Trajectories of infrastructure in Brazil. Conceptions, operationalizations, and conceptual frameworks in perspective

Trajetórias da infraestrutura no Brasil. Concepções, operacionalizações e marcos conceituais em perspectiva

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Abstract

Incompatibilities arising from the implementation of infrastructures over consolidated territorial dynamics are recurrent. Based on this axiom, the objective is to investigate the involvement of infrastructure planning in such incompatibilities. Methodologically, the analysis is based on theoretical schools that relate infrastructure and the city and uses studies on new infrastructures or interventions in existing infrastructures. The text provides a brief review of historical infrastructural patterns, addresses priorities in their conceptions, and studies their operational cycles. From this framework, it was possible to formulate the argument that, in Brazil, infrastructure is designed to (re)structure sectors, and when implemented, it (de)structures places. This argument motivated the investigation of new conceptual frameworks that allowed us to advocate that the design of infrastructures should be based on territorial evidence.

Keywords: urban infrastructure; regional infrastructure; territorial planning; urbanization; planning.

Resumo

São recorrentes as incompatibilidades derivadas da implantação de infraestruturas sobre dinâmicas territoriais consolidadas. Partindo desse axioma, o objetivo deste artigo é investigar como o planejamento de infraestruturas incorre nessas incompatibilidades. Metodologicamente, o estudo apoia-se nas escolas teóricas que relacionam infraestrutura e cidade; e utiliza análises de novas infraestruturas ou de intervenções em infraestruturas existentes. O texto se desenvolve por breve revisão dos padrões históricos infraestruturais; pelo entendimento das prioridades nas suas concepções; e pelo estudo dos seus ciclos operacionais. Desse quadro, foi possível formular o argumento de que, no Brasil, a infraestrutura é concebida para (re)estruturar setores e, quando implantada, (des)estrutura lugares. Esse argumento motivou a investigação de novos marcos conceituais que permitiram advogar por infraestruturas que sejam concebidas por evidências territoriais.

Palavras-chave: *infraestrutura urbana; infraestrutura regional; ordenamento territorial; urbanização; planejamento.*

Introduction

The nature of infrastructure is to equip the land in order to enable the permanence and movement of people, ideas and capital. The arguments in its defense are often based on the desire for development and social well-being, the struggle against inequality and the reduction of vulnerabilities. However, its provision has contradictory effects, such as the exploitation and scarcity of natural resources, ideological domination resulting from the construction of cultural symbols and values, and the concentrated appropriation of income and profit, which accentuates inequality. These factors demonstrate how the conception, management and use of infrastructures generate permanent incompatibility between existing territorial dynamics and new overlapping functionalities.

Firstly, some assumptions can be recognized. Infrastructure is a general condition of production because it acts in the generation and distribution of wealth (Lefebvre, 1999, pp. 137-161), in the concentration and dispersion of products (Lojkine, 1981, pp. 137-158), and constitutes fixed capital (Folin, 1977, pp. 28-110) for spreading gains. It can also be considered a technical and social piece that relates to political ambiguities (Ballent, 2022, pp. 3-15) arising from the circulation of ideas, knowledge and technologies (Carse, 2017, pp. 27-39) that consolidate urban cultures and lifestyles. This is because infrastructure is in line with the demands of cities even when it is implemented in a rural environment, and it interferes with or contributes to the transformation of the urban dimension even when it is conceived on a regional scale.

Infrastructure, therefore, has a broad and multifaceted scope of influence. And in the face of a myriad of divergent motivations, it is nothing new that its installation provokes clashes on several levels. These clashes are adverse reactions to the incompatibility of infrastructural provision with the pre-established dynamics in the places where it is implemented. Because infrastructure is generally designed to respond to the economic, logistical, transport and financial sectors, among others. And when operationalized, it results from a scalar compartmentalization and thus confers new functional, formal, topological, technological and symbolic dynamics to these places.

The aim of this article is to investigate the origins and motivations behind this incongruity. This issue will be detailed based on a chronologically longitudinal analysis, because from a long-term perspective it is possible to understand the impacts of infrastructure in an operational and multidimensional cycle, in order to observe urban and regional aspects simultaneously (Geels, 2019). To this end, the article proposes a theoretical-conceptual approach. Recent examples of the provision of new infrastructure or interventions on existing infrastructure will be incorporated from academic analyses to demonstrate the empirical repercussions. These examples are limited to the 1990s and 2010s, given the intense provision and modernization of infrastructure in the country during this period and the profusion of analyses of their impacts.

Methodologically, the discussion will be based on theories that look at the relationship between infrastructure and cities from a historical, social, economic and technological perspective. This aspect will be presented in

the first section of the article to problematize this relationship. The article has three sections: a brief bibliographical review presenting the transit of ideas and practices of infrastructure in Brazilian cities marked by divergent techniques and knowledge that overlap in time and space; an analysis of plans and programs at the national level that have consolidated a way of conceiving infrastructure based on a sectoral-scalar dichotomy; and a proposal for understanding infrastructure based on operational cycles from which it is possible to map the recurrence of incompatibility.

The discussion proposed after these sections will make it possible to formulate the central argument that, in Brazil, infrastructure is designed to structure and restructure sectors and, when implemented, it dismantles places. This argument will lead to the investigation of new conceptual frameworks for infrastructure, seeking to understand it as a social factor. In conclusion, this condition will allow us to advocate infrastructure as an opportunity for citizens, a social factor whose planning should not disregard dialog with territorial evidence.

Problematizing infrastructure in the city

In an introductory theoretical problematization of the relationship between infrastructures (urban and regional) and cities, it can be stated that infrastructure propagates new technical systems with updated morphologies and technologies, forming infrastructural topologies (Vallejo and Torner, 2003) that overlap with the existing urban fabric and form a network urbanism (Dupuy, 1991). Infrastructure is confronted with systems — old and new — of long scope (known in international literature as large technical systems, or LTS) that give rise to corridors (Whebell, 1969, pp. 1-27) and axes of development (Pottier, 1963, pp. 58-132), redefining the conditions of management and production of space. From regional infrastructure systems, local relationships integrated with global dynamics are articulated (Turner, 2018), breaking down an internal national hierarchy and creating specific spaces using specific regulations to allow infrastructure to function in an integrated manner.

At the other extreme, urban infrastructures (or infrastructural lives) also operate as a strategy for class disputes (Graham and McFarlane, 2015) and confirm that infrastructure as a promoter of society's well-being must be relativized by its technical and social issues (Rutherford, 2020), which are always intertwined but not always convergent. The ideas of disrupted cities and splintering urbanism (Graham, 2010; Graham and Marvin, 2001) seek to describe the results of the relationship between cities and infrastructural operations, including, in this context, their failures. And these visions are interesting because they present a contemporary panorama of these conflicts on a global scale. But in the case of Brazil, it is important to delve deeper into particularities, because although this case has parallels with examples in international literature, the national infrastructure has specificities that need to be discussed beyond its finalistic purposes.

The advancement of infrastructure practice in Brazil has meant that it is no longer exclusively about construction, but also about interpretation. And it is based on the historical interpretation of the advance of

infrastructure that we intend to summarize some of its particularities. Therefore, we start from the assumption that there is no seminal framework for infrastructure, as it transforms and advances over time and space, shaping the process of urbanization.

In response to demands, the infrastructure that operates today with greater intensity in the national territory is derived, to a large extent, from the great transformations of the mid-19th century that sought to modernize cities to enable industrial activity. This infrastructure corresponds to European geopolitical influences radiating from France, England and Germany for their technologies and morphological solutions; and to North American influences deriving from the Welfare State and — more recently — associated with logistics and neoliberal global economic development.

From Europe, infrastructure — considered as equipment, works and fixed or mobile machinery — provided instruments that facilitated modern life (Béguin, 1991, pp. 39-68). Infrastructure corresponded to the different scales and complexities of society's activities, which were saturated by problems of hygiene, congestion, pollution and lack of housing, and which needed improvements that could establish public order (Bresciani, 1999, pp. 1-31). Infrastructure was linked to the essentially urban habitability, healthiness and economic production of specific actions linked to articulated plans.

The improvements and beautification of cities (Sakaguchi, 2005) began to integrate networks and systems, helping to spread not only the materiality of their benefits (provision of drinking water, waste disposal, electricity generation, transportation, housing construction, etc.), but also institutions, technologies, doctrines, principles, ideas, knowledge and ideologies. In this way, the great urban reforms of European centers influenced Brazilian urbanization with the modernity of rail transport (streetcars and trains), the production and distribution of electricity, the radial-concentric system of roads, modern road grids, zoning and an institutional and market framework that guaranteed the reception of this infrastructural repertoire.

At the end of the first half of the 20th century, infrastructure became the means for the state to control, universalize and standardize social welfare. The political and economic hegemony of the USA was consolidated in the post-war period and represented the pinnacle of infrastructure provision linked to projects of territorial domination, supranational strategies and international development. Infrastructure came to be treated as an economic asset and the social capital of services and equipment emanating from the nation-state. Technical rationality, standardization and the expansion of international markets for technologies and know-how created a new hegemony of technical networks and institutions to disseminate them, based fundamentally on multilateral organizations such as the UN (United Nations), the IMF (International Monetary Fund) and the World Bank.

The local and regional dimension predominant in the first period moved on to the national and global dimension, accompanying the rise of modern states as key players in the provision of infrastructure. In the inter-war period, the Pan-American perspective was fundamental for the dissemination of investments to amalgamate the vision of the Americas. And with the end of the Cold War,

the subcontinental blocs (the North America Free Trade Agreement [NAFTA] and the Southern Common Market [Mercosur], for example) motivated these investments guided by the formation of the European Union (EU) and linked to neoliberal paradigms (Rufino, Faustino and Wehba, 2021, pp. 9-33) and their expressions in urban and regional development, such as the Initiative for the Integration of Regional Infrastructure in South America (Iirsa). The city was at the center of infrastructural provision, which, in turn, was guided by regional paradigms (subcontinental, subnational, etc.) materializing international desires.

Circulation of ideas and practices in the provision of national infrastructure

From this intercontinental trajectory, it is possible to identify three periods in the configuration of infrastructure in Brazil from the 20th century onwards. These periods confirm that the time and space of ideas and practices converge, but their interests and purposes diverge. These divergences were synthesized by the transition in functional values attributed to the structuring of the territory, which went from the search for proximity to that for accessibility, then to that for connectivity.

These periods are linked to technological domains with different topological solutions that reinforce and, at times, give identities to local, regional and national dynamics, synthesizing their development. In these periods, the hegemony alternates, but the precursor infrastructure is not extinguished: it influences the implementation of new infrastructure. Environmental conditions also influence the arrangements of these periods. The ease of implementation, the consolidated routes, the natural barriers and the environmental resources direct ways and means of exploiting or overcoming them.

The first period was characterized by infrastructure linked to agricultural society and propagated from the end of the 19th century, with a strong role for private capital. It constituted important railway complexes (Matos, 1974) in the 20th century, which contributed to the emergence of new cities and the development of existing ones. A technical and aristocratic elite that owned property and modernized abroad collaborated in the expansion of this knowledge and economic assets with investments in rail transport (D'Alessandro and Bernardini, 2022, pp. 53-70). This innovation was accompanied by changes in the urbanized areas, with the implementation of streetcar lines, water distribution and electricity networks that made it possible to build the identity of an urban life inspired by the *belle-époque*. Reforms were carried out in central areas, marked by the creation of public spaces, paving, the opening of avenues, widening and changes in the structure of their growth (Pereira, 1996, pp. 363-365).

This infrastructure was predominantly linear and based on the premise of circulation, following Saint-Simon's doctrine, as Offner (2001) recalls, which constituted energy, transport and sanitation systems and collaborated in the formation of urbanized nuclei. Stations (ports, railway stations, power stations) became important links in these systems and their implementation redefined

the boundaries of cities with a relatively cohesive, areal growth based on location and the possibility of commuting (Villaça, 2001, p. 23). Proximity to opportunities, services, institutions, etc. became an attraction and a factor in land appreciation.

The prominence of an industrial society, stimulated by the national state after 1930, advocated the universality of social benefits, ushering in the second period of infrastructure in Brazil. Poor areas and regions affected by inequality began to be tackled by systemic planning solutions. During this period, regional approaches, multiple uses of water resources (Chiquito and Trevisan, 2022, pp. 33-52), road plans with integrated land, water and air modes, and more capillary and sectorized road and air plans and programs predominated (Brasil, n.d.). Service facilities also spread into education, health, sports and leisure networks, based on mass production (such as housing by the National Housing Bank (BNH), after the civilian--military government). And so they helped constitute an urban hierarchy that reinforced the interpretations of central places (Christaller, 1966) as places of regional dominance: the equipment that attracted services and commerce was concentrated there.

The instrumentalization of the concept of pole (Perroux, 1966, pp. 3-8), which was accentuated by these locations, reinforced regional imbalances, as the privilege of proximity was replaced by that of accessibility. Living far from opportunities was no longer an obstacle as long as places were integrated by transport systems or served by service networks. The urbanized area expanded intensely as it absorbed the rural exodus and formed connected and continuous fabrics, giving the metropolises their identity. This condition favored the extemporaneous incorporation of Chicago School's center--periphery model (Eufrasio, 2013) to describe the urban structure of Brazilian metropolises as a rich center and a poor periphery, which were generally distinguished by the location of social classes attracted and/or selected by the concentration of infrastructure and the land costs resulting from this concentration.

From the last quarter of the 20th century, successive global crises (economic, environmental and fiscal crises) led to paradigm shifts and the rise of international neoliberal policies (Dardot and Laval, 2016). Thus began the third period, with large infrastructures being provided without any connection to a national project, but in line with the private interest in investing in places that posed less risk to the growing economic returns. Infrastructures became more diffuse, deconstructing the political centrality and territorial domination of state power.

The scarcity of public resources and the attribution of the responsibility of investing in and operating infrastructure to the market (or even to the beneficiary itself) resulted in locational selectivity, widening regional inequalities. This is the case, for example, with the private management of green infrastructure in public spaces, waste treatment or water collection in condominiums, internet control and alternative sources of energy generation. They are often more geared towards endogenous development (Costa, 2010, pp. 90-91) and the qualification of territories that are already equipped or have the potential to provide benefits and exclusivity to certain social classes.

In this sense, connections became more important and the territory was structured in a nodal way with complementary infrastructure (ring roads, multimodal infrastructure, communication infrastructure, connection infrastructure). Today, the places with the greatest connectivity are the most privileged, with the greatest potential for development, even though this connectivity is not necessarily physical or coincident with the location of infrastructure.

The image of a pulverized urban mosaic with no distinction between urban and rural, which characterizes the city-region (Scott et al., 2001, pp. 11-25), has gained strength in more contemporary attempts to explain this period characterized by enclaves and urban dispersion based on metropolization and segregation. Thus, infrastructures have been implemented based on a succession of divergent ideals and practices, amalgamating different overlapping temporalities in the formation and transformation of Brazilian cities.

Conceptions of national infrastructure at the federal level

Based on the historical arc of the last three decades, it is possible to say that infrastructure has been formulated from a conservative state discourse grounded on "bottlenecks" or “chokepoints” considered obstacles to Brazilian economic production. This discourse reproduces the arguments put forward by the Brazil-United States Joint Commission at the end of the 1940s, according to which the modernization of the country should take place via major investments in infrastructure in order to overcome precariousness and the obstacles to development.

The federal Multi-Year Plans (Planos Plurianuais – PPAs) since 1991 (especially the 1991-1995 PPA, the 2004-2007 PPA and the 2012-2015 PPA) and the analyses related to the Growth Acceleration Program (Programa de Aceleração do Crescimento - PAC) (Campos Neto et al., 2009) respectively reiterate and prove the permanence of this argument, even in the face of a substantial change in the patterns of space production and urbanization over the last seven decades. This permanence provides the conditions for a continuation of the infrastructure model that predominated in the 20th century and is still practiced in the 21st century, while inhibiting daring conceptions that go beyond this model. Apparently, this continuity is based on an — increasingly accentuated — sectoral-scalar dichotomy that groups together, on the one hand, economic and regional infrastructure (transportation, logistics, communications, energy); and on the other, social and urban infrastructure (sanitation, mobility, housing, health, education, leisure, sports).

Economic infrastructure is not synonymous with regional infrastructure, just as social infrastructure is not synonymous with urban infrastructure, because they are concepts coined in different periods and with different trajectories, and there is no consensus on their definitions (Costa, 2010, pp. 19-43). But this dichotomy has been perpetuated by the technical and political dogmas of public management (the fundamental milestone of which was the Ten-Year Plan, of 1967), which began to separate investments by

sector (economic and social) and by scale (regional and urban) and thus came to be recognized in recent decades as divergent fields of conception, complementary and interdependent in practice.

In the first case, the grouping of economic and regional infrastructure, infrastructure is justified by the pursuit of development and designed regionally so that the struggle against inequalities can activate productive sectors. And so it is also called productive (law n. 8,173, 1991) and forms technical and logistical corridors, as well as competitive territories for production (law n. 9.276, 1996; law n. 9.989, 2000; Cardoso, 2001; Cardoso, 2008). For this reason, it is a top priority for federal investments aimed at activating production chains and exploiting natural resources in the context of global markets (law n. 10,933, 2004; Brasil, 2006).

Under the banner of integration, it provides energy generation and distribution, transportation and logistics links (national and South American; overland and bioceanic), communication policies, as well as intensified partnerships with the Global South via subsidies, equipment and company markets, and loans from national and multilateral institutions. But it also generates major socio-environmental impacts, affects native communities and alters local dynamics, based on the logic of the international market (Pimentel, Costa and Ravena, 2023).

In the second case, the grouping of social and urban infrastructure, infrastructure is confined to urbanized areas and is an asset for social inclusion. It is designed to increase quality of life and opportunities, reduce the risks and vulnerability of social groups and promote agglomeration economies. It consists of essential health, education, culture, social assistance, social security, labor, public safety and public financial institutions (Matijascic, Guerra and Silva, 2010, pp. 47-92) set up separately or as a network, forming public or collective services.

This infrastructure (social and urban) is also defined by the basic elements for the constitution of urban land by equipment, networks and solutions for circulation, water, sewage, drainage, public lighting and electricity (law n. 6,766, 1979). And in practice, with the most recent federal public programs and policies (Brasil, 2010; Brasil, 2014; Brasil, 2018), it has broadened the understanding of regulations and incorporated housing, environmental sanitation systems (including solid waste), solutions to combat geological/geotechnical risks, squares, parks and heritage as synonymous with infrastructure.

The PAC synthesized these patterns because it presented, in its conception, the division between logistics, energy and social--urban infrastructure with large investment portfolios, conceived, regulated and managed by this sectoral-scalar dichotomy. This situation confirms and demonstrates how the upsurge in infrastructural provisions from the 1990s to the 2010s resulted in the culmination of a technical--bureaucratic structure that was built up over the course of the 20th century and – with rare exceptions – reinforced the sectionalism of decisions without scalar integration in the territory. The PAC was the triumph of this period, but also proof of the exhaustion of an uninventive model based on the paradigms of the 19th century industrial city, the basis of recent infrastructure trajectories.

In this context of plans and investments, infrastructure has become a complex of technologies, parts, devices, services and places that are designed by groupings of sectoral and scalar functions. Thus, its repercussions arise from strong reciprocal impacts, from interdependencies that are not always foreseen, but stem from their relationship with natural resources, with people and with development. These facts prove that the central problem is not the sectoral--scale conception, but the lack of a social and territorial perspective for its integration.

The benefits of regional and economic infrastructure rarely occur in the places where it is installed, but they do have a direct impact on its surroundings. The modernization and expansion of ports and airports, for example, bring efficiency to transport and logistics, but cause an increase in land traffic in their areas of influence. Similarly, the implementation of urban infrastructure that tends to solve local and geographically close demands often overloads regional infrastructure, impacting the national system of these services. The expansion of metropolitan mass transit lines and the construction of large peripheral housing interfere with the demand for roads, energy production and the use of water sources (dams and reservoirs) for supply – that is, they impact regional infrastructure.

At the end of every chain of operation for regional infrastructure, there is an urban infrastructure. And for every expansion of urban infrastructure, there is an overload of regional infrastructure. With increasing frequency and intensity, the functioning of infrastructure of different functions and scales is becoming more dependent on the functioning of other infrastructure. However, although the volatility of the political agenda, which leads to the pragmatic management of infrastructure, has met urgent and necessary demands, it has also caused territorial conflicts, as the potential for reciprocal influence between different types of infrastructure has been little relativized.

Infrastructure operation cycles in Brazil

Taking into account the performance of infrastructure in the territory, it is possible to observe infrastructure from a number of successive patterns that can be considered stages in its useful life, as they form operational cycles. Characterizing these stages and cycles makes it possible to recognize how they lead to the recurrence of conflicts and, ultimately, to identify and combat the risks to which users are subjected by the eminence of incompatibility, failure or collapse of infrastructure.

In Brazil, it is possible to identify four main stages that mark the operational cycle of infrastructure and summarize its formation, rise, depreciation and renewal. They are: the Pioneering Infrastructure stage, the Paradigmatic Infrastructure stage, the Obsolete Infrastructure stage and the Adapted Infrastructure stage. This interpretation is guided by theoretical and historical references and is supported by evidence derived from examples relating regional infrastructure to urban infrastructure. Therefore, before detailing each cycle and its evidence, it is important to highlight the theoretical and historical bases that served as reference.

According to Offner (1993), the formation of infrastructure is marked by technological innovation and the balance between supply and demand; by the development that occurs from its adaptation to the social body, which leads to its popularization; by the transformation of its use via functional compatibility and the sharing of structure; and by the maturation resulting from stability, which is accompanied by decadence and its replacement process.

Similarly, Johnson and Turner (2017, pp. 7 and 8), identified the main weaknesses in the useful life of infrastructure: its obsolescence when it is no longer relevant to needs; its aging when it degrades over time; its catastrophic complexities when they cause failures due to the complexities of its operations; failures in institutions when there are problems with regulations, the direction of solutions, etc.; and nodal failures, when there are problems with connectivity and the sustainability of systems.

Velázquez (2021), considering the case of Latin American railways, listed: the period of introduction of new technologies; public promotion to provide specialized means and labor; the nationalist and transnational ideological predominance; the improvement of connections and networks of these railways; the dismantling of public policies and locational privileges of investments for productive activities; the replacement of the passenger modal by highways and airports; and the resurgence of public policies for urban mobility linked to new environmental demands, such as the privilege given to transport with low carbon emissions and clean technology (ibid., pp. 47-64).

And lastly, considering the same model, but inserted in the Brazilian urban environment, Maia and Santos y Ganges (2022, pp. 3-16) presented a synthetic but complete repertoire of the influences of infrastructure. First, they highlighted the contradictions in the development of rail transport: it was a benchmark of modernity when it first emerged, but, with the advance of the automobile industry, it became an urban barrier; it provided general services (passenger and freight transport) and, later, the specialization of logistics; and it promoted technological advances that were accompanied by its decline. And, conclusively, they pointed out stages that, in the urban environment, interfered with the wealth of cities; the formation of networks; the urban fabric and the natural environment; the attraction of investments; and the role played by the city hosting the infrastructure.

Prompted by these readings, the proposal of the four stages seeks to characterize a cycle of infrastructure operationalization in Brazil and identify some of the causes of territorial incompatibility, because by identifying these cycles, it is possible to identify how the reproduction of patterns leads to the reproduction of conflicts. For this reason, the assessment was not carried out looking at one specific sector (e.g. transport) or at a single scale (e.g. urban) and the stages were illustrated by provisions, events and interventions that took place predominantly between the 1990s and 2010s, given the intensity of the implementation of new infrastructure and intervention in existing infrastructure during that period. Without disregarding historically

known cases, recent studies were used, as the choice of multiple cases helps to understand conflicts over a wide range of time periods and at different operational levels of infrastructure, according to the steps described below:

a) Pioneering Infrastructure: this is the stage in which infrastructure stems from existing but still incipient demand; implemented with the start of a new economic cycle, a new production chain, technological advances or new forms of urban life. It is marked by innovation, but also by experimentation and, therefore, by diversity in its dissemination, with different solutions for the same function. It responds to new cultural values whose purpose, in general, is to strictly fulfill the functions for which it was designed.

It requires even more new infrastructure for its operation and expansion, and therefore attracts complementary services or changes urban functions. This was the case, for example, with the expansion of railroad sidings, which, by consolidating cities as regional centers, required the implementation of avenues and sanitation networks (Minaré, 2023) to ensure adequate conditions for the concentration of services and productive activities. However, this chain of impacts is not always entirely beneficial, as it conflicts with pre-existing situations. The construction of the Barra Olympic Park (in Rio de Janeiro, completed in 2016) required new road works to allow access, and these works caused the removal of approximately 550 families from Vila Autódromo (Sánchez, Oliveira and Monteiro, 2016), resulting in resettlements marked by social damage.

b) Paradigmatic infrastructure: this is the stage in which a hegemonic standard of infrastructure is consolidated by a well-defined program of requirements and prospects. It derives from improved, consolidated solutions that become hegemonic after the selection process that takes place during the Pioneering Infrastructure stage. At this stage, infrastructure is designed and implemented as a model that can be reproduced on a large scale, which means it has a strong political and ideological character. Its implementation generally reinforces existing urban fabric patterns, seeks to solve large-scale problems, hides conflicts so as not to weaken their propagation and is linked to well-established lifestyles and production chains.

Its implementation responds to objectives that are not limited to its exclusive functions, such as the provision of housing to accelerate economic growth with the civil construction sector. In general, this stage is marked by national and international market disputes, technology monopolies and impacts that occur in a network or systemically in cities, such as the expansion of subway lines.

The conflicts of this stage are made evident by the investments linked to national macroeconomic development. The construction of the Belo Monte Dam, which began in 2011 in Pará, has had repercussions for riverside communities (Fleury, 2013) due to the reproduction of a large-scale energy generation model, with historically consolidated technologies, but with little socio-environmental adherence, which causes irreversible impacts. In the urban context, the

recent duplication of the BR-262 highway (as a result of the PAC works between 2009 and 2016) has intensified the integration of the national and international consumer market in the constitution of the East-West corridor of South America, but it has also generated inter-urban conflicts, segregation of neighborhoods and districts, intermunicipal concurrences and the regional traffic inside the urban fabric (Lima, 2023).

c) Obsolete infrastructure: this is the stage at which the system and network, or part of them, have their function replaced by a pioneering or paradigmatic infrastructure, which does not retain new investments or does not adapt to new demands and technologies, no longer responding efficiently and safely to its original functions. With trivial investments, this infrastructure fails to take account of exogenous changes such as system overload, changes in the environment, the incorporation of new technologies or the incidence of extreme climate events. At this stage, the infrastructure is dismantled and decaying, with the underutilization of territorial assets, their depreciation or precariousness, predatory uses, abandonment, aging, failures and collapse. This is the period when infrastructure becomes unsafe, a territorial waste, a social burden in its area of influence, a cause of socio-environmental degradation and a risk to life.

Dams operating at maximum capacity and/or without maintenance exemplify this situation, which represents the most compromising stage of infrastructure in relation to cities and the environment, as occurred with the collapse of the tailings dam in Brumadinho-MG (2019), which caused 270 deaths, as well as social and environmental damage in the Paraupebas River and São Francisco River basins (Duarte et al., 2020). Other examples are the new logistics operations taking place on traditional railway branches, with routes that run through urban centers and expose them to noise pollution, the frequent interruption of local traffic, the risk of accidents and the collapse of century-old retaining structures that are not designed for the speed and weight of current trains (Tavares, 2022, pp. 53-85).

d) Adapted Infrastructure: this is the stage in which infrastructure undergoes renovations to adapt to new demands, in order to minimize obsolescence. Infrastructure can be given new functions, receive a landmark status or undergo recovery, restoration, renovation, revitalization and/or preservation. These adaptations seek to minimize the impacts of aging, inefficiency, risks or inoperability of the infrastructure. They occur due to social pressure, changes in the environment or updates in the production and technological chain or the direction of national public policies. This is the stage most frequently demanded due to the damage caused in the Obsolete Infrastructure stage.

This damage provides recognition of the material and immaterial value of infrastructure, urban landscapes and architectural heritage, and reinforce the need to review paradigms due to exogenous changes that cause obsolescence. These adaptations can lead to new functions being given to public facilities (railway sidings, administrative buildings, etc.) even before they become precarious, so as to respond to specific demands.

But they also occur for more pragmatic purposes such as the attempt to overcome historical and complex conflicts, like those arising from the construction of the Elevado João Goulart (the former Elevado Presidente

Costa e Silva, or Minhocão), which was inaugurated in 1971 in São Paulo to serve the transport sector. Its implementation in the city center caused damage (Schenk, 1997; Artigas, Melo and Castro, 2008) to properties and the quality of life of residents and users of its area of influence, giving rise to discomfort, insecurity and health risks. Another recurring case is the modernization of airports, which also has a negative impact on the surroundings of these facilities, as the expansion of terminals and runways which generates more traffic and attracts greater demand on the consolidated urban fabric. This effect forces changes in land use and occupation (Scatena, 2022) that result in the removal of vulnerable social classes.

In Brazil, the constantly unfinished implementation of infrastructure and institutional volatility have contributed to these cycles because they alternate responsibilities, political choices, size of investments, technological benchmarks and, above all, priorities and locational choices. Treating infrastructure as a government agenda rather than a state policy compromises the continuity of actions, speeds up the transition between these stages and increases the recurrence of these conflicts. With each cycle, these conflicts are repeated or renewed, increasing the complexity of possible solutions.

Conceptual frameworks in perspective

So how can we overcome the impasses of infrastructure provision patterns in Brazil, marked by these clashes? In a hegemonic way, infrastructure is propagated by the state via plans, programs, projects, works, regulations; and it is appropriated by the market via concessions, services or the capture of surplus value. This logic leads to a predominance of infrastructure, which leads to overlapping facilities and services that are not always compatible with each other.

Looking at the results of this process and focusing on its contradictions and conflicts, it is plausible to say that in Brazil, infrastructure serves to structure and restructure sectors by structuring and destructuring the places where it is implemented, because it changes territorial dynamics without necessarily serving them. The finalistic purposes and scalar compartmentalization accentuate these effects, which take shape at each stage of the operational cycle of infrastructure. And in order to move forward in this battle, it is necessary to understand infrastructure as a more complex phenomenon and beyond its own exclusive functions, using new conceptual frameworks to recognize infrastructure as a social factor.

Nowadays, the meaning of the word infrastructure relates to subordinate parts of many projects that are derived from systems responsible for the movement of material resources, energy, waste, people and power. This complexity carries with it the function of guaranteeing security, information, health, finances, political transit and environmental awareness. Its meaning can be summarized as an idea in formulation (event in thought), as rationally programmed steps that articulate specific knowledge and social expectations applied to people's daily lives.

Its meanings are often incorporated by (and incorporate) discourses on economic factors, development, governance and technology. And the supposed global universality

based on technical standards guarantees its insertion in transport, communication and logistics as a means of applying homogeneous solutions to adverse conditions (Carse, 2017, p. 28). The definition of infrastructure therefore involves understanding it as complex systems made up of a plurality of integrated parts that are the basis of a project that is always more comprehensive than its conception.

As a social factor, according to Harvey, Jensen and Morita (2017, pp. 2-22), infrastructure retains a symbolic aspect because it causes changes or intensifies power relations, supports connectivity and reconfigures the daily lives of those who inhabit it or live around it. It can be interpreted by the improvement it brings about in life expectancy, commercial relations, and the reconfiguration of bodies, societies and knowledge, as long as it works properly. And despite the more orthodox understanding of its invisibility, it can also be defined as arranged material sets that generate effects and structure social relations. But what can be observed is that its evolution cannot be attested to as synonymous with improvement. Interactions become increasingly difficult and, after a certain level of complexity, undefined.

Understanding infrastructure, its reproduction and the technologies that enable its widespread dissemination means understanding what patterns people live by, what forms subject social relationships with political ideologies or sectoral criteria that have decided on certain solutions. It is therefore not only a technical, constructive or ideological character, but one of social relations and, strictly speaking, of the materiality that structures part of these immaterial relations. If, on the one hand, political, economic and social events decide for certain types of infrastructure, on the other, these types of infrastructure cause territorial and social relations to be redesigned, forming connections or obstacles, facilitating or preventing their development. Contradiction is innate to infrastructure, as all provision articulates and connects, but also forms barriers and interrupts flows.

Understanding infrastructure as a social factor also means moving on from understanding it as a service or equipment. In this sense, the scale of infrastructure does not depend on its size, but on the radius of its influence. And, topologically, infrastructure needs to be observed for its complementarities and dualities: linear infrastructure is not large, but extensive, capillary; radial-concentric infrastructure integrates spatially, but constitutes centralities and dependencies; infrastructure in open systems has more options for functioning, but is more vulnerable to external factors; networked infrastructure breaks down hierarchies, but requires simultaneity in order to be effective. And even in the immateriality of energy and communications, infrastructure is material and is made concrete by the equipment that supports these immaterial flows.

With this social perspective and based on city life, Easterling's (2014) understanding makes sense: infrastructure has become a set of norms that shape and dominate people's daily lives, forming the infrastructural space. And these regulations occur on a global scale, shaping ways of life by conditioning actions and decision-making, even if they are not laws. These determinations are

called extrastatecraft and consolidated by different agents and governments that take place outside the traditional bureaucracy. Like an exurban or extra-state enclave guided by international standards of relations, exchanges, flows and domains.

What has come to be called urban infrastructure, even at the international level and especially in Latin America (Jirón and Imilán, 2021, pp. 246-247), are the services, basic facilities and organizational structures that are fundamental to the proper functioning of cities, communities and systems in general, for economic and business activity, economic and social cohesion, spatial integration, improved accessibility and poverty reduction. Thus, urban infrastructure is considered to include public utilities (communication systems, telephone lines and cell towers, water and electricity lines, sewage systems, sanitation, garbage collection and dumps, gas systems and pipelines); public works (streets, bridges, dams, reservoirs); transportation (train lines, mass transit systems, air control towers); public institutions (schools, hospitals, clinics, health centers, post offices, prisons, fire stations); parks, recreational areas and public spaces.

Interpreting infrastructure as a social factor means understanding how technical relations contribute to the affirmation of power and inequality. Ballent (2021, pp. 169-171) has already shown how great works are preceded by small works, eminently urban decisions, political acts and social representations at various levels (national, provincial, local). And Gruschetsky (2021, pp. 155-160) demonstrated how the real estate market takes advantage of public investments, especially in highways, to expand its business and increase the demand for urbanized land.

This is why infrastructure can be seen as an artifact (Singh, Piglia and Gruschetsky, 2021, p. 9) that transforms the territory on an urban, regional and global scale and, in the form of a network, connects and disconnects by conducting and regulating flows (of information, people, money, resources); mobilizing social, political and material forces. And while infrastructure often materializes the state in the territory (via planning, construction, management, works and services), in Latin America, the interests of autonomy in the face of territorial imbalances still prevail.

Infrastructure as a public policy is therefore a symbol of modernity, but also of the limitations and tensions of the state and between the state, the market and civil society. The presence of the state or private initiative has been a global trend, which is why infrastructure is, above all, the result of the international circulation of knowledge, specialists, capital and technologies (ibid., pp. 9, 17 and 18). It is therefore a symbol of modernization, but also of dependence, as it is one of the means of global domination.

Conclusions

Given this situation, it can be said that there are three factors that contribute, with specific influence, to the conflicts generated in the places where infrastructural provision falls upon: the overlapping of infrastructure facilities with different temporalities and functionalities; the conservative sectoral--scalar dichotomy that influences their design; and the hegemony of operational cycles that reproduce conflict patterns. The high degree

of interdependence and the contradiction inherent in the topology of infrastructure facilities reinforce incompatibility, which proves the central argument.

Conceptually, infrastructure can be understood as technological systems based on knowledge, work and nature. And as an institution or organization, infrastructure is the basis on which the theories and ideologies that make up society materialize or dematerialize. In this way, infrastructure is regime, management, discourse, construction and governance. It provides support for relationships and sustains – and is sustained by – the asymmetries and conflicts of development. It dialogues with the values and symbols of society and, to a certain extent, transforms itself into them, emerging as a superstructure. It depends on specific knowledge, but also operates in a panorama of generalized decisions as an instrument for economic growth, political domains, the reproduction of capital, the construction of communities, cities, regions and territories. It merges with the history of technology, progress and modernity, but it also synthesizes its injustices and contradictions, reaffirming them in the planning of the territory. It therefore remains an essential condition for urbanization.

And this form of urbanization based on high technology, speed, communication, the expansion of consumption and the transformation of cities has also led to fiercer disputes over air, water and, above all, land. Climate change, water insecurity and unequal access to property contrast with advances in autonomous equipment, app-based services, the permanent monitoring of everyday life, smart cities, green infrastructure and a carbon market based on new technologies.

In Latin America, and especially in Brazil, infrastructure is synonymous with public policies and the presence of the state, albeit indirectly, via regulations and inspections. But it is also an inexhaustible field of dispute over greater profit, power and domination, which oscillates according to economic cycles and the cultural hegemony. And regardless of its motivation or impact, it is often understood as a synonym of or factor for improvement and therefore always justifiable, even if its results are contradictory. Infrastructure, when provided over the territory, constitutes land equipped as a synthesis of society because it interferes with the land structure and has a high capacity to intensify inequalities and segregation.

There is evidence that advocates for the understanding of infrastructure as a social factor to assimilate it as equipment, as a process, a service, a device, a facilitator, a fixed asset, an inducer, a symbol, a space, a contradiction and a conflict. Because in Brazil, infrastructure is opportunity. More infrastructure does not necessarily mean more opportunity. But without infrastructure there is no opportunity, and when infrastructure is conceived based on territorial evidence, it can be practiced as a social factor in the struggle against inequality, vulnerability and segregation.

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Acknowledgements

Grant # 2022/01583-9, São Paulo Research Foundation (Fapesp)
Grant # 308936/2020-5. CNPq, PQ Modality, Level 2
Rede CIAMClima. Grant # 409032/2021-2. CNPq Universal Modality
CPQ-IAU/USP Research Commission

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Translation: this article was translated from Portuguese to English by Sofia Schwabacher and reviewed by Cristina Saez; email: traducao@tikinet.com.br.

Received: July 12, 2023
Approved: September 10, 2023