https://doi.org/10.55343/CogSust.112

What is the difference between climate resilience and climate resistance in transport infrastructure?

Andrej DAVID
https://orcid.org/0000-0002-4820-6521
Zilina University
Zilina, Slovakia
andrej.david@uniza.sk

Abstract

In this paper, the author is willing to define resilience. Then, the paper will focus on developing transport resilience, adaptability, absorption, human factors, and recovery. Also, the author defines the resistance and its connection to transport. Finally, the author tries to build up the difference between resilience and resistance and help reveal the cognitive dissonance between resilience and resistance.

Keywords
transport resistance, cognitive dissonance, transport resilience

1. How does climate resilience in transport infrastructure differ from climate resistance?

The impact of climate resilience and climate resistance on the design and maintenance of transport infrastructure involves understanding the challenges and opportunities associated with integrating these concepts into transport infrastructure planning and development (*Maternová, Materna, Dávid, 2022*). Considering the environmental and economic implications of prioritising climate resilience over climate resistance in this context is essential.

– *Climate Resilience* refers to the ability of transport infrastructure to absorb and recover from climate-related disruptions, emphasising adaptability and flexibility (*Chirisa et al., 2023; Hayes et al., 2019*)

– *Climate Resistance* focuses on the ability of infrastructure to withstand and resist climate-related impacts, often through traditional engineering approaches (*Hayes et al., 2019*)

Climate resilience in transport infrastructure emphasises the need for paradigm shifts in engineering, planning, and design, requiring a framework for evaluating benefits in financing adaptation projects to improve resilience (*Martello and Whittle, 2023; Armstrong et al., 2014*). Meanwhile, climate resistance often aligns with a traditional "engineering resilience" approach, which involves increasing the strength and rigidity of assets to withstand the impacts of climate change (*Hayes et al., 2019*).

Challenges include a lack of data and knowledge on climate change impacts, difficulties in designing and prioritising remedial actions, issues with budgeting and planning for climate change, and the need to identify and engage with stakeholders (*Greenham et al., 2023*). Opportunities lie in developing practical, relevant, and usable data, tools, advice, and support for at-risk transport networks to climate change, as well as leveraging socio-ecological resilience theory and biomimicry for resilient and regenerative infrastructure (*Hayes et al., 2019; Greenham et al., 2023*).

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Figure 1. **Conceptual figure: difference between resilience and resistance**

Source: Copilot AI drawing based on the article

Prioritising climate resilience over climate resistance can lead to improved road infrastructure design, proactive maintenance, and reduced vulnerability to hazards, ultimately minimising the impact of climate change (*Biosca Amat et al., 2022*). Furthermore, the ongoing climate change is expected to increase its impact on transport infrastructures, exposing people to unacceptable risks, thus necessitating more frequent adoption of prevention and protection measures for collective safety (*Moretti and Loprencipe, 2018*), (*Galieriková, et al., 2021*).

Integrating climate resilience and resistance in transport infrastructure planning and development presents challenges and opportunities with implications for transport networks' environmental and economic sustainability. While climate resilience emphasises adaptability and flexibility, climate resistance focuses on withstanding and resisting climate-related impacts, both of which are crucial for the long-term sustainability of transport infrastructure. In this paper, the author explores and compares these two topics.

2. What key factors contribute to climate resilience in transport infrastructure?

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The key factors contributing to climate resilience in transport infrastructure include environmental factors, technological advancements, economic considerations, and policy and governance factors.

Climate change poses significant threats to transportation infrastructure, including rising temperatures, increased flood risk, and other potential hazards (*Chirisa et al., 2023*). Extreme weather events such as heat waves, wildfires, drought, flooding, tropical storms, and heavy downpours have the potential to become more frequent and severe. These may damage transportation infrastructure and result in expensive repairs (*Holsinger, 2017*). Climate change and sea-level rise pose significant threats to transportation infrastructure in coastal cities, necessitating an understanding of projected future climate extremes and their impacts on the transportation system (*Martello and Whittle, 2023*).

Technological advancements that contribute to climate resilience in transport Infrastructure need to be investigated. Firstly, paradigm shifts in infrastructure engineering, planning, and design are required to improve the resilience of transportation infrastructure systems, necessitating new frameworks for evaluating benefits in financing adaptation projects to improve resilience (*Martello and Whittle, 2023*). Leveraging socio-ecological resilience theory and innovation inspired by nature (biomimicry) can support resilient and regenerative infrastructure, introducing potential tools and frameworks for enhancing climate resilience in transport infrastructure (*Hayes, 2019*).

Also, economic considerations must be formulated to enhance climate resilience in transport infrastructure. Efforts to decrease the vulnerability of transport networks have been largely limited to understanding projected risks through governance and administrative efforts, with physical adaptation measures typically aligned with a traditional "engineering resilience" approach (*Markolf et al., 2019*). A life-cycle resilient performance measurement framework can comprehensively capture the significant underlying perspectives for understanding the current resilience level of transport assets. Such measurement results and measures taken based on them may lead to a higher ability of the assets to adapt to environmental changes in the future (*Liu et al., 2019*).

Finally, the third key factor is policy and governance, which influence climate resilience in transport infrastructure. A prioritisation framework and case study have been presented addressing climate change adaptation for transportation infrastructure, based on the outcomes of engineering assessments, development of policies for including risk as part of decision making, and methods for prioritising improvements to reduce/eliminate risks to the existing network (*Armstrong et al., 2014*). The responsibilities of EU Member States and critical entities in increasing their resilience to current and supposed future risks have been addressed. Additionally, a framework for assessing the resilience of critical entities in the transport sector has been proposed, along with possible adaptive measures to increase resilience to the adverse effects of climate change (*Luskova and Leitner, 2021*).

The key factors contributing to climate resilience in transport infrastructure encompass environmental factors, technological advancements, economic considerations, and policy and governance factors. These factors are crucial for understanding and addressing the challenges climate change poses to transportation infrastructure.

3. How can climate resistance be integrated into the transport infrastructure design?

The following insights can be derived from the literature on integrating climate resistance into transport infrastructure design. Climate change and extreme weather events pose significant risks to transportation infrastructure, including damage and loss of service (*Holsinger, 2017; Martello and Whittle, 2023; Liu et al., 2023*). Transport infrastructure is vulnerable to climate impacts due to its long operational life and susceptibility to deterioration and disruption (*Picketts et al., 2016*). There is a growing concern for the resilience of transportation infrastructure in the face of climate change and extreme weather events (*Martello and Whittle, 2023; Armstrong et al., 2014*).

There are existing strategies for policy integration. *Adaptation Planning*: Integrating climate resistance involves incorporating climate change considerations into infrastructure planning, design, and maintenance (*Liu et al., 2023; Picketts et al., 2016; Armstrong et al., 2014*). *Multi-Dimensional Approach*: Climate-resilient transportation infrastructure requires paradigm shifts in engineering, planning, and design, as well as the development of new frameworks for evaluating benefits in financing adaptation projects even at the social level (*Martello and Whittle, 2023*). *Risk Assessment and Prioritisation*: A framework based on engineering assessments and developing policies for including risk in decision-making can help identify at-risk facilities and prioritise improvements (*Armstrong et al., 2014*).

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4. What cognitive techniques differentiate transport resistance and transport resilience?

The author faced the fact that, in some cases, experts even used resilience and resistance as synonyms. This last section of the paper thus focuses on defining and enlarging the cognitive gap. Transport resistance refers to a system's ability to withstand external shocks or disturbances without significantly disrupting its functioning. It encompasses several key aspects, such as robustness, which relates to how well the system can function according to its design specifications for integrated modes and routes before any perturbations occur. Also, redundancy is very important, as it measures the degree of duplication of traffic routes and alternative modes. It helps maintain service persistence during disruptions.

Meanwhile, transport resilience describes how fast the system can be restored after perturbations. This could include resourcefulness the capacity to identify operational problems, prioritise interventions, and mobilise necessary resources for recovery. Additionally, rapidity is crucial; it describes the speed at which the system fully recovers all modes and traffic routes in the urban area.

Moreover, transport resilience refers to a system's ability to absorb disturbances, maintain its basic structure and function, and recover to a required level of service within an acceptable time and cost after disruptions. Key characteristics of transport resilience include adjustment, which means how a resilient system can adapt its functioning before, during, and after changes or disturbances. Continued performance is also important: the system performs as required, even after a disruption or major mishap. However, stress tolerance is also considered here: the system operates effectively under continuous stress.

As for a small amount of theoretical criticism of cognitive science in terms of discovering the differences and similarities, the author defines cognition as a concept encompassing various mental processes involved in acquiring knowledge, manipulating information, and reasoning. It includes understanding and distinguishing between similar words or concepts. From this, one could easily derive cognitive abilities, which describe a person's capacity to process information, solve problems, and adapt to new situations. Cognitive abilities help us discern subtle nuances and context-specific meanings when comparing synonyms. Intelligence involves overall cognitive functioning, describing the adaption capability of a person. It enables us to recognise synonym distinctions based on context, connotations, and usage. Being aware of language nuances and semantic variations aids in understanding synonyms. It involves recognising when to use one term over another. Insightful individuals can grasp deeper meanings and subtle differences between synonyms. They consider context, tone, and cultural implications. The ability to comprehend complex ideas and nuances helps us appreciate distinctions between synonyms. It involves grasping both denotative and connotative meanings.

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