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Sustainability in traffic systems: Indicators for a systemic view in science and planning

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Background

The covid-19 pandemic has made it clear: External uncontrollable events have the potential to impact the use and acceptance of sustainable transportation systems massively around the world. For this reason, it is important to pursue a comprehensive concept of sustainability in the design of transport systems, which not only includes a focus on reduction in emissions of climate-damaging gases, but also resilience to disruptive events such as pandemics or climate change. This raises the question how many different aspects of the concept of sustainability should be considered when analyzing transport systems. Different works in the past have approached this problem in different ways. Here, a clear and manageable set of core indicators of sustainability is proposed that can define the concept as it pertains to transport systems in a comprehensive and yet economically measurable way.

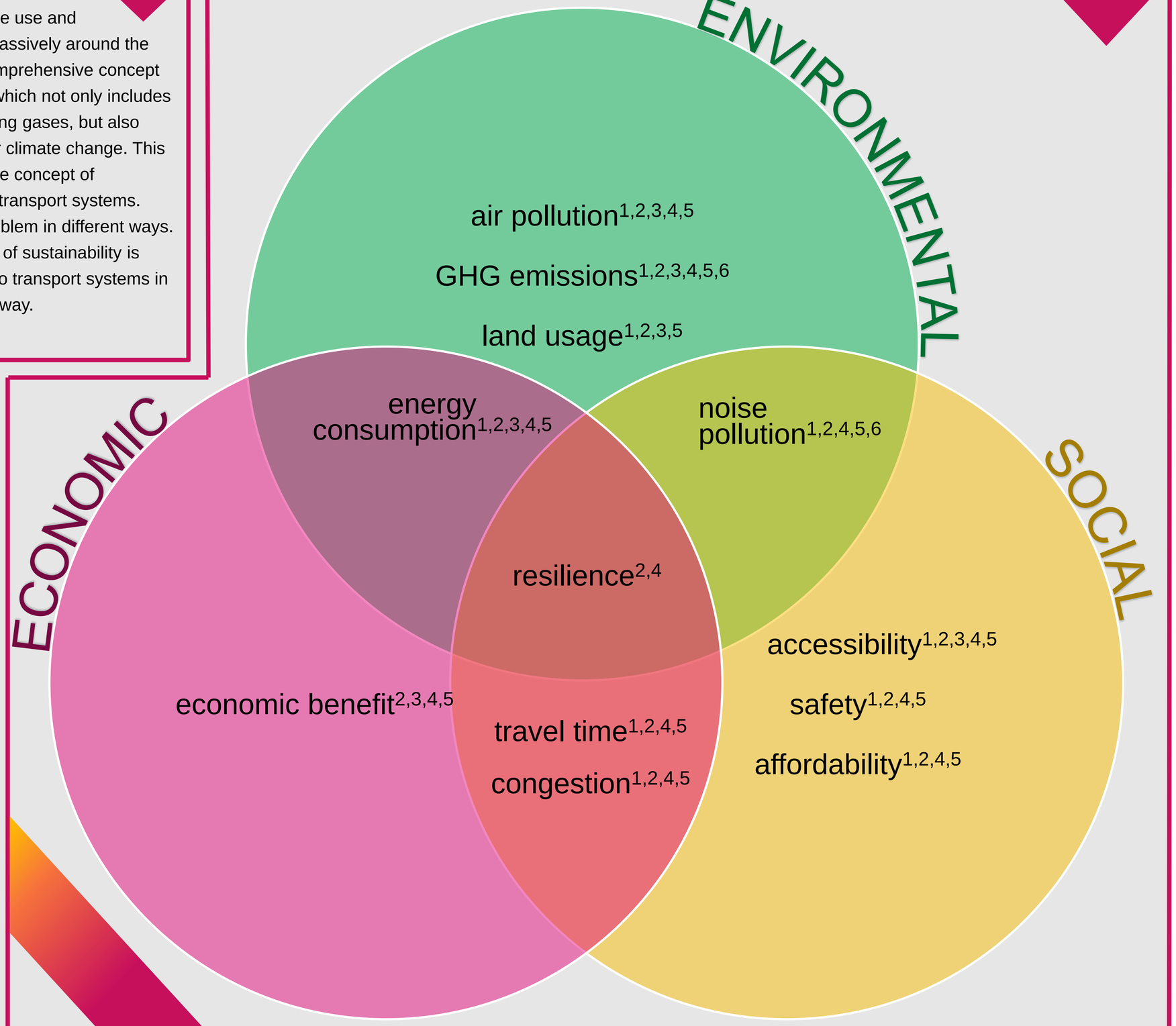
Method

A thoroughly conducted literature review revealed several works of the past have dealt with attempts to clearly define sustainability in general and later in the context of transport systems. A comparison of these works made it possible to outline established elements of sustainability as well as discuss and consolidate more recently introduced aspects.

The above-mentioned indicators were selected from literature on sustainability in traffic. A consensus of at least two thirds of considered works in literature was necessary for an indicator to be considered a core element of sustainability. After careful consideration, the indicator „resilience“ was added despite failing to meet the aforementioned criteria. Only in recent years since the covid-19 pandemic, the view of resilience being an essential component of sustainability has become established (Zeng et al., 2022) and thus is not reflected in earlier literature.

Subsequently, the resulting set of indicators was assessed for measurability.

Fig.1 *The set of indicators.*



Results

In figure 1 these indicators were placed within the tree pillars of sustainability (social, economic and environmental sustainability) whose conception „has become ubiquitous“ (Purvis et al., 2019. p. 681). Energy consumption was placed in the overlapping section between economic and environmental sustainability. Noise pollution was placed in the overlapping section between environmental and social sustainability, while travel time and congestion were placed in the overlapping section between social and economic sustainability. Resilience was placed in the middle where all three pillars intersect. Table 1 shows possible measures for each selected indicator.

Table 1. Possible measures for each indicator.

Indicator	Possible measurement
Air pollution	NO_x; PM25; PM10
GHG emissions	$CO_{2,eq}$
Land usage	share of sealed traffic surface
Energy consumption	share of renewable energies in energy consumption
Economic benefit	ratio of gross fixed capital formation to GDP
Travel time	Average door-to-door travel time per 10km journey
Congestion	Ratio between peak period and off-peak travel times
Affordability	Cost for typical public transport use by lower-income groups
Safety	Number of accidents with injury and death
Noise pollution	Percentage of affected people
Accessibility	Average appreciation of comfort of transport by elder people and people with reduced mobility
Resilience	Measures of planning reflectiveness, robustness, redundancy, flexibility, inclusiveness (Zeng et al., 2022)

Discussion and outlook

This set of core indicators is not designed to reflect each and every aspect of sustainability in transport systems but to achieve adequate balance in the trade-off between comprehensiveness and feasibility. Accordingly, there may be certain aspects of sustainability that aren‘t included in this set even though previous literature found them to be at least somewhat relevant. The described procedure ensures inclusion of essential indicators that are most important for the task of assessing transport systems for their sustainability. The proposed assessment of sustainability is independent of different modes of traffic. Advantages of traffic systems with well integrated intermodal solutions that encourage forms of active mobility such as cycling also are reflected in the indicators. In this way, this work can serve as a general basis for both planners and researchers in various use cases without having to define specific sets of indicators for unique situations beforehand. Therefore, this set of core indicators paves the way for a generalized understanding of the abstract concept of sustainability in transport systems that applies to experts from different backgrounds and fields.

Further research has to be conducted to find concrete measures for the different indicators. Furthermore, these indicators could be analysed within a statistical model to find consensus on how to individually weight them in in relation to one another. If this were to be achieved, the model could be used as a combined measurement for the sustainability of traffic systems in science as well as planning.

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