

# Incorporating Disaster Risk Management in the Transport Sector in Brazil

Challenges and Opportunities





## Contents

1



**Introduction**

Go!



2



**The Brazilian  
Context**

Go!



3



**Towards a Resilient  
Transport Sector  
in Brazil**

Go!



4



**Moving forward,  
Challenges  
and Opportunities**

Go!



5



**Conclusions**

Go!



# 1



## Incorporating Disaster Risk Management in the Transport Sector in Brazil

Challenges and Opportunities

# Introduction





## Federative Republic of Brazil

Capital  
Brasilia

Population  
193,946,886 habitants

Total area  
8,515,767 km<sup>2</sup> (3,287,597 sq mi)

Total GDP  
USD \$2,356 trillion





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Very little is known about the real economic impacts<sup>1</sup> of disasters from natural events in Brazil. While the disaster risk management (DRM) subject has been growing in importance in the public agenda, many are the challenges involved in achieving a remarkable progress and therefore better manage the risks and vulnerabilities for a more sustainable development.

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The popular nationwide behavior, both from government officials and the general public, that Brazil is a disaster free country has led many regions and communities to a series of problems that are now a major setback for its sustainable development. For instance, with more than 85% (approximately 160 million people) of the total population living in cities that lack on investments in infrastructure as well as urban management plans, risks and vulnerabilities have surpassed acceptable levels over the past

decades. The situation gets more critical when data shows an increasing number of disasters being recorded over time in Brazil.

Historically, a much reactive approach has been adopted across Brazilian institutions, but now prevention and disaster reduction have an uphill challenge. In order to properly handle challenging climate variability issues, manage disaster events and reduce both damage and losses in a systematic and sustainable manner, it is necessary to adopt

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1. According to the United Nations Economic Commission for Latin America and the Caribbean's (ECLAC) Damage and Loss Assessment Methodology, Economic Impacts are defined as Damage (replacement value of totally or partially destroyed physical assets) and Losses in the flows of the economy that arise from the temporary absence of the damaged assets.





long term strategies and policies ranging from risk mapping to integrated urban and infrastructure management. Whenever government parties and communities do not comply with formal processes that allow a better understanding of the risks<sup>2</sup> they are subject to results that can be shattering such as the recent disasters occurred in Santa Catarina 2008, Pernambuco and Alagoas 2010 and Rio de Janeiro 2011.

In this backdrop, not only the human losses have shown to be a major concern for the country, but mostly the economic impacts from such events. The disturbing nature of the disruptions caused by the recent disasters abovementioned have triggered an unprecedented reaction in the Brazilian history: in early January 2011, President Dilma Rousseff has launched a special task force to respond to the floods and landslides at the Região Serrana in Rio de Janeiro as well as

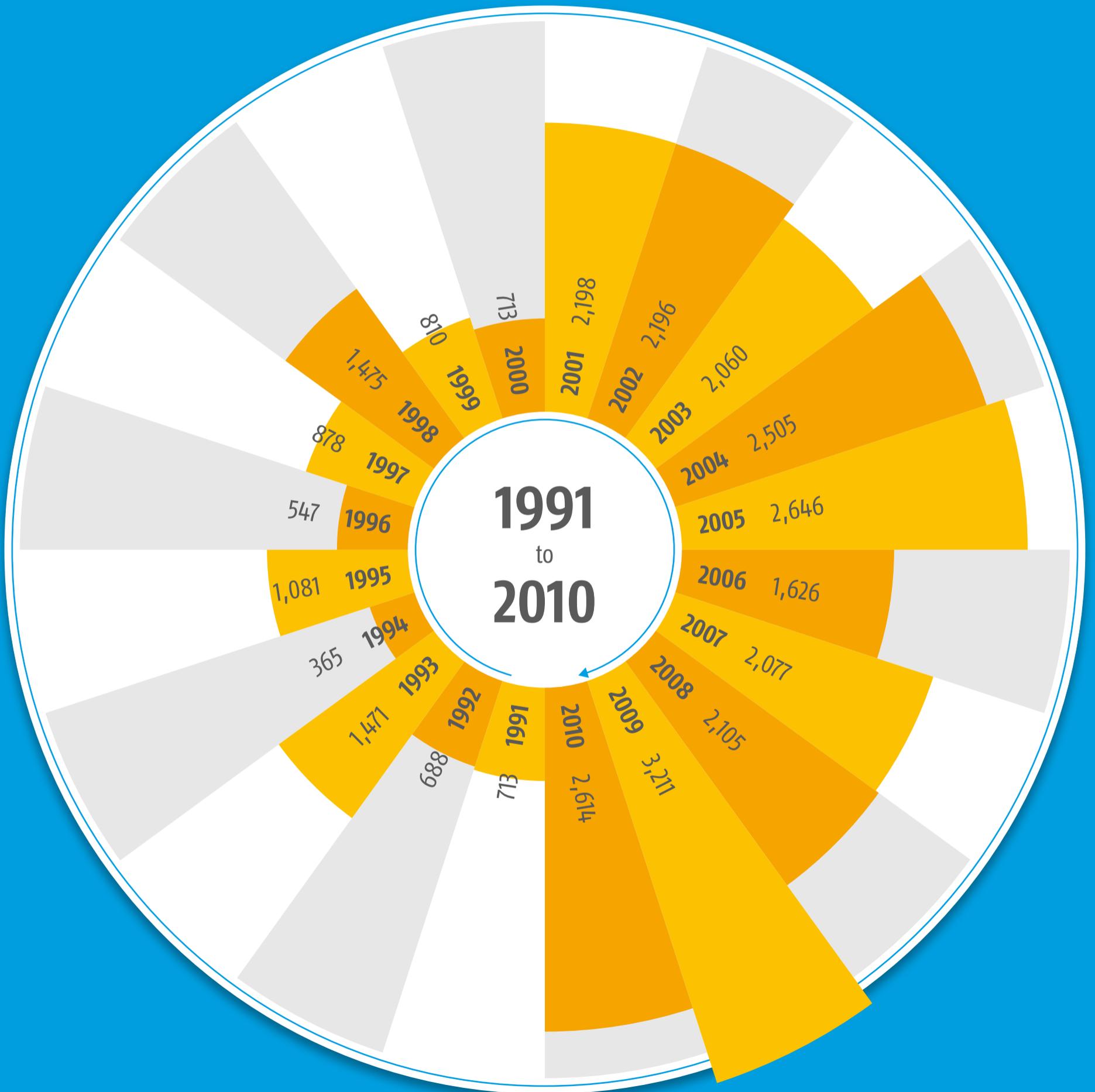
demanded the implementation of long lasting actions to manage disasters and risks at national and local levels.

Thus, as already identified by the World Bank in Brazil, it is urgently needed to advance the DRM agenda in the country from a reactive perspective towards a preventive approach. Successful models have already been developed and implemented worldwide following the basic steps of risk identification, risk reduction, preparedness, financial protection, and resilient recovery. Nonetheless, to successfully achieve these steps it is deemed necessary to engage in a multisectoral approach in order to consider the issue under a holistic approach.<sup>3</sup> This paper focuses on the specific case of transports due to the critical role it plays in the economic development not only at regional level, but also at the broader context in Brazil.

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2. Risks are a combination of both hazards (conditions imposed by the natural events) and vulnerabilities (intrinsic characteristics of infrastructure components).
  3. Transport projects are usually designed with specific and limited focus on transport issues (i.e. capacity, traffic safety issues, operational speed, etc). It is hence necessary to tackle such projects with the incorporation of the DRM pillars in order to ensure that the physical infrastructure are not only appropriate in terms of transport requirements, but also physically resilient and financially protected according to the general DRM framework endorsed by the World Bank.



# Number of recorded events



# 2



## Incorporating Disaster Risk Management in the Transport Sector in Brazil

Challenges and Opportunities

# The Brazilian Context





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Among a number of activities to support the DRM agenda development in Brazil, the World Bank has conducted the first ever study on the economic impacts from disasters in the country.<sup>4</sup>

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Making use of ECLAC's Damage and Loss Assessment (DaLA) methodology, the results indicated that the perception that disasters are of no major concern to the Brazilian economy is actually misleading. The studies have shown that approximately R\$15.5 billion (over US\$7.5 billion) were lost only in the four major disasters in the States of Rio de Janeiro, Santa Catarina, Pernambuco and Alagoas in the past five years. These findings are of greater concern when considering that such events partially represent the current reality in the country

as well as the analyses were essentially underestimated due to lack of data.

In regards to total costs, R\$9.4 billion were due to damage (direct impacts) and R\$5.9 billion related to losses. Furthermore, the private sector corresponded to 52 percent of the total costs while the remaining 48 percent were related to public damage and loss. Sector wise, housing was the most severely impacted sector with approximately R\$7.3 billion followed by transports which accounted for R\$2.8 billion.

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4. The World Bank Damage and Loss Assessment Reports on Floods in Santa Catarina in 2008, Floods in Pernambuco and Alagoas in 2010, and Landslides in Rio de Janeiro (Região Serrana) in 2011 were published in 2012 (in Portuguese).

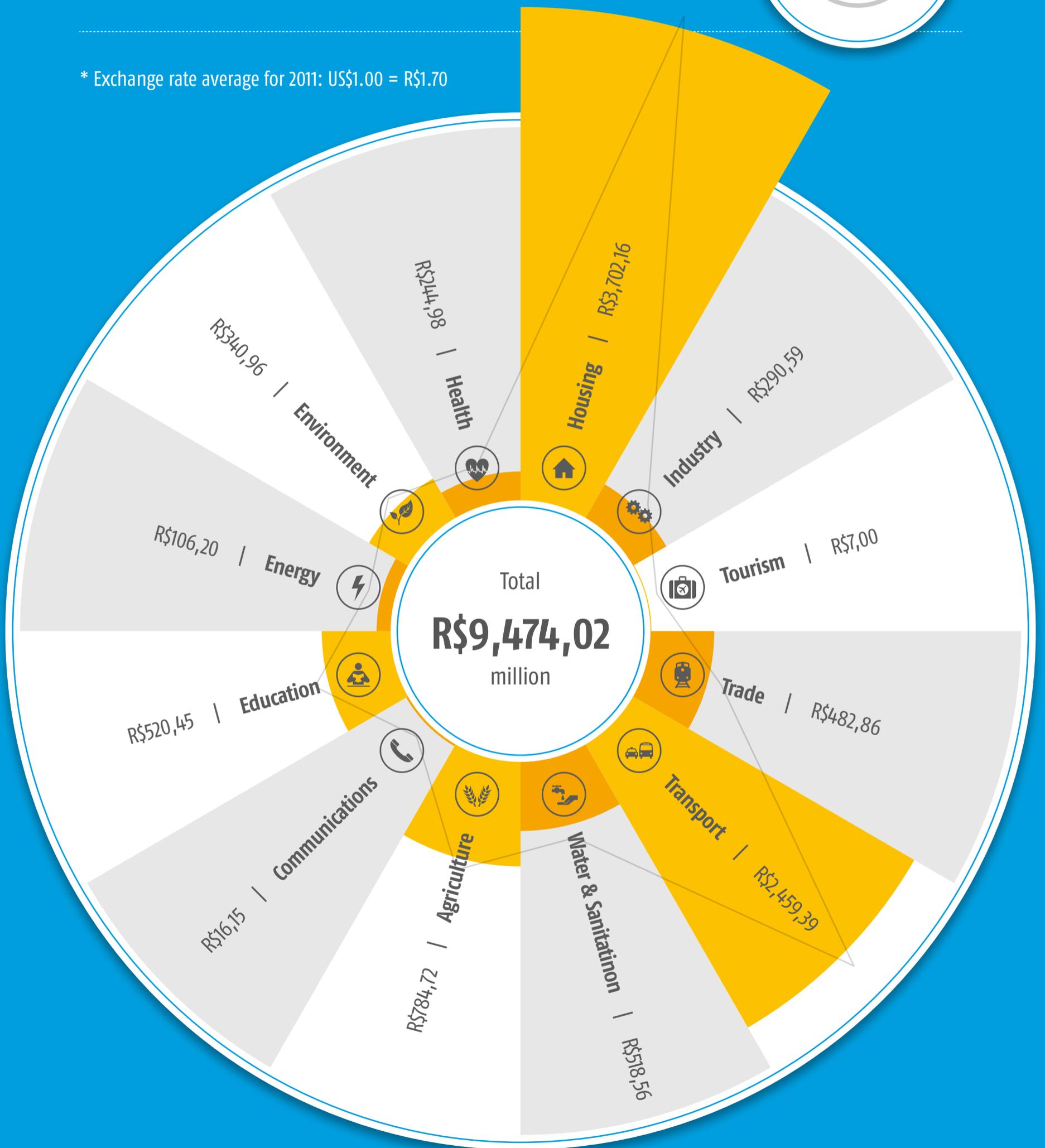


# Damages by sector

(R\$ in Millions\*)



\* Exchange rate average for 2011: US\$1.00 = R\$1.70





# The Transport Sector in Brazil

## Key for Development yet Vulnerable to Hazards

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Brazil's transport infrastructures inherit a historical gap in investments and proper plan towards a strategic development which leads to a sector globally inefficient. Additionally, strong focus in roading and poor multimodal investments further contributes to a fragile setup that can be badly impaired whenever a disruptive event takes place.

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Significant efforts over the past ten years to progressively redress the situation were taken, notably on the investment side. Nonetheless, the strong dependence on highways (it is estimated that road transport account for 95 percent of passenger trips and 61.1 percent of cargo<sup>5</sup>) points to lack of redundancy and leaves no room for adaptation to reduce the possible economic impacts associated

with disasters. Thus, the World Bank has been leveraging investments and supporting activities in order to better identify the risks associated with disruptions in transport infrastructures in order to promote a more resilient development of the national economy, which heavily depends on transport (e.g. 15 percent to 18 percent of the National GDP is related to transport activities).

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5. The National Confederation of Transports (NCT) conducts a yearly survey known as "Pesquisa CNT de Rodovias", in which highway condition and maintenance are assessed in order to provide both public and private sectors with an updated diagnosis of the roading infrastructure.





According to The World Bank damage and loss assessment studies, the housing sector seems to yell far greater priorities for public funding for reconstruction and relocation when compared to the transport sector. While it is difficult to conclude which sector deserves more attention from both public and private decision-makers (i.e. transport or housing), it is key to understand that the transport sector can impair a number of economic activities.

Transport infrastructures are of paramount importance to daily operations of many different businesses. Interruptions can therefore generate a chain reaction of indirect impacts in large number of economic activities at regional and/or national and international levels.<sup>6</sup>

Furthermore, note that the estimated proportion of damage and losses for the transport sector is highly unbalanced (refer to

damages and losses figures). While damage estimation is straightforwardly performed by accounting repair costs and estimating the total value of non-repairable assets, the losses are of difficult nature to be estimated. The lack of knowledge and alternative means to estimate post-disaster economic activities impaired by hampered transport network is crucial to proceed with the evaluations so that the analyses tend to be underestimated. Anecdotal evidence and international experiences suggest that the indirect impacts from disaster events in the transport sector are highly prejudicial.

The following section presents a project in the São Paulo State financed by the World Bank, in which the inclusion of DRM practices aims at both reducing possible effects from disasters occurrence as well as ensuring the development of a more resilient sector.

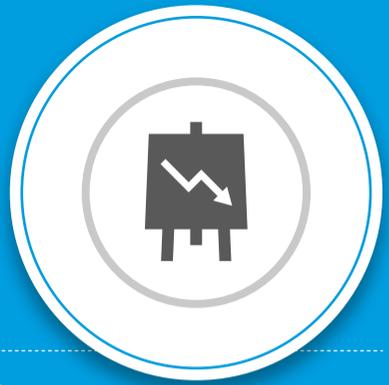
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6. The 2011 Great Eastern Japan Earthquake and Tsunami affected global supply chains worldwide. For instance, car and computer parts were on shortage at different countries due to the interruption of production in the Tohoku region in northern Japan. In the same year, floods in Thailand were also responsible for Japanese car parts stocks running short in numerous markets.

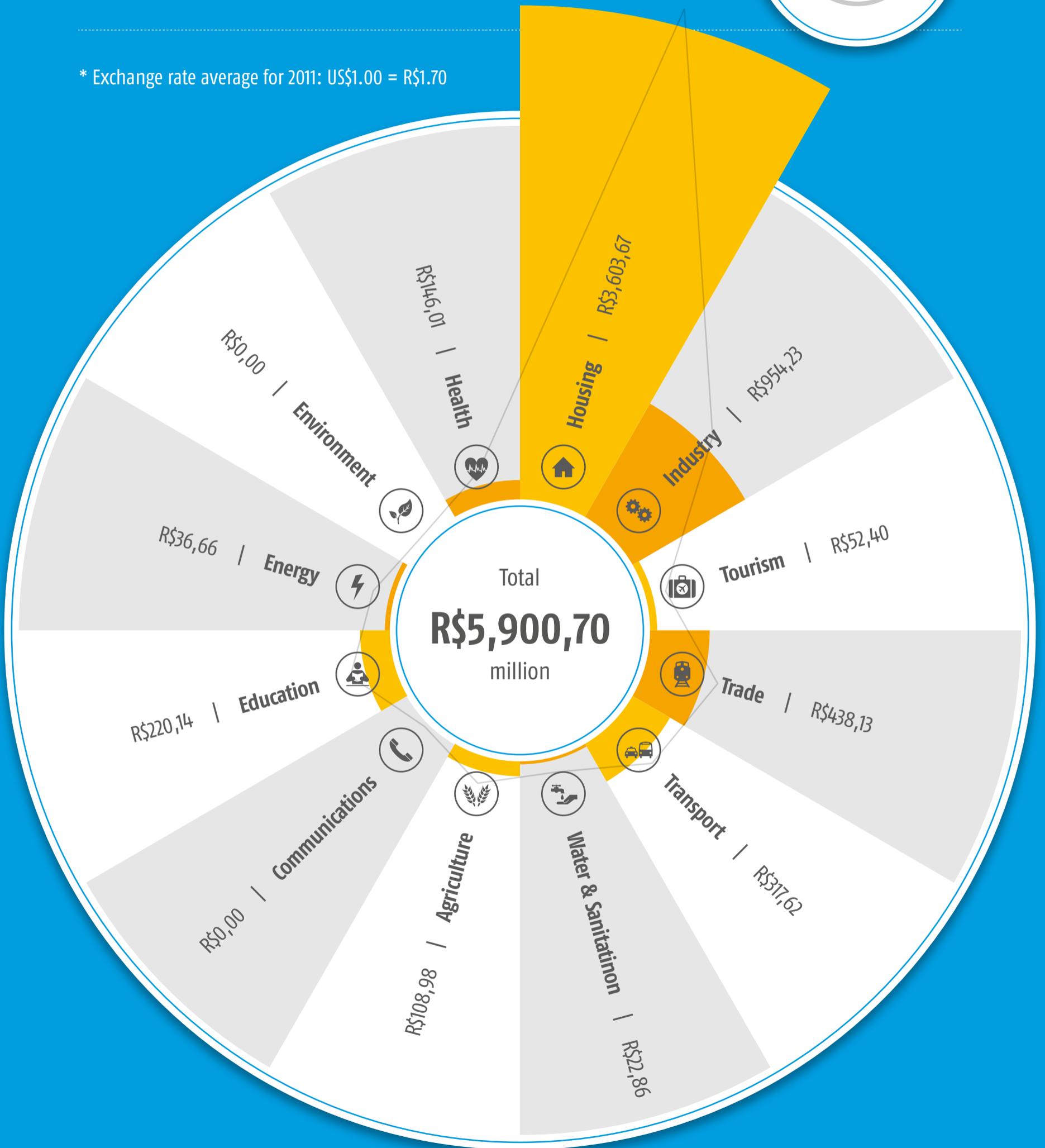


# Losses by sector

(R\$ in Millions\*)



\* Exchange rate average for 2011: US\$1.00 = R\$1.70



# 3



Incorporating Disaster Risk Management  
**in the Transport Sector in Brazil**

Challenges and Opportunities

# Towards a Resilient Transport Sector in Brazil

The case of São Paulo





## Municipality of São Paulo

### Area

Municipality  
1,522,986 km<sup>2</sup> (588,028 sq mi)

Metropolitan Area  
7,943,818 km<sup>2</sup> (3,067,125 sq mi)

### Population

Municipality  
11,316,149 habitants

Metropolitan Area  
19,889,559 habitants





As highlighted by the AELG (Auckland Engineering Lifelines)<sup>7</sup> the transport sector is key for both business as usual and disaster situations and in São Paulo this is no different when dealing with the broader field of disaster risk management. Also, hydrometeorological events are rather frequent and incur in numerous extreme events all over the State. Between the years of 1991 and 2010, the Atlas Brasileiro de Desastres Naturais indicates to over 452 flood occurrences registered in the State as well as 3.7 million people affected in the State.

While numerous transport projects are developed in Brazil every year, very few or none have a strong concern in ensuring the application of DRM practices in a holistic manner. Some might consider common engineering approaches such as the use flooding modeling information for the structural design of infrastructures, but a comprehensive approach under a DRM strategy<sup>8</sup> is seldom observed.

The novelty associated with the São Paulo project originates from a thoughtful interaction among three fields (transports, environment and disaster risk management) targeting both structural and

non-structural measures. In the specific context of DRM and among the overlaps between the abovementioned fields, it is aimed to use cutting edge hydrological and geotechnical engineering modeling to map risks and identify vulnerable areas as well as support the implementation of the State Natural Disasters Prevention and Geological Risk Reduction Program (PDN). Note that risk mapping information are key inputs for the transport sector to both identify and reduce risks while the PDN program goes beyond and can positively impact different sectors (e.g. housing, commerce) and protect infrastructures.

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- 7. The Auckland Engineering Lifelines states that many organizations depend on road transport to conduct their aid activities during response and recovery (AELG – Auckland Engineering Lifeline Group, 2005). Resources Available for Response and Recovery of Lifeline Utilities. Technical Publication No. 282 (Version 1.0). ISBN: 1-877416-02-9. Auckland Regional Council, Auckland, New Zealand).
  - 8. The World Bank’s DRM strategy comprises five pillars: risk identification, risk reduction, preparedness, financial protection and resilient recovery.





## Transport Development Leading Plan (PDDT), Economic and Ecological Zoning (ZEE)





Moreover, it is expected that the availability of risk information will allow the transport sector to better prepare for future foreseeable events as well as motivate the adoption of financial protection measures accordingly to its known infrastructure vulnerabilities and projected impacts on operations.

In this respect, two main activities were identified:

1. To improve the State capacity to mainstream DRM in transport planning and program execution through studies, small works and the acquisition of goods including:

- I. Mainstreaming disaster and climate change risk in the State's Transport Masterplan (PDLT), comprising the assessment of the sector's vulnerability to disasters, potential socio economic impacts for the State, and developing an integrated disaster response plan for the transport sector.
- II. Reviewing technical specifications for road design with a view to integrate DRM linked to climate variability and for maintenance and operation practices to improve resiliency of road infrastructure exposed to mapped risks.

2. To enhance DRM policies and institutional capacity with focus at strengthening the State's overall capacity of disaster risk prevention,

fostering management initiatives through studies and the acquisition of goods and to support the implementation of the PDN, including inter alia:

- I. Mainstreaming DRM practices at planning level, through supporting the design of DRM frameworks (risk identification, mitigation, preparedness, financing), improving comprehensive conceptual and practical understanding of hazards, vulnerabilities and risks (including linked to climate change), assessing economic and social impacts of particular disasters, designing management tools for the resettlement of populations located in immitigable high-risk areas.
- II. Improving policies and procedures to better and more effectively respond to disasters, through the development of early warning systems, methodologies, information and knowledge.

In face of the ambitious objectives proposed, a set of two indicators were prepared to properly monitor





the project development: (i) Improved monitoring of climate risk factors measured by the road extension monitored with automatic stations and (ii) Increased number of municipalities in the São Paulo Metropolitan region with a concluded disaster risk mapping. Note that the first indicator is directly related to the transport sector while the second has a greater emphasis on general DRM topics for the metropolitan region. Nonetheless, the transport network within the urban area is key for most of the economic activities as well as is recurrently impacted by flood and flashflood events. It is also worth noting that the required data to feed the indicators are to be collected from two counterparts: Geological Institute (IG) and the State Department of Transportation (DER).

Finally, São Paulo State has a major component of a critical infrastructure, namely Ligação Planalto / Baixada Santista. This is a complex highway network which connects the coastal region and the Port of Santos<sup>9</sup> to the São Paulo metropolitan region. It is estimated the approximately 25 percent of the National GDP depends on the Anchieta / Imigrantes complex and almost the totality of passenger trips as well as 90 percent of freight shippers uses this network to move between the

two previous mentioned regions. There are no alternative routes (at least economically wise) and recent studies show that a quarter of all Brazilian exports and 40 percent of agribusiness depend on this transport infrastructure.

Hence, a special Technical Assistance Project (TAP) was designed within the operation in order to better prepare transit authorities and road users to both manage the risks and respond to extreme events. In general terms, actions regard to risk identification, reduction and monitoring for floods and landslides as well as contingency planning for improved decision making and proposal of strategic planning in regards to infrastructure upgrading.

The envisaged TAP has potential to become a pioneer approach for DRM in the transport sector in Brazil. The proposed framework aims at the integration between geotechnical / meteorological monitoring and highway management and operation in order to ensure the adoption of structural measures to reduce identified risks as well as support the adoption of non-structural procedures to better manage traffic in case of disaster occurrence.

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9. A CODESP (Companhia Docas do Estado de São Paulo) study projected a growth of 80 percent in container movements in the Port of Santos – from 100 million ton to 180 million ton yearly – until 2024 posing extra stress in the already congested roading network (CODESP. Plano de Desenvolvimento e Expansão do Porto de Santos – PDEPS. Elaborado por Louis Berger Group e Internave, 2009).





It is estimated the approximately 25 percent of the National GDP depends on the Anchieta / Imigrantes complex.<sup>10</sup>



10. Anchieta highway (SP 150) is one of the most busiest roads in Brazil due to freight transport demand originated in the Port of Santos. It was built in the 1930's and can have the flow fully reversible according to real time needs. In 1974, a new highway namely Imigrantes was inaugurated due to Anchieta's traffic saturation. The new highway has 44 viaducts, 7 bridges and 11 tunnels. Together, both highways are of paramount importance for the Brazilian and State of Sao Paulo economies.





# February 22nd, 2013 Landslide Events at Anchieta – Imigrantes Highways

The recent events occurred at the city of Cubatão highlight the urgent need for the State of São Paulo to better integrate DRM practices at institutional levels as well as the importance to incorporate DRM knowledge into the transport sector.

The unfortunate series of events also pointed to key contributions that the São Paulo can inherit from the proposed operation in order to build resilience at the sub national level by protecting a sector that plays a major role in their economy.



## Cubatão

### Area

142,281 km<sup>2</sup>  
(54,935 sq mi)

### Population

120,271 habitants

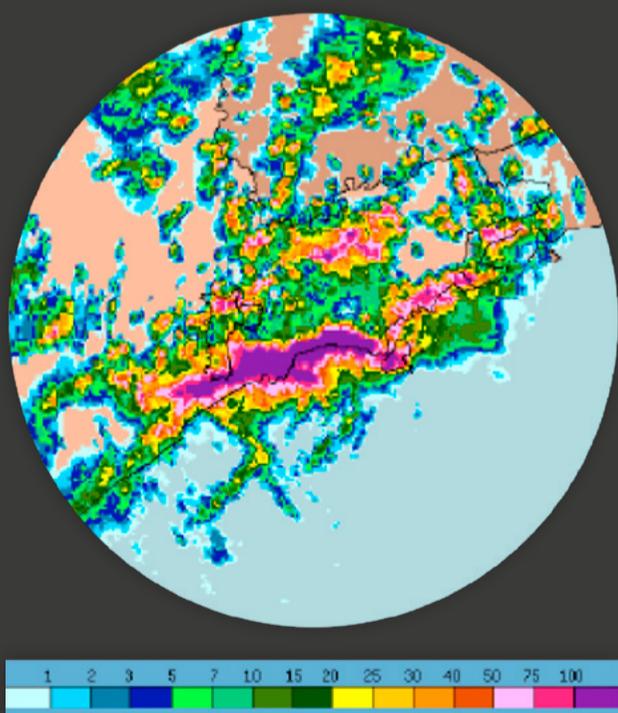




## Event Description

In the afternoon of February 22<sup>nd</sup>, 2013, the coastal region of São Paulo State experienced heavy rain fall.

At kilometer 49 of Imigrantes Highway, it was recorded over 107 millimeters (mm) of cumulative rain fall in approximately a one hour period (from 3:30 p.m. to 4:50 p.m.) with a peak of 23 millimeters in ten minutes. The figure illustrates the cumulative rain fall for a 15 hours period acquired from the meteorological radar under the management of Sistema de Alerta a Inundações do Estado de São Paulo (SAISP). Additionally, the Cubatão field station recorded over 271 mm of rain in less than 24 hours (from 3:40 p.m. – February 22<sup>nd</sup> – to 6:50 a.m. – February 23<sup>rd</sup>). A series of outcomes were experienced as a consequence from the events described in the previous paragraph.



[www.saisp.br](http://www.saisp.br)

The following presents a non-exhaustive list of impacts:



**Cubatão landslides and flooding.** Numerous flooded areas and landslides at both Cubatão’s urban center and outskirts, Piaçaguera-Guarujá highway closure due to flooding and Transpetro industrial complex flooded due to Cubatão river overflow.



**Serra do Mar landslide.** Mass movement (soil, rock and vegetation) at kilometer 52 of Imigrantes Highway blocking tunnel. The material spread out for over four kilometers affecting three subsequent tunnels.






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Overall, geotechnical and climatic variables are to be monitored simultaneously and in real time by installing sensors of precipitation (rain), moisture content and suction of the soil in experimental fields.

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Activities can also be incorporated to study the influence of anthropogenic factors in induced landslides in urban areas from the analysis of slope stability simulations that consider different scenarios observed in risk areas already mapped in the municipalities. Experimental fields will be implemented preferably in basic land units where soil present geological and geotechnical characteristics with greater natural susceptibility to the occurrence of landslides. The study of mechanical and hydraulic properties of soils will be done through field and laboratory testing and by monitoring climate and geotechnical variables aiming at a better understanding of the process of infiltration of rainwater in different soils profiles. It can be also targeted to create a database with the geotechnical soils properties

(shear strength, water retention curve, hydraulic conductivity) representative of areas with higher probability of any event occurrence.

**a. Impact and Losses**

At Imigrantes Highway it was registered one death associated with landslide material which intercepted 23 motorcars and one truck. The north bound lanes were also closed to traffic incurring in major delays for countless passenger vehicles and freight trucks.

Flooding in Cubatão heavily impacted the local population as approximately 2,300 houses were affected, 1,500 people needed shelter and 36 houses were destroyed. The industrial complex





reported the need to stop the operations in an petrol refinery (additionally the operator reported not been able to put in place its business continuity and contingency plans due to the time of day and difficulty to access the location) and chemical material was discharged at the Cubatão river after the industrial treatment station was flooded. Moreover, the Cubatão water treatment station was impacted and chemical components (approximately 5 cylinders of 900 KGs of Chlorine) were washed out to Cubatão river.

### **b. Initial Findings**

The event and the series of consequences associated with its occurrence highlights both

the urgency to improve DRM practices into State institutions as well as the complexity of managing extreme events. In the context of the proposed São Paulo operation, the focus on the transport sector is confirmed by the key role that such infrastructures play not only during response but also in business as usual situations.

The event's aftermath pointed to a series of response actions which could not be implemented due to road closures (no access to the petrol refinery) as well as indicate to significant direct and indirect economic losses (although not yet estimated by private and public actors), such as infrastructure damage and economic activities disruptions.



# 4



## Incorporating Disaster Risk Management in the Transport Sector in Brazil

Challenges and Opportunities

# Moving forward Challenges and Opportunities





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The attempt to develop a multisectoral project demands strong engagement from the many implementing actors in São Paulo State (e.g. State Department of Transportation, Secretariat of Environment, Geologic Institute). In the specific case of the transport and DRM overlap, a major obstacle refers to the lack of awareness that transport agents currently have in regards to DRM. Anecdotal experiences point to limited recognition and knowledge from the transport sector associating damages and losses to the occurrence of recurrent disasters events in Brazil.

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In this backdrop, the World Bank team has been promoting a close dialogue with Government of São Paulo's representatives in order to clearly present how natural events can impact transport operations as well as how a better understanding of these impacts can lead to a proper identification of sector wide vulnerabilities. Along with international experiences such as the impacts on worldwide supply chains after the recent 2011 Great Eastern Japan Earthquake and Tsunami and national cases (e.g. 2008 Floods in Santa Catarina State and the subsequent impacts on the Port of Itajaí, 2010 Floods in Parana State and lost highway connections with the coastal area), representatives from the transport sector in São Paulo were encouraged to be engaged in the project.

The abovementioned draw a set of opportunities to improve the sector's resilience against natural disruptive events as well as highlights a series of challenges in order to properly accomplish the project development objectives. These as listed as follows with the ultimate aim to promote the development of studies and the implementation of practices that can reduce economic and human impacts whenever transport infrastructures are partially or fully impaired.

**a.** To identify hazards and vulnerabilities inflicting transport infrastructures depends on the engagement of different institutions in São Paulo, namely Geological Institute (IG) and the State Department of Transportation (DER). While





IG presents the capacity to both identify and map risks as well as monitor developing situations, it is necessary an implementation agency such as the DER to use the information generated in practical grounds, i.e. highway operation.

**b.** To integrate both planning and operations from the State Department of Transportation (DER) and the Geologic Institute (IG) in order to allow for the development of ex-ante approaches to reduce damages and losses in the case disaster occurrence. Such challenge refers to findings from numerous DRM studies that conclude that investments in prevention are more efficient than investments in post-disasters situation. Thus, contingency plans developed in parallel by DER and IG could be an effective way to reduce post-disaster expenditures and better prepare the transport sector to respond to disasters.

**c.** To serve as a successful cross sectoral experience between transport and DRM in face of the intrinsic criticality of the transport sector in Brazil and worldwide. Combining

the complexities from the transport sector and the conceptual frameworks from the DRM field is rather a complex activity, but with great benefits for economy and communities the context of development.

**d.** The event and the series of consequences associated with its occurrence highlights both the urgency to improve DRM practices into State institutions as well as the complexity of managing extreme events. In the context of the proposed São Paulo operation, the focus on the transport sector is confirmed by the key role that such infrastructures play not only during response but also in business as usual situations.

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# 5



## Incorporating Disaster Risk Management in the Transport Sector in Brazil

Challenges and Opportunities

# Conclusions





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While the previous described operation has a great potential to increase the resilience of the transport sector against natural extreme events, it is of paramount importance to ensure that the proposed activities reach practical outcomes.

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Worldwide experiences show that mainstreaming DRM in sectoral levels is only successful when the proper motivations and needs are clearly identified so business as usual practices can be incorporated with DRM components. Hence, without the proper engagement from the targeted sector and the definition of clear methodologies, the development of DRM practices can potentially become a theoretical endeavor.

In this context, it is needed to convey clear messages to the different counterparts that DRM is indeed a tool to protect the development process from disruptive events and therefore shall not be regarded as a sector or limit its influence into single sectors. Furthermore, growing interdependencies among different

sectors (transport, health, economy, electricity, environment) and greater exposure of critical infrastructures point to the urgent need to frame DRM under a multisectoral and multidisciplinary approach.

For São Paulo case, the transport sector was chosen due to its high importance at both national and sub-national levels. Further to that, São Paulo State sits among the most prepared ones in terms of technical capacity and funding availability to embark in such a novel exercise in the country. It is hoped that the operation will lead to new and practical findings that will support Brazil to quickly move the urgent DRM agenda through either replication or adaptation of the model developed and adopted in São Paulo in other States.





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Challenges and Opportunities



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