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Editorial

Towards a decent transport for all: The transport dimension of decent living standards for just transitions to net-zero carbon emission

Just transitions to net-zero carbon emission

Global climate change is a major challenge to the sustainable development of human society. Carbon dioxide emitted by human activities is a major contributor to global climate change. With the acceleration of urbanization in many regions, the intensity of human activities and the demand for transportation continue to increase. In recent years, the diverse impacts of transport-related energy consumption and CO_2 emissions but also noise, air pollution, congestion and land-use, have gradually received the attention of society. The transport sector has become the second-largest CO_2 emitter, after electricity and heat producers (ahead of industrial and residential sectors). In 2021, the transport sector accounted for 23% of CO_2 emissions among all industries worldwide. Taking China as an example, from 1990 to 2021, CO_2 emissions from the transport sector in China increased from 94,152 Mt to 969,447 Mt, a 10-fold increase (IEA, 2023).

In recent years, the concept of just transition has received sustained global attention in achieving climate goals (McCauley and Heffron, 2018; Zimm et al., 2024). It advocates for diverse justice concerns for the whole of society in the transitions to net-zero carbon emission. At its core, the just transition is about maximizing social and economic benefits without leaving anyone behind in climate action. For example, climate change and mitigation policies can have various impacts on different populations, with the poorest often disproportionately being affected. The just transition is to put "people" at the core of the transition to develop principles, tools and agreements. We need to capture the "just" process for all individuals and communities, including diverse population groups, generations and countries when societies move towards net-zero carbon emission. Such a just model of transition is necessary for sustainable development and acknowledges that diverse approaches will outperform "one-size-fits-all" solutions.

Decent living standards (DLS) and decent transport

In the context of sustainable development, we want to provide human society with adequate services for livelihoods at minimal energy consumption and environmental pollution. Decent living standards (DLS) (Rao and Min, 2018) have been used in research with focus on just transitions to net-zero carbon emissions.

Achieving DLS represents a minimum level of justice, a floor. Several studies have estimated DLS, so as to "equitably obtain sustainable development" and balance the relationship among development, resources and environment. So far, DLS gaps have been assessed globally (Kikstra et al., 2021), and for some emerging economies such as Brazil, India and South Africa their energy requirements have been assessed (Rao et al., 2019).

Different dimensions are included in DLS that require materials for meeting basic human needs, such as nutrition, shelter and living conditions, hygiene, clothing, transport, etc. Among them, the research on the transport dimension of DLS is still in its infancy. Improvement of people's access to transport systems is a sub-target in the Sustainable Development Goals (Fisch-Romito, 2021; UN 2015). Existing studies have only briefly elaborated the transport dimension of DLS, by arbitrarily assuming base estimates of transport requirement (i.e., a minimum for the total mobility people require) for urban and rural areas respectively. In some studies, about 8500–10,000 person-kilometres per year are used as proxies for achieving DLS (Kikstra et al., 2021; Millward-Hopkins, 2020; Rao and Min, 2018).

In a sustainability context, we put forward the notion of decent transport to define the transport dimension in DLS, which should capture the basic need of accessibility which is often proxied with mobility. In the literature, relevant studies have proposed similar concepts, such as transport poverty (Churchill and Smyth, 2019), universal basic services of transport (Coote, 2021), sustainable transport (Zhao et al., 2020), transport needs (Mattioli, 2016), and decent mobility (Virág et al., 2022). These studies all provide

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some insight into the minimum levels of mobility, however the concepts tend to be macro and focus only on specific aspects (such as energy needs, environmental concerns or social equity). These studies often take distance travelled or passenger turnover as indicators of mobility, or focus only on energy supply and infrastructure provision, failing to capture both the supply and demand sides of transport services and the interaction between them.

In order to meet the increasingly diversified activities and travel needs of residents while transitioning towards the net-zero carbon emission goal, it is essential to conduct comprehensive studies among multimodal transport networks, human activity-travel behavior choice and DLS. This is the origin of our idea of decent transport. It is worth noting that the focus of this idea is on passenger transport (i.e., excluding freight transport) in urban areas (in order to better account for multimodal travel). We need to explore social justice in the passenger transport system, such as accessibility and transport equity between different groups of people and between different regions. In the process of just transitions to net-zero carbon emission, using the concept of decent transport to give due consideration to social justice is an effective link in the decarbonisation of transport systems. However, this issue has not been adequately researched.

Directions for decent transport study

1. Establishment of a framework for decent transport

The transport dimension in DLS is closely related to energy needs and carbon emissions as this was the original objective of the DLS. Many places in the world experience serious challenges in their transport systems, such as widening inequality in accessibility, affordability but also energy shortages and environmental pollution. It is worth considering how different transport levels and modes affect (or are affected by) energy consumption and carbon emissions, whether such effects have different characteristics in different geographical regions and different populations, and whether decent and also higher affluent transport standards can be achieved with low environmental and societal impacts.

In order to meet the increasingly diverse travel needs of residents in the process of achieving net-zero carbon emissions, advanced intelligent transportation system technology, various travel demand management schemes, carbon taxes, carbon trading and other policies have been widely implemented in many regions. However, the current decarbonisation of transport systems lacks sufficient consideration for equity and cannot eliminate inequalities across population groups, generations and countries. Therefore, for achieving decent transport, there is an urgent need to develop a new conceptual framework based on DLS, linking energy needs and carbon emissions to the various aspects of transport choices associated with residents' basic needs and affluence, and defining the connotation of justice in relation to a just transition within a broader systems perspective. Transport systems interact closely with energy, socioeconomic and land-systems. We consider the interaction between the supply side and the demand side of transport services, and identify relevant factors involved in this framework. Through the establishment of this framework, we can clarify the possible relationship between decent transport and just transitions to net-zero carbon emission.

2. Indicators and thresholds for decent transport

We use decent transport to represent a comprehensive but minimum set of mobility requirements, which is in line with the growing trend of developing various indicators representing transport equity. Definitions, indicators and threshold quantities of decent transport across different modes with respect to accessibility are needed. Multi-source data (including household travel survey data, land use data, multimodal transport data, etc.) should be applied in quantifying the indicators. The questions addressed here are: (i) what kinds of indicators can depict the decent transport? (ii) should the indicators be from the perspective of transport demand or transport supply or both? (iii) how do we determine "the decent transport is achieved" (i.e., how do we determine the thresholds of the indicators) with regards to accessibility?

In the existing studies, there is no consensus on the definition, indicators and thresholds of transport dimension of DLS (Lucas et al. 2016; Kalt et al., 2019). Some studies use trip characteristics as indicators, such as travelled distance (Millward-Hopkins et al., 2020) and passenger turnover (Yu et al., 2022), of which travelled distance is the most commonly used because the data is well accessible and easy to understand. Some studies use the level of infrastructure provision as an indicator, for example, Virág et al. (2022) estimate transport infrastructure stocks for achieving decent transport in different countries.

These DLS-based indicators, which focus on energy needs, group all material satisfiers into several needs categories, and fail to address the complexities of transport system which has accessibility at its core. For a just transition of the transport system, we need to identify relevant transport elements related to demand/supply side from individual level, household level, network level and other levels that are all relate to accessibility.

3. Interests of different stakeholders and their heterogeneity

The net-zero carbon transition at the transport level involves the interests of residents, governments (or transport authorities), operators, investors and other stakeholders. Residents care about the quality and price of transport services; governments focus on the overall costs, benefits and impacts of the transport system; operators pay attention to the net profit of transport operation; investors focus on the short- and long-term benefits of transport projects (Fu et al., 2022). Thus, the just transition of transport systems to net-zero carbon emissions involves multiple stakeholders. At present, most studies on the decarbonisation of transport systems focus only on one or two stakeholders, and there is no systematic solution to analyze the complex game processes and equilibrium conditions for multiple stakeholders to achieve decent transport. It is necessary to explicitly investigate the relationship between stakeholders in the policy-making process of transport planning towards a decent transport for all.

In addition, due to the heterogeneity among individuals in transport systems, even for the same type of stakeholder, the behavior of multiple individuals is different under the same decision-making situation. This heterogeneity depends not only on observational socioeconomic characteristics such as gender, age, income, and education, place of residence but also on factors that cannot be directly observed, such as norms, cultures, risk attitude and low-carbon environmental awareness. Heterogeneity among individuals directly affects their transport needs and choices, energy consumption, carbon emissions, and their responses to the policies or strategies for the just transition. Many existing low-carbon transport policies and strategies do not take decent transport for all into account. That is, they do not adequately account for the differences among stakeholders or individuals.

4. Big data analytics for decent transport

We need new data systems to find out how to achieve decent transport. Based on the framework for decent transport elaborated above, we summarize seven types of big data in order to link energy demand, carbon emissions and transport choices associated with basic needs and affluence: (i) full observations of individual trip chains of large samples; (ii) land use and population distributions with detail characteristics; (iii) aggregated mode-specific link/path flows and traffic states which reflect the mobility of the transport system; (iv) various energy consumption data related to human activity or travel in transport systems; (v) data relating to carbon emissions and other environmental impacts for various transport modes; (vi) future transport and land-use planning data, e.g., future multimodal transport network design, infrastructure plan, new facility layout, low-carbon zone setting, etc.; (vii) real traffic data before and after network/land-use change for comparative analysis. It is worth noting that the collection of multi-source big data is a major challenge and that overly relying on data from existing transport systems can mask truly transformational solutions.

Most of the current research on DLS focuses on energy and population data, with little use of real mobility data. In recent years, real mobility data, including mobile phone signaling data, smart card data, vehicle trajectory data, video data, sensor data, etc., have opened up new ways to study transport. The most suitable sources of data will be chosen for each step of analysing energy consumption and carbon emissions in multimodal transport networks. New data mining methods, computational intelligence and machine learning techniques will be applied to extract useful information from massive multi-source and multi-type raw data. From this, we can construct indicators and thresholds for decent transport and provide initial estimates of the complex relationships among travel behavior, energy demand, carbon emissions, and social justice.

5. Multimodal transport network analysis

Under decent transport conditions, people need to have access to adequate opportunities (such as work and leisure activity participation) to meet basic needs, and these opportunities must be available within a certain distance or travel time from each person's home (or via connectivity digitally). It is all about accessibility. There is a big difference in accessibility between single-modal and multimodal transport networks (Zhang et al., 2024). Public transport and non-motorized ones (e.g., walking and cycling) can help the transition to net-zero carbon emissions. As also the use of electric vehicles can reduce carbon emissions we need to understand how the uptake of electric vehicles, public transport and active modes can be supported. How do we consider the accessibility, affordability and substitutability of different transport modes? Are the criteria for decent transport the same for every group of people using multimodal transport networks and are they changing over time and across space? These are the questions that need to be answered in multimodal transport network analysis in order to achieve decent transport.

We need to develop new multimodal transport network models that integrate energy consumption models and carbon emissions models to examine how different transport policies or strategies affect the just transition to net-zero carbon emissions. The multimodal transport network models need to have two functions: (i) current demand estimation (e.g., energy demands and travel demand) and accessibility-related indicators calculation with current data; (ii) future demand forecast and accessibility-related indicators calculation based on future transport policies, strategies or network plans. The problems that need to be solved here are: (i) how to simulate the cost (or utility) of different activity and travel choices in the multimodal transport network model; (ii) how to utilize initial energy demand estimates based on big data analytics; (iii) how to develop efficient algorithms to solve the multimodal network equilibrium and optimization problems. One big challenge in this field is the lack of data for the future transport systems we want to design. The super-network modeling framework for multimodal transport networks, advanced equilibrium formulations, bi-level programming methods, and fast algorithms with new features, will be adopted and developed for solving these problems.

Furthermore, in multimodal transport network analysis, we need to fully consider the complexity of travel choice behavior, including (i) multi-level heterogeneities in travel preferences and decision-making mechanisms with respect to multi-levels of choice scenarios, e.g., personal level, traffic analysis zone level, and time interval level; (ii) the correlation between energy consumption, carbon emissions and different modes of transport, in particular the complementarity and substitution between environmentally friendly transport modes and other modes.

Concluding remarks

Multimodal transport systems in urban areas support residents' daily activity and travel choices, and play an important role in the just transitions to net-zero carbon emissions. Examining how different transport policies and strategies affect the just transitions to net-zero carbon emissions has important implications for deeper understanding of poverty eradication and inequality reduction for the whole society. Decent transport, as a transport dimension in DLS, provides us with a transport standard that starts from the basic needs of people, and is an important part of achieving the just transitions.

Previous transport studies have been aimed at exploring and predicting the patterns and causes of human movement through model-based and data-driven approaches. Now we can still use these methods in transport studies but we need to expand our thinking.

The task of transport studies is not only to improve mobility and accessibility, but also to address the environment and justice issues that humanity is facing. Therefore, we need to develop more comprehensive estimates of human activity-travel patterns and associated energy consumption and carbon emissions, as well as study the impact of multiple technology and policy innovations on reducing carbon emissions from transport systems. There are many efforts worth trying, such as urban planning for walkable cities, putting forward car-use reduction initiatives, deploying intelligent transportation systems, improving public transport services, and optimizing the allocation of public facilities. Exploring the relationship between multimodal traffic flow, social justice, energy consumption and carbon emissions to gradually achieve decent transport for all is an interdisciplinary topic that deserves to be studied by researchers as soon as possible. The results of the studies will provide guidance for the improvement of the service level of low-carbon and high-equity multimodal transport systems in countries around the world, and provide policy recommendations for sustainable transport- and energy-related social development.

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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