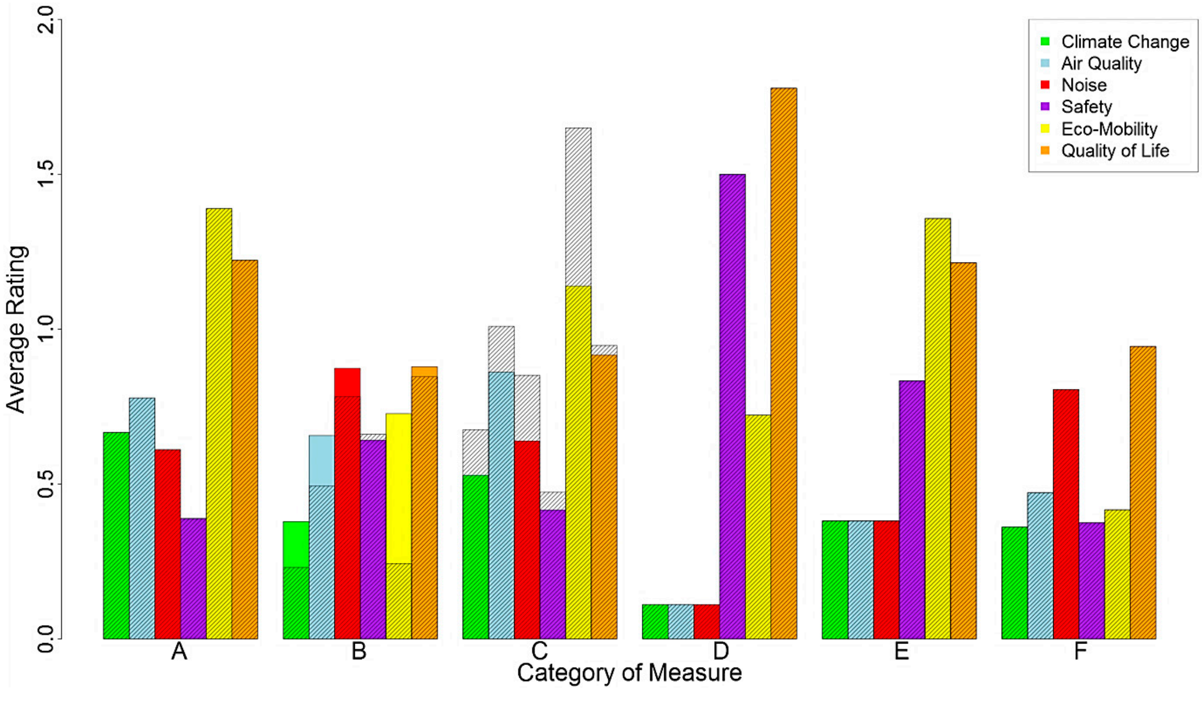

Figure 4. Average rating of all sectors of measures in all impact categories. The gray bars indicate what the results would look like if the park + ride measures were moved from category (B) to (C), as explained in Section 4.2.

3.3. Final Priority List

The final priority list was created as described in Section 2.4 using the weighting method based on legal requirements and the city's priorities. It was divided into 4 groups between the 25th, 50th, 75th percentiles labeled "very high", "high," "medium" and "low" priority groups. Due to the uncertainties inherent in the scoring process it was decided not to rank the measures within the priority groups. An overview version of the final list is given in Table 3 with the generic titles of the types of measures, the original list is included in the Appendix (in German). This means that the generic titles can appear in all priority groups, however representing different specific measures (the complete list of measures can only be made available by the city of Potsdam itself). To give an example of these translations, one measure was an "expansion of the streetcar route from (city location a) to (city location b) through construction of the necessary infrastructure". This measure would fall under category (C) public transport and is reported in Table 2 as "public transport infrastructure", as the actual location information/street names in Potsdam are not relevant to this discussion. This example also illustrates why the generic translation of such a measure might appear in more than one category, since such extensions of transport routes might have greater or lesser impact depending on the amount of the population reached, other public transport options already in place, *etc*.

Table 3. Overview of generic measures in the final priority list.

Generic Measure Type	Number of Specific Measures of the Generic Type Included in the Priority Group	Category of Measure
group 1 (very high priority)		
connecting public transport options with cycling and motorized traffic	5	C
public transport infrastructure	3	C
cycling infrastructure	2	E
parking	2	B
mobility management	1	many
integrated urban development	1	F
new or re-construction of street sections	1	B
group 2 (high priority)		
pedestrian friendly city	2	D
new or re-construction of street sections	2	B
new mobility options	2	C
service around cycling	1	E
parking	1	B
speed limits	1	B
public relations work	1	A
emission reduction for vehicles	1	B
connecting public transport options with cycling and motorized traffic	1	C
mobility management	1	many
higher quality of public transport	1	C
group 3 (medium priority)		
renewed street surfaces	3	B
new or re-construction of street sections	3	B
public transport infrastructure	2	C
noise protection	2	F

Table 3. *Cont.*

Generic Measure Type	Number of Specific Measures of the Generic Type Included in the Priority Group	Category of Measure
cycling infrastructure	1	E
emission reduction for vehicles	1	B
traffic management	1	B
speed limits	1	B
new mobility options	1	C
group 4 (low priority)		
new or re-construction of street sections	3	B
parking	3	B
higher quality of public transport	2	C
traffic management	2	B
cycling infrastructure	2	E
public relations work	1	A
emission reduction for vehicles	1	B
connecting public transport options with cycling and motorized traffic	1	C
speed limits	1	B
retro-fitting buses	1	C
service around cycling	1	E
renewed street surfaces	1	B

The very high priority group included extension of park and ride facilities (connecting public transport with cycling and motorized traffic), enhancement of infrastructure for public transport and cycling, managing parking spaces in the city (to discourage driving) as well as the creation of a mobility agency. The high priority group included measures regarding traffic regulation through construction, car-sharing and further infrastructure development for walking and cycling. These were followed by more technical measures such as installation of noise reduction walls in the medium priority group. Lastly, rather specific and geographically limited measures tended to fall in the low priority group.

To double check this weighted result for any biases it was compared to the ranking based on highest synergies (see Section 2.4). Briefly, 9 measures among the top priorities in the final list were also among the 13 most positive synergistic measures. The most synergistic measures were the extension/creation of park and ride facilities as well as the creation of a mobility agency. Based on the good agreement between the two ranking methods the list derived from the weighting method was declared final.

4. Discussion

In the following section, we discuss several aspects that are important to consider for practitioners and researchers when developing and applying similar approaches. This includes more general reflections on the transdisciplinary working group and the co-developed integrated assessment methods themselves in the context of city administrations, as well as specific reflections on the role of problem framing and decision-making-given uncertain and heterogeneous data and dynamics of evaluations in breakout groups for the final results.

4.1. Working Group Approach

This project was characterized by a top-down mandate and a clear objective born out of a specific need by the city of Potsdam to spend a limited amount of money on measures with the highest impacts for sustainability-fostering approaches within the mobility sector. The basis on which the working group operated were exclusively measures from concepts that were agreed upon by the city council beforehand, and the evaluation criteria were based on these concepts. The process of creating these concepts includes extensive involvement of citizens and interest groups through public discussion events, publishing of documents and request of comments among others. In addition, a political discussion and decision process needs to take place. Therefore, no specific external stakeholder consultation was included as a part of the working group process. The mandate of the working group focused on the evaluation and decision making process to facilitate the redistribution of financial resources to already planned efforts under budgetary constraints. In addition, there were few resources for supporting e.g., data collection or scientific modeling, for an estimation of the measures' impacts where information was not already available. Even though this situation added difficulties to make the creation of a priority list difficult, this challenge was met by applying a transdisciplinary research approach including different knowledge bases.

To ensure a more scientific grounding of the process and the solution relative to what would have been developed in case of an only internal Potsdam municipality initiative, they invited two scientists to co-design the assessment method and prioritize the measures with them. This led to greater willingness to engage as well as the acceptance among working group members to be held accountable for the results. This was due to the simple fact that they had the control over all decisions, which were consensus based, and the process was backed up by scientific input. The integrated assessment approach served to create the priority list of measures according to which the city's transport-related budget will be spent within the next six years to fulfill the vision of a climate friendly and livable city. In addition, the development of the integrated assessment approach triggered further scientific research regarding the question of how to provide decision-support for considerations of cross-sectoral impacts in strategic urban infrastructure planning (beyond the mobility sector). Urban infrastructure is crucial to the development of a future sustainable city transport and hence emissions because it will determine resource consumption and emissions of sectors such as transport, energy supply, or buildings for decades to come. Often data and knowledge of the linkages and interactions between, for example, air pollution, local city climate, global climate, green spaces and lifestyle development are not available at local levels while simulations are run at larger scales, regional or global [37].

A crucial aspect specific to this working group was the need for consensus for each intermediate decision as basis for a next step in the process. In situations where the group leader and/or the scientists proposed to move forward but not everyone in the working group had understood the details of the decision, there was pushback and this particular item was reiterated until everyone agreed with the intermediate result. These consensus points guaranteed ownership for all working group members during all phases of the project. While several iterations sometimes prolonged the process, at the same time, they offered opportunities for a more thorough joint learning process resulting in enhanced capacity for sustainable traffic-infrastructure planning within the working group especially with respect to considering the linked effects within the six assessment categories.

4.2. The Integrated Assessment Approach

The development of a multi-criteria assessment technique tailored to the needs of the city of Potsdam had several benefits. Generally, the version of MCA used here had many advantages over the previous decision-making process typically applied by the city, which employed more informal judgments.

The new approach was open and explicit and the choice of criteria and weighting factors were open to analysis and changes if they were perceived as inappropriate. In addition, the scores attributed to each measure in the evaluation were traceable. This allowed for transparency and communication of the outcome to both the wider public as well as political assemblies deciding on budget allocation. The latter was especially important in this case, as the primary purpose of the priority list was to assure financial means for implementation in the coming years, which was achieved. More specifically, the here developed technique allowed for straightforward integration of the criteria deduced from the various environmental and strategic plans of the city for a sustainable mobility system into the assessment method. The method accounted for the heterogeneous data and the uncertainties associated to them and was simple enough for application in a one day workshop to over 75 different measures. The time commitment required for such an approach is important to consider for assessing feasibility. Finally, this simple technique can be transferred to the specific needs of other complex sectors, such as energy supply or the built environment.

4.3. Impact of the Overall Framing

The focus of the integrated assessment approach was the motorized traffic sector, which is the main cause for many of the challenges that cities face regarding air quality, noise pollution, climate change, safety, eco-mobility and quality of life. This framing has led to an overall bias towards action in the motorized private transport sector. However measures from other sectors can also influence these challenges as well as personal decisions about mobility, but those were beyond the scope of this initiative and will be addressed in a later phase of the three year overall project. In some cases the focus on motorized private transport resulted in highly scored action in the eco-mobility sector to counter-act it. However, improved conditions for pedestrian or bike traffic in cases where they were not considered an alternative to motorized private transport received lower priorities even though such measures could improve the overall sustainability of urban mobility. This is visible in the overall evaluation of sectors (D) walking, (E) biking, and (F) miscellaneous (compare Figure 4). For example, this was the case when measures were concerned with covering long distances. In addition, the narrow formulation of the task to produce a priority list of the measures did not include the possibility of creative thinking outside of this framing to come up with alternative solutions.

Furthermore, while for most of the six assessment categories the definition was clear for the Potsdam specific circumstances based on the guiding questions created for the assessment, the framing of the category “climate” was less useful for the decision-makers in the working group. Even though the change in greenhouse gas emissions in relation to the emissions in Potsdam as a whole was considered, climate impacts of all measures were generally evaluated to have minimal effects, with little variation between the different measures. This has likely led in some cases to an underestimation of the potential reduction in GHGs specifically regarding improvements in the public transport sector such as emissions reduction for buses compared with e.g., connecting two bike routes. A different framing supporting higher differentiation between the effects of various efforts might have led to different ratings in the climate category. Examples for highly, moderately and minimally effective measures for GHG reduction could have been given to provide anchors.

4.4. Decision-Making

Some measures, especially those unprecedented or very recently introduced in Potsdam for the first time, received on average higher scores than measures where long-term experience existed. Among those were the creation of the mobility agency, the encouragement of using environmentally friendlier transport options for longer distances or inter-urban traffic, and the enhancement of park and ride facilities. This positive bias was most likely due to the projection of future green visions for the city into these efforts based on the intuitive judgment mode. It has been found that the analytical mode, due to the higher cognitive effort needed, will make negative aspects more salient. Hence, it can be expected that judgment based on the intuitive mode rates the measures where little data is available higher due to desirability [34,38]. However, it has also been observed that thinking out loud induces the analytical mode of thinking [39]. In this case, another potential influence for the high rating could have been confirmation bias due to group homogeneity leading to the same initial decision preferences [40].

Except for such new measures all other efforts were assessed based on reference data and previous experiences as proxies for actual future changes in emissions and related effects. In addition to this expert judgment, more subjective factors based on practical knowledge were included in the assessment such as public acceptance. An example is the projected usage of park and ride facilities, which also included an assumption that to a certain extent their usage would be required and not wholly optional, either by severe parking restrictions in the inner city and/or limiting traffic flow into the city. Another critical point was that the realization of measures over a time period of six years, *i.e.*, at least two city budgets negotiations, was considered. This is important because some principal measures would lead to higher impact only together with additional efforts that alone however are minor, e.g., connecting two close but disjoint bike routes for the overall cycling network in the city. Such measures could then be assessed in the larger context and the realization of more long term structural changes was thereby not inhibited by short-term thinking like in the case of the mobility agency.

While some measures were considered in larger contexts, and thereby not rated based on their stand alone and immediate effects other measures received scores only due to their first order effects. Among those measures was e.g., synchronizing traffic lights for cycling. The primary aspect that was assessed were the consequences for the motorized traffic where more stop and go could be expected and hence higher emissions. Few people were expected to switch from car usage to cycling because of this advantage for bikers. Second order effects, including the transformation to a generally more cycling friendly city and subsequent re-orientation in mobility choices, were not considered. Such indirect effects however can be responsible for significant improvements in sustainable urban traffic as several examples show [41].

In addition to such inherent considerations, a practically motivated value judgment was included in the final creation of the priority list by weighting impacts on air quality and noise threefold. The underlying reasoning was that limit values for air quality and noise are compulsory. To ensure future compliance, measures that would have high impacts in currently critical zones were prioritized. A similar argument was applied to weighting positive impacts on climate, safety and eco-mobility twice because these are crucial elements to the effort to become climate-friendly and a more livable city.

5. Conclusions and Outlook

In a one year transdisciplinary research process, the Potsdam working group on "Mobility and Climate" designed and applied an integrated assessment approach to create a priority list of all planned passenger transport-related measures. All measures received scores based on their estimated impacts in the categories air quality, climate change, noise, road safety, eco-mobility, and quality of life. These categories were chosen as criteria based on Potsdam's strategic plans, infrastructure development concepts, legal obligations and the vision to become a climate-friendly and livable city with good mobility options. Three sub-groups of the working group independently assessed all measures attributing points between −3 (very adverse impact), 0 (neutral impact) and +3 (very beneficial impact). Based on these data, a priority list was established where the categories air quality and noise were given three times the weight of other categories because of regulatory limit values, and climate, road safety and eco-mobility twice the weight because they are crucial for the city's vision. The final rankings also reflected the high potential for synergies by certain measures which were located at the top of the list. This result has already and will guide decision-making and budget spending for the next six years in the city's mobility infrastructure development sector (see Figure 2 box "implementation of measures"). Significant budget relocations were achieved to assure the implementation of group 1 and 2 measures by the time of the submission of the manuscript.

The co-development of the prioritization among the city administration and scientists helped to create ownership and confidence in the solution for sound future political decisions. It also generated insights based on which a new research project is being created for the development of a decision-support tool that makes the linkages between urban infrastructure development and its long-lasting impacts on air quality, climate, citizen behavior, *etc.* explicit for strategic sustainable urban planning. The first phase of this follow-up project has shown that in addition to the multi-criteria assessment, the here applied working group methodology as well as the institutionalization of an authorizing working group is of high relevance to other city administrations. It is planned to adapt and apply this approach to other areas of planning in Potsdam such as energy supply or the building sector as well as in other cities where a suite of measures has already been decided on but where, due to different types of constraints, priorities based on multiple criteria need to be worked out in short time in line with strategic planning objectives and legislation. One aspect not considered at this stage of the transformative process in Potsdam, was the importance of motivating behavioral change for sustainable urban mobility. Individual mobility choices, however, will be significant for successfully increasing the share of non-private motorized transport e.g., [42]. This aspect will be covered in the second year of the working group. To track the impact of this effort, the same working group is currently developing a monitoring and evaluation plan to track changes resulting from the implementation of the prioritized measures.

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Author Contributions

Axel Dörrie, Julia Schmale and Erika von Schneidemesser conceived and designed the methodological approach of this work and guided all processes of the working group; Julia Schmale and Erika von Schneidemesser analyzed the data; Axel Dörrie contributed background information; Julia Schmale and Erika von Schneidemesser wrote the paper.

Appendix

Table A1. Original list of prioritized measures.

Thema	Maßnahme	Maßnahmenbereich
	Gruppe 1: Maßnahmen mit sehr hoher Priorität	
Verknüpfung ÖPNV und Kfz-/Radverkehr	Realisierung bzw. Qualifizierung von P+R-Anlagen: Bornstedter Feld Pirschheide Wetzlarer Straße/Nuthestraße Kirschallee *in Verbindung mit:* Nutzungsbedingungen für P+R verbessern (z.B. 10-Minuten-Takt im ÖPNV)	MIV
Radverkehrsinfrastruktur	Umsetzung prioritärer Routen/Radverkehrskonzept *in Verbindung mit:* Weiterentwicklung/Verdichtung des Radroutennetzes *in Verbindung mit:* Verbesserung Stadt/Umland-Verbindungen (z. B. mit Hilfe von Radschnellverbindungen)	Radverkehr Radverkehr
ÖPNV-Infrastruktur	Verlängerung des Straßenbahn-Nordast bis Nedlitzer Holz *in Verbindung mit:* Neubau P+R-Anlage Campus am Jungfernsee	ÖPNV MIV
Ausbau der ÖPNV-Infrastruktur	Flächenfreihaltung Straßenbahnneubaustrecke Stern/Drewitz bis Teltow	ÖPNV
Mobilitätsmanagement	Einrichtung einer Mobilitätsagentur Potsdam/Potsdam-Mittelmark	Verkehrsmittel-übergreifend
Parken	Erhöhung der Parkgebühren um 100%	MIV
ÖPNV-Infrastruktur	Straßenbahnneubaustrecke Babelsberg (Großbeerenstraße) bis J.-Kepler-Platz (weiterer Untersuchungsbedarf)	ÖPNV
Parken	Ausdehnung der Parkraumbewirtschaftungszonen 1 und 2	MIV
Integrierte Stadtentwicklung	Entwicklung der Kaserme Krampnitz zu einem beispielhaften Stadtteil für nachhaltige Mobilität (vorbereitende Untersuchungen)	Sonstiges

Table A1. *Cont.*

Thema	Maßnahme	Maßnahmenbereich
Neubau/Umgestaltung von Straßenverkehrsanlagen	Umbau Leipziger Dreieck (mit veränderter Verkehrsführung Leipziger Straße und Brauhausberg und Prüfung der Verlagerung der Fahrbahnachse der Straße Brauhausberg in Richtung Westen)	MIV
	Gruppe 2: Maßnahmen mit hoher Priorität	
Fußgängerfreundliche Stadt	Erarbeitung einer umfassenden Strategie zur Förderung des Fußverkehrs (ggf. in teilräumlichen Konzepten)	Fußverkehr
Service rund ums Radfahren	Langfristige Fortführung der Qualitätsoffensive Radverkehr	Radverkehr
Neubau/Umgestaltung von Straßenverkehrsanlagen	Bauliche Erweiterung der Behlertstraße (im Abschnitt zwischen Berliner Straße und Mangerstraße) zur Entlastung der Hans-Thoma-Straße	MIV
Neue Mobilitätsangebote	Initiierung eines Modellprojekts "nachhaltiger Wirtschaftsverkehr" zur Förderung umweltfreundlicher Fahrzeuge/Antriebstechnologien im Wirtschaftsverkehr (u.a. E-Lastenräder für Lieferdienste oder Kleinunternehmen)	Sonstiges
Neubau/Umgestaltung von Straßenverkehrsanlagen	Pflanzen von ein- oder beidseitigen Alleebäumen (z.B. Behlertstraße, Breite Straße, Horstweg, Neuendorfer Straße)	Sonstiges
Fußgängerfreundliche Stadt	Ausbau/Umgestaltung der Straßenräume im Hinblick auf Fußgängerfreundlichkeit *in Verbindung mit:* Realisierung u.a. von Querungshilfen (z.B. Fußgängerüberwegen), von Gehwegüberfahrten bzw. -aufpflasterungen sowie von Knotenpunktaufpflasterungen und grundsätzliche Parallelfreigabe zum Kfz-Verkehr zur Verbesserung der Querungsmöglichkeiten von Fußgängern an Hauptstraßen	Fußverkehr Fußverkehr
Parken	Erarbeitung von Kfz-Parkflächenkonzepten (Innenstadt, Babelsberg, Potsdam-West etc.)	MIV
Geschwindigkeitsreduzierung	Reduzierung der zul. Höchstgeschwindigkeit im Hauptstraßennetz auf 30 km/h (ganztags)/Prüfung und Anordnung je nach Prüfergebnis: Charlottenstraße (zw. Am Bassin und Schopenhauerstraße) Karl-Liebknecht-Straße (zw. Großbeerenstraße und Rudolf-Breitscheid-Straße) Pappelallee (zw. Eduard-Engel-Straße und Georg-Hermann-Allee)	MIV
Öffentlichkeitsarbeit	Mobilitätsoffensive zur begleitenden Umsetzung des Stadtentwicklungskonzepts Verkehr *in Verbindung mit:* Werbung für das Verkehrsmittel Fahrrad durch verschiedene Veröffentlichungen, Aktionen etc.	Sonstiges Radverkehr
Emissionsreduzierung bei Fahrzeugen	Erneuerung der Kraftfahrzeuge mit dem Ziel der Reduzierung des CO_2-Ausstoßes unter Einbeziehung alternativer Antriebstechnologien (Vorbildwirkung von SVP und städtischen Unternehmen)	MIV
Neue Mobilitätsangebote	Ausweitung des Carsharing-Angebots; Schaffung von priviligierten Carsharing-Stellplätzen im öffentlichen Straßenraum	Verkehrsmittel-übergreifend
Verknüpfung ÖPNV und Kfz-/Radverkehr	Einrichtung Fahrradstation Hauptbahnhof	Radverkehr

Table A1. *Cont.*

Thema	Maßnahme	Maßnahmenbereich
Mobilitätsmanagement	Aufbau eines betrieblichen Mobilitätsmanagements bei der Stadtverwaltung Potsdam	Verkehrsmittel-übergreifend
Verbesserung der Qualität des ÖPNV	Neubeschaffung von Bussen	ÖPNV
	Gruppe 3: Maßnahmen mit mittlerer Priorität	
Radverkehrsinfrastruktur	Aufbau einer Fahrradstaffel beim Ordnungsamt zur Kontrolle speziell von Park-/Halteverbotsverstößen durch Kfz im Zusammenhang mit dem Radverkehr	Radverkehr
Erneuerung von Fahrbahnoberflächen	Austausch der Pflasterbereiche im Gleisbereich	MIV
ÖPNV-Infrastruktur	Einsatz lärmarmer Oberbauformen (u.a. Einsatz schwingungsarmer Gleis- und Lagerungsarten, Einsatz von Rasengleisen)	ÖPNV
Erneuerung von Fahrbahnoberflächen	Austausch von Pflaster- oder Betondecken gegen Asphalt:	MIV
	Neuendorfer Straße	MIV
	in Verbindung mit: Markierung eines Radfahrstreifens in der Neuendorfer Straße	Radverkehr
	An der alten Zauche	MIV
	Zum Kirchsteigfeld	MIV
	Hiroshima-Platz	MIV
	Maulbeerallee (zw. Kronprinzenweg und Sizilianischem Garten; ggf. lärmoptimierte Sanierung des Pflasters)	MIV
	Kastanienallee	MIV
Emissionsreduzierung bei Fahrzeugen	Einhaltung der Euro-VI-Norm bei Bussen bis Ende 2014 (ggf. beschränkt auf Großbeeren- und Zeppelinstraße)	ÖPNV
Schallschutz	Einbau von Schallschutzfenstern (z.B. im Rahmen eines städtischen Förderprogramms) als passiver Schallschutz	Sonstiges
Verkehrsmanagement	Schaffung zusätzlicher bzw. Ausweitung vorhandener verkehrsberuhigter Bereiche und von Tempo 30-Zonen	MIV
Geschwindigkeitsreduzierung	Reduzierung der zul. Höchstgeschwindigkeit im Hauptstraßennetz auf 30 km/h (nachts)/Prüfung und Anordnung je nach Prüfergebnis: Zeppelinstraße (zw. Schopenhauer Straße und Forststraße) Breite Straße Brauhausberg (zw. Max-Planck-Straße und Am Havelblick) Großbeerenstraße (zw. Pestalozzistraße und Ahornstraße) Rückertstraße (zw. Potsdamer Straße und Marquardter Chaussee)	MIV
Neue Mobilitätsangebote	Einrichtung eines Carsharingangebots mit Elektrofahrzeugen in der Gartenstadt Drewitz	Verkehrsmittel-übergreifend
Erneuerung von Fahrbahnoberflächen	Fahrbahnoberflächensanierung schadhafter Asphaltdecken:	MIV
	Ketziner Straße	MIV
	Horstweg	MIV
	in Verbindung mit: Markierung eines Radfahrstreifens im Horstweg (zw. Heinrich-Mann-Allee und Nuthestraße)	Sonstiges
	Reiherbergstraße	MIV
	Templiner Straße (innerorts)	MIV

Table A1. *Cont.*

Thema	Maßnahme	Maßnahmenbereich
Verknüpfung ÖPNV und Kfz-/Radverkehr	Ausweitung des Angebots von PotsdamRad (qualitativ und quantitativ)	Radverkehr
Neubau/Umgestaltung von Straßenverkehrsanlagen	Neubau Abfahrtsrampe Nuthestraße zur Friedrich-Engels-Straße	MIV
ÖPNV-Infrastruktur	weitere ÖPNV-Beschleunigung und -Bevorrechtigung an LSA	ÖPNV
Neubau/Umgestaltung von Straßenverkehrsanlagen	Reduzierung der Fahrbahnanzahl oder -breiten bzw. grundhafte Umgestaltung von Straßen:	Sonstiges
	Dortustraße (im Rahmen Realisierung Stadtkanal)	Sonstiges
	Potsdamer Chausse (Groß Glienicke)	Sonstiges
	in Verbindung mit: Ergänzung/Verbreiterung von Gehwegen	Fußverkehr
	in Verbindung mit: Reduzierung von Verkehrsflächen an Knotenpunkten und Verbesserung der Querungssicherheit	Sonstiges
Neubau/Umgestaltung von Straßenverkehrsanlagen	Reduzierung von Verkehrsflächen an Knotenpunkten und Verbesserung der Querungssicherheit: Charlottenstraße/Hebbelstraße Rückertstraße/Potsdamer Straße	Sonstiges
	Gruppe 4: Maßnahmen mit geringer Priorität	
Verbesserung der Qualität des ÖPNV	Behindertengerechter Haltestellenumbau	ÖPNV
Öffentlichkeitsarbeit	Presse- und Öffentlichkeitsarbeit im Zusammenhang mit der Umsetzung der einzelnen Maßnahmen	Sonstiges
Verkehrsmanagement	Umweltorientiertes Verkehrsmanagement in hoch belasteten Abschnitten und LSA-Pförtnerung zur Entlastung der Innenstadt *	MIV
Verbesserung der Qualität des ÖPNV	Neubeschaffung von Straßenbahnen	ÖPNV
Emissionsreduzierung bei Schiffen	Einbau von Filtern in Schiffen zur Minderung von Schadstoffemissionen (z.B. bei Schiffen der Weißen Flotte)	Sonstiges
Verknüpfung ÖPNV und Kfz-/Radverkehr	Verbesserte Abstellmöglichkeiten an ÖPNV-Haltestellen für B + R	Radverkehr
Neubau/Umgestaltung von Straßenverkehrsanlagen	Verlängerung der Wetzlarer Straße mit Anbindung des Industriegebiets	MIV
Parken	Bau eines Parkhauses Friedrich-Ebert Straße/Helene-Lange-Straße	MIV
ÖPNV-Infrastruktur	Friedrich-Ebert-Straße: Untersuchung hinsichtlich Geschwindigkeitsreduzierung	ÖPNV
Parken	Bau eines Parkhauses im Umfeld Berliner Straße/Am Kanal	MIV
Service rund ums Radfahren	Einrichtung von verschiedenen Serviceangeboten, z.B. Reparaturstationen	Radverkehr
Parken	Ausbau/Erneuerung des Parkinformationssystems entsprechend der Veränderungen im Parkraumangebot	MIV
Verkehrsmanagement	LSA-Koordinierung in der Heinrich-Mann-Allee für eine Geschwindigkeit von 45 km/h	MIV
Radverkehrsinfrastruktur	Verbesserung Radwegweisung	Radverkehr

Table A1. *Cont.*

Thema	Maßnahme	Maßnahmenbereich
Erneuerung von Fahrbahnoberflächen	Einsatz von Lärmmindernden Asphaltdecken (Einsatz z.B. in der Behlertstraße, Zeppelinstraße, Breite Straße prüfen)	MIV
Radverkehrsinfrastruktur	Beschleunigung/Bevorrechtigung des Radverkehrs (z.B. grüne Welle)	Radverkehr
Neubau/Umgestaltung von Straßenverkehrsanlagen	Prüfung des Zulassens von Parken auf dem rechten Fahrstreifen in der Breiten Straße, der Schopenhauer Straße (zw. Zeppelinstraße und Hegelallee) und der Neuendorfer Straße	Sonstiges

* bewertet wurden nicht die bereits umgesetzten Maßnahmen sondern nur die mögliche Ausweitung des Systems; MIV = motorisierter Individualverkehr; ÖPNV = Öffentlicher Personennahverkehr.

Conflicts of Interest

The authors declare no conflict of interest.

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