# Resilience of Urban Infrastructures in a Pandemic Scenario

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## Abstract

Most of the work on resilience of urban infrastructures focuses on their technical performance and reliability in disaster situations. In general, when we link urban infrastructure and Civil Engineering, we think of technology, engineering, constructions and technical or control buildings. In a state of pandemic like the current one, the study of the relationship between urban infrastructures and resilience is a phenomenon scarcely studied in the literature. The main objectives of the article are to analyse, from a Civil Engineering and actors' perspective, the role and behaviour of urban infrastructures for the maintenance of the wellbeing of the community in a pandemic situation, and to fill a gap in the existing bibliography. The authors argue that the human factor is the most important element for infrastructure to be resilient in a Covid-19 situation. To achieve the objectives, a review of the literature was carried out considering the works published in the last 10 years. Then, a reflection is made about the influence of the resilience in infrastructures during a pandemic situation considering the relevant sustainability factors. As practical implications of this article, the drawn conclusions are expected to represent value for the societies of the future.

**Keywords:** Urban Infrastructures, Resilience, Pandemic, Civil Engineering, Sustainability

## Introduction

The present work intends to show and to outline how to face the analysis of resilience in a state of global pandemic in critical infrastructures of mobility and transit of passengers and goods, based on a review of the bibliography of the last 10 years. This type of infrastructure is going to be essential to controlling the spread of the disease. Secondly, the dimensions of sustainability in a pandemic situation will be analyzed.

As it is intended to focus on the issue of the resilience of the infrastructures named above in a pandemic scenario, sudden disruptions due to structural collapse, earthquake, tsunami or other catastrophic events that may occur simultaneously are not considered. In the case of pandemics, the role of people is central and important. It is the people who operate the urban infrastructure, who remain in their jobs and who keep them up and running.

When a relationship is made between urban infrastructure and Civil Engineering, common sense leads us to think about technology, engineering and other types of buildings. As a result, most of the work on urban infrastructure resilience focuses on their technical performance in the event of a catastrophe. However, it turns out that, in a pandemic case like the current one, people are the most important element for the whole system to be resilient.

Among natural disasters like earthquakes, many of the world's most destructive catastrophes are centered around water, through floods (excess of water in the wrong places); droughts (lack of water in the places where it is needed); contamination (useless or risky water) (Feagan et al., 2019; Fox-Lent & Linkov, 2018; Heinzlef, Becue, & Serre, 2020; Moatty & Reghezza-Zitt, 2019; Rezende, Franco, Oliveira, Jacob, & Miguez, 2019; Sauter, Feldmeyer, & Birkmann, 2019; Vamvakeridou-Lyroudia et al., 2020; Vitale, Meijerink, Moccia, & Ache, 2020). We are currently experiencing an even more destructive catastrophe than the previous ones, since it affects people's health when a society declares a state of health alarm or pandemic. Therefore, critical infrastructures for the mobility and transit of passengers and goods are going to be essential for controlling the spread of the disease.

The Royal Spanish Academy defines a pandemic as “an epidemic disease that spreads to many countries or that attacks almost all individuals in a locality or region”; this Academy defines resilience as “the ability of a living being to adapt to a disturbing agent or an adverse state or situation”, or as “the ability of a material, mechanism or system to recover its initial state when it has ceased the disturbance to which he had been subjected”.

Urban resilience is based on the conception of the city as a system of systems, a complex entity that, like the human body, needs the different organs to function properly in order to enjoy good health. The Royal Spanish Academy defines infrastructure as “a set of elements, endowments or services necessary for the proper functioning of a country, a city or any organization”; there is currently talk that infrastructure must adapt to the effects of global warming with a view to the societies of the future. The Intergovernmental Group of Experts on Climate Change (Bernstein et al., 2008), in 2007, defined resilience as “the capacity of an ecological or social system capable of absorbing disturbances while maintaining the same structure and basic forms of functioning, the ability to self-organize and the ability to adapt to stresses and changes”. Regarding urban resilience, the most accepted definition (AA.VV., 2020; Masik & Grabkowska, 2020), is the one proposed by Meerow et al. (2016): "urban resilience refers to the ability of an urban system - and all its constituent socio-ecological and socio-technical networks acrosstemporal and spatial scales - to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" (Meerow, Newell, & Stults, 2016, pp. 39, 45).

To develop resilience in infrastructures, all possible vulnerabilities and risks, whether infrastructural or operational, related to their proper functioning must be identified. Once identified, they would be analyzed and evaluated, through data analysis, projections, modeling and simulations, to establish possible adaptation strategies to apply at the territorial level.

Therefore, we can affirm that the meaning of a resilient infrastructure is the one that must be prepared to provide service in any adverse situation. Urban infrastructure is based on different networks that provide citizens with water, energy, transportation, waste management, healthcare, education, and other basic services. These networks that form the urban infrastructure are fundamental for life in modern cities and when these fail, human health, well-being, and the economy are endangered putting consequently the pillars of sustainability at risk.

Within urban infrastructures, in this work we will only deal with resilience for critical mobility and transit infrastructures for passengers and goods (elements such as roads, bridges, railway lines, airports and ports) in a pandemic scenario. Infrastructure resilience has been treated in the literature from different aspects, such as from the perspective of terrorism, from the perspective of natural disaster, climate change, etc., but studies of infrastructure resilience from the perspective of a state of a global pandemic such as that currently experienced with Covid-19 are scarce.

As we know, humanity requires useful infrastructures and governments need to invest in road works, bridges, railway lines, tunnels, dams and ports, so that they are resilient, and they need to be operational even in situations of sanitary emergency. It is demonstrated that for the proper functioning of an infrastructure in a state of sanitary alarm, collaboration, control and the involvement of the human factor as the main agent (military control, police control, health control, etc.) are essential. Social fear, family recruitment, military and health control mean that infrastructures need to have action plans to have resilience capacity in migratory movements due to the impacts of a health emergency such as the one we are suffering with the Covid-19. Currently, it has been demonstrated that societies must have contingency plans for critical mobility and transit infrastructures for passengers and goods framework, in order to reduce the problems of their use due to the health emergency, and above all to avoid the spread of the illness.

## Resilience in urban infrastructures in a pandemic scenario

Resilience can also be defined as the capacity of a socio-ecological system to anticipate, manage changes and recover from the effects of a disruption when exposed to disturbances and trends, whether economic, environmental, social or political. This can only be achieved by maintaining the long-term absorption, adaptation and transformation capability of the system (Paz, Méndez, & Mukerji, 2017).

The literature has generally focused its resilience analyzes on climatic aspects, calling climatic resilience as the combination of absorption, adaptation and transformation capacities, which can be delineated according to the responses to climatic disturbances and stresses that they provide (Giz, 2014; IUCN, 2014). Regarding the above, we define:

The absorption capacity of a system, as its capacity to repair or recover from the impacts of negative events using predetermined confront responses in order to preserve and restore basic and essential functions and structures (Béné, Devereux, & Sabates-Wheeler, 2012; Cutter et al., 2008). In short, it can be summarized as the system's response capacity to a threat.

The adaptability capacity of a system, such as its capacity to adjust, modify or change its characteristics and actions in order to better respond to existing and future climate shocks and stresses and take advantage of opportunities (Béné et al., 2012; Brooks, 2003; IPCC, 2012).

The transformation capacity of a system, such as the capacity to fundamentally change its characteristics and actions when existing conditions become unsustainable in the face of climatic disturbances and stresses (Béné et al., 2012; Walker, Holling, Carpenter, & Kinzig, 2004).

The previous definitions have been developed in a concept of resilience in infrastructures from a climate change point of view. For example, if we think of a flood-prone area, we should have a levee system. At this point it is worth asking what should the previous capabilities of a mobility infrastructure (absorption, adaptation and transformation) be like if there is a pandemic state?

It should be noted that the concept of resilience is still relatively recent in the field of Civil Engineering, which is why many studies are based on and adapt existing definitions (Wang, Xue, Wang, & Zhang, 2018). This did not restrict the attempt to define infrastructure resilience as “the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event” (United States National Infrastructure Advisory Council, 2009 apud Quitana, Molinos-Senante, & Chamorro, 2020).

If we recall the sustainable development goals of the 2030 Agenda, the ninth goal marks us: “To develop reliable, sustainable, resilient and quality infrastructures, including regional and cross-border infrastructures, to support economic development and human well-being, with special emphasis on affordable and equitable access for all".

In a pandemic state, human well-being is diminished by the possible threats of contagion that make it possible to spread the disease, which is why we ask ourselves: has it been considered how a system acts in a situation of pandemic state? The answer is obvious, the only responsible for absorbing, adapting and transforming the infrastructure is the human factor together with technology, for migratory control and preventing the spread of the disease. But are the critical infrastructures of mobility and transit of passengers and goods resilient in a pandemic scenario? They can only be resilient if there are people who operate them. In this situation it is important to have assets that immediately replace operators who become ill. Have you ever imagined a metro network where water is continuously pumped so that the network is not flooded? This is a situation that exists in many cities. Without the man, these pumps could still work for a while, but then they would stop. Why? Because there would be no one to operate or repair them. Despite the computerized world in which we live, the human factor remains fundamental. Table 1 compares the actions of resilience of such infrastructures in climate, war and pandemic scenarios.

Table 1 – Comparison of actions in infrastructures of mobility and transit of passengers and goods (authors)

<table>
<tr><th>Critical infrastructure for mobility</th><th>Climate scenario</th><th>War scenario</th><th>Pandemic scenario</th></tr>
<tr><td>Roads/Bridges/Tunnels</td><td rowspan="4">Climate changes due to temperature; Environmental disasters (example: Sea level rise, Rains, Seismic problems).</td><td rowspan="3">Alternative route</td><td rowspan="4">Passenger control (temperature measurement);<br>Isolation of affected people;<br>Social distance;<br>Border closure;<br>Packaging disinfection points;<br>Cleaning and disinfection;<br>Isolation rooms.</td></tr>
<tr><td>Railways/Subways</td></tr>
<tr><td>Ports</td></tr>
<tr><td>Airports</td><td>Panic room</td></tr>
<tr><td>Ability to absorb, adapt and transform</td><td colspan="2">Improvement of the infrastructure's stability against unexpected mechanical actions derived from climatic or warlike changes</td><td>Human factor and technology</td></tr>
</table>

## Sustainability in a pandemic scenario

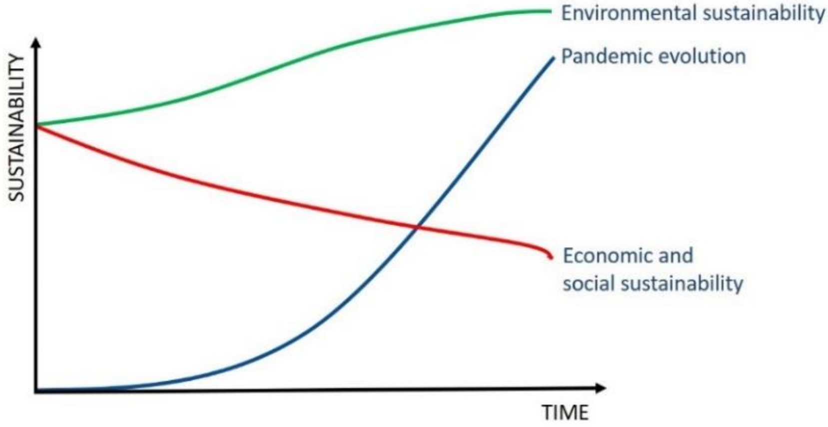
The concept of sustainability was first introduced in 1972 at the United Nations (UN) Conference on the Human Environment held in Stockholm. Later in 1987, most definitions of sustainability established by the World Commission on Environment and

Development (WCED, also called the Brundtland Commission), indicate that sustainable development refers to “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (ONU, 1987), being this the definition of sustainable development that has been used by many researchers. The terms sustainability and sustainable development have varied widely over the years (Kaye, Gabriela, & Nijaki, 2012) and both have multiple interpretations and often mean different things to different people (Illankoon, Tam, & Le, 2016). According to Ross (2009), sustainability refers to things that can be done for longer periods without unacceptable consequences. Therefore, the concept of sustainability and resilience are very similar in that they share “enduring time and responding to changes”. Ortiz, Castells & Sonnemann (2009) identified sustainability as a concept to improve the quality of life and, therefore, allow people to live in a healthy environment and improve environmental, economic and social conditions for present and future generations. Weybrecht (2010) defined sustainability as the incorporation of the economy, the environment and equity in political values and objectives.

The United Nations indicates three “pillars of sustainability”: economic, social and environmental (ONU, 2002). Akadiri (2011) insists that for a development to be sustainable, social, ecological and economic factors must be considered. Du Plessis (2007) pointed out that the relationship between humans and their environment is determined by a certain number of factors. Therefore, over time, new pillars were added to the three basic pillars, with which sustainable development was fed. To date we can talk about the economic, social, environmental, ecological, technological, competitiveness, equality, eradication of poverty, labor well-being, economic growth, etc. as new pillars of sustainability.

*Figure 1* generically represents the economic and social sustainability of a given country or city with a single curve, environmental sustainability with another curve, and depicts an increasing evolution of the pandemic over a certain period of time. The behavior of economic and social sustainability as the pandemic evolves, decreases due to the lack of social integration of the community affecting the economic cycle of the region. However, by reducing pollution due to a confinement state, environmental sustainability is improved.

Figure 1 – Evolution of sustainability in a pandemic state (authors)




## Conclusions

The issue of resilience in a pandemic period has been of fundamental importance in the recent months. This work reflects on the concept of resilience of critical infrastructures for the transit of passengers and goods in times of pandemic. This theme is scarce in the scientific literature, what makes this topic current.

It is verified through this review that the resilience of infrastructure in times of health alarm does not depend on the infrastructure itself, since the capacities for adaptation, absorption and transformation go hand in hand with the human factor and technology.

It has been verified that the infrastructure needs resilience to control the spread of the disease. Countries should develop contingency plans to evaluate options that allow infrastructure to behave appropriately for migratory transit and for disease control.

This study can be used so that stakeholders can make decisions that improve the resilient behavior of cities by optimizing disease control by the human factor and technology at the service of future societies.

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