Municipal Risk Reduction Plan as a tool for risk management

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Abstract

In 2007, the Institute for Technological Research (IPT) developed, for the Ministry of Cities, the methodology to map landslide risk and river erosion margin adopted throughout the national territory. The unified methodology allowed the Ministry of Cities to launch public policies for risk reduction and address high and very high risk situations for landslides. In the São Paulo State between 2005 and 2018, five municipalities were mapped following this methodology twice during this period, named Cunha, Guarujá, Itapevi, Santos and São Paulo. The present paper will address the number of sectors mapped, if the stipulated degree of risk remained between the mappings or if there was a reduction in the same. In a first analysis it can be observed that the number of mapped areas increased from one mapping to another, as in the case of the municipalities of Cunha, Itapevi, Santos and São Paulo. However, for the city of Guarujá there was a reduction in the number of landslide risk sectors. In 2013 for the municipality of Cunha 12 landslide risk sectors were mapped and in the year 2018 13 sectors were mapped. For Itapevi, in 2006, 76 sectors were mapped and in 2009, 149 was mapped. In the municipality of Santos, in 2005, 76 sectors were mapped and in 2012 a total of 102 sectors. For the city of São Paulo, in 2003, 533 risk sectors were mapped. And in 2010, the number of sectors mapped was 1179. Regarding the degree of risk in the municipality of Cunha, there was a reduction in the number of sectors classified as high risk from seven to four sectors. In the city of Guarujá, there was also a reduction in the number of high-risk sectors from 22 to 14. And the 17 very high-risk sectors were reclassified to high-risk sectors or to monitoring sectors due to increased occupation or structural works. In the municipality of Itapevi, the opposite was true: an increase in the number of high and very high risk sectors from 28 to 52. The same occurred in Santos, where 55 high and very high risk sectors were mapped to 63. In the city of São Paulo, the number of high and very high risk sectors increased from 310 to 602. It should be noted that, for the municipalities that had an increase in the number of high and very high risk sectors there was also an increase in the number of slums mapped.

1 INTRODUCTION

Due to the economic and social conditions of the last decade, there has been an increase in the number of people living in landslide and flooding risk areas in Brazil.

Natural and technological disasters have increasingly affected several countries in the world, and Brazil is not immune to these events. Societies around the world are constantly living under the impact of the most varied threats, be them natural (such as landslides), technological (such as fire from dangerous cargo), or even social (terrorism is one of many examples).

Global concern about this issue is clearly expressed in the themes of the last two World Disaster Conferences sponsored by the United Nations (UN). The 2nd World Conference on Disaster Risk Reduction in Hyogo (Japan) in 2005 focused on disaster reduction, and the 3rd Conference in Sendai (Japan) in 2015 focused on risk management.

The perfect equation of these problems necessarily involves risk management systems that can be established at the three levels of government: federal, state and municipal. However, it is in the municipalities that the problem occurs with greater intensity. Since the responsibility for planning and controlling land use and occupation is municipal, and where the affected population lives, although part of the legislation for authorizing the operation of various enterprises is not under the jurisdiction of the municipalities, but of federal and state governments. The establishment of the risk management process in the cities is not, in any way, something simple and fast. In Brazil, disaster management is the focus of almost all of our administrations; so much is that, the topic of risk is centered in the structures of prompt response, invariably civil defense, when it exists and is active, or the fire departments.

Thus, identifying, characterizing the situations, and guide decision making for risk mitigation actions resulting from landslide and erosion margin undermining processes is the most important role when preparing the Municipal Risk Reduction Plan (PMRR). These goals are achieved through the mapping and characterization of the risks regarding housing conditions, construction and technical and managerial references which, from an extensive survey and analysis of data, enable the public manager to program and implement structural and non-structural interventions considered priority. These can reduce and mitigate the occurrence of landslide on the slope in the case of houses located on unfavorable reliefs to occupation (hills of high slopes), and erosion of margin (in the case of houses located at the valley bottom), according to the history of occurrence of accidents recorded and indicated by the teams of the Municipalities.

Several municipalities have advanced in terms of preparing their Municipal Risk Reduction Plan, especially after the approval of Law No. 12.608/2012 (Brasil 2012), which instituted the National Policy for Civil Protection and Defense, providing for the National System of Civil Protection and Defense and the National Council for Civil Protection and Defense, where, in its Article 2, emphasizes that it is "the duty of the Union, the States, the Federal District and the Municipalities to adopt the necessary measures to reduce disaster risks.

In the State of São Paulo, between 2005 and 2018, five municipalities were mapped twice during this period, following the methodology developed by the Institute for Technological Research (IPT) in 2007 for the Ministry of Cities to map the risk of landslides and the margin erosion of rivers. This methodology, adopted throughout the national territory, allowed the Ministry of Cities to launch public policies to reduce risks and address situations of high and very high risk landslides, as occurred in the municipalities of Cunha, Guarujá, Itapevi, Santos and São Paulo (Figure 1)

The present work will address the number of mapped sectors, whether the stipulated risk degree remained during the interval between the mappings or if there was a reduction in it.

2 RISK MAP METHOD

The methodology of the work followed the methodology adopted and published by the Ministry of Cities (Ministério das Cidades; Instituto de Pesquisas Tecnológicas – IPT, 2007).

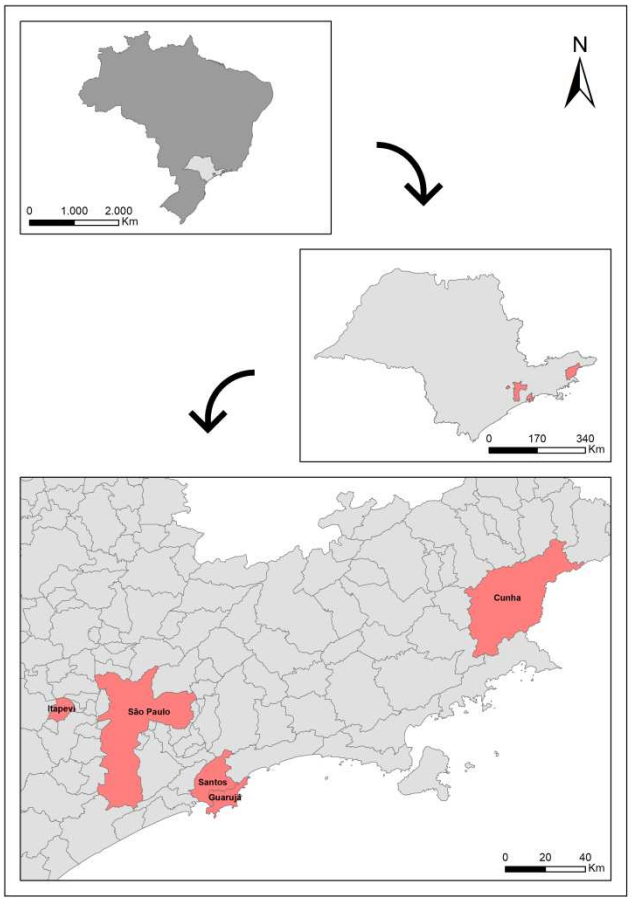

Figure 1. Location of the five municipalities.

The survey and analysis of data was carried out, essentially from the files existing in the Municipalities, Municipal Civil Defenses and data collected by the IPT team. It was the responsibility of the Municipalities to provide copies of the projects, plans, aerial photographs and studies related to the subject including: history of interventions in the risk sectors, history of occurrences attended in the risk sectors, planialtimetric maps, photographic documents and other materials.

These data were organized and systematized through maps, files and photographic documentation in order to establish criteria and procedures for the evaluation of the sector risk in the areas and the establishment of guidelines aimed at minimizing risks, in order to subsidize risk management, as well as to establish technical and social parameters, together with the municipality technicians, in order to promote greater safety of the population and/or eliminate risks. The field work for the evaluation of the current situation of risk areas in the municipalities was carried out by the IPT team, with the assistance of the technicians from the Municipal Civil Defenses.

The most critical areas for landslide and flooding processes correspond, in most cases, to those places where the infrastructure is sometimes not adequate to solve the problems related to the processes of the physical environment in the face of the interventions made by the occupation.

In all areas selected for risk mapping, oblique photographs were taken by unmanned aerial vehicle (UAV) overflight at average heights between 100 m and 150 m from the ground, which were used to delimit the risk sectors identified during field work and also to indicate possible structural interventions (engineering works) for the sectors with High Risk (R3) and Very High Risk (R4). Besides the oblique photos, aerial photos (orthophotos) were used in order to spatialize, on a larger scale, the distribution of the areas in the municipality.

In the mapped areas, potential situations of landslide, erosion of margin, and flooding were analyzed, and the following procedures were adopted:

a) Characterization of geological and geomorphological features and processes occurring in the area, including the characterization of soil profiles;
b) Inspection in each area, by means of geological and geotechnical surface investigations, in order to identify conditions of the instability processes, evidence of instability, signs of the development of destructive processes and the severity of the process that affects the elements at risk for landslide;
c) Inspection in each area, by means of surface geological-geotechnical investigations, aiming to identify process triggers, evidences and signs of achievement, evidences of the process range and the severity of the process that affects elements at risk for flooding;
d) Record, in field sheets, the characteristics of each mapped sector and the results of the geological-geotechnical investigations;
e) Delimitation of risk sectors, representing them in the oblique aerial photographs obtained by UAVs and in orthophotos, in a Geographic Information System - GIS environment;
f) Estimation of the potential consequences of the expected process, through the evaluation of the possible forms of

development of the active destructive process (for example, mobilized volumes, debris trajectories, flooding range areas, maximum level of flooding, etc.), and the number of houses threatened, in each sector of risk;

g) Evaluation and definition of the risk degree of the stabilization (landslide, rockfall and erosion margins), or flooding, valid for a period of 1 (one) year, according to criteria of the methodology for mapping risk areas (Ministry of Cities, Technological Research Institute, 2007); and

h) Indication of the appropriate intervention alternatives for the R3-High and R4-Very High risk sectors for landslide, with their respective cost estimates.

The risk sectors were delimited with the indication of the probable destabilizing processes, which is, landslides on natural slopes or cutting slopes and embankments. The criteria for judging the probability of the destabilizing processes of occupied slopes landslides kind, as well as the parameters analyzed for further procedures are presented in Table 1 (Macedo *et al*., 2011).

Table 1. Criteria for determining the probability degree.

PROBABILITY DEGREE	
R1 - Low Risk	R3 - High Risk
Concerning to evaluated indicators, the area shows low risk to develop landslides processes	Concerning to evaluated indicators, the area shows high risk to develop landslides processes. Relevant indicators of instability processes can be observed
R2 - Medium Risk	R4 - Very High Risk
Concerning to evaluated indicators, the area shows medium risk to develop landslides processes. Just some indicators of instability processes can be observed.	Concerning to evaluated indicators, the area shows very high risk to develop landslides processes. Almost all the indicators of instability processes can be observed. It is the most critical condition.

3 COMPARE LANDSLIDE MAP RESULTS

The risk mapping was performed by the technical team of the Institute for Technological Research (IPT). The analysis of the data allows us to observe if the structural interventions indicated by IPT were adopted for risk reduction.

In a first analysis we observed that the number of mapped areas increased from one mapping to another, as in the case of Cunha, Itapevi, Santos and São Paulo municipalities.

In 2013 for the municipality of Cunha were mapped 12 landslide risk sectors and in the year 2018 were mapped 13 sectors. Regarding the risk degree in the Cunha municipality, there was a reduction in the number of sectors classified as high risk from seven to four sectors (Figures 2 and 3).

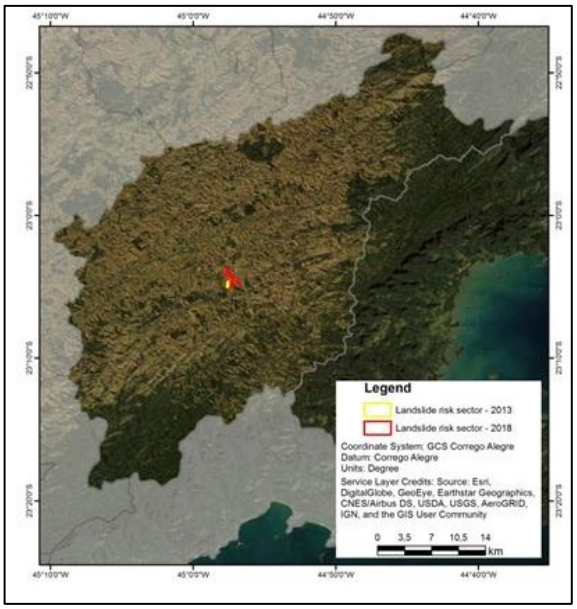

Figure 2. Landslide risk map for Cunha count.

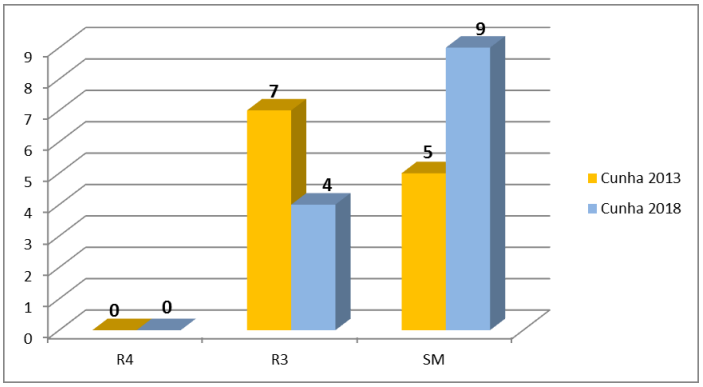

Figure 3. Results of risk mapping for the Cunha municipality.
Note: Very high risk – R4; High risk – R3 e SM – Low or Medium risk sector

In the comparative analysis for the Itapevi municipality, it can be seen that in 2006, 76 sectors were mapped and in 2009, 149 was mapped. Figure 3 shows an increase in the number of high and very high risk sectors (Figures 4 and 5).

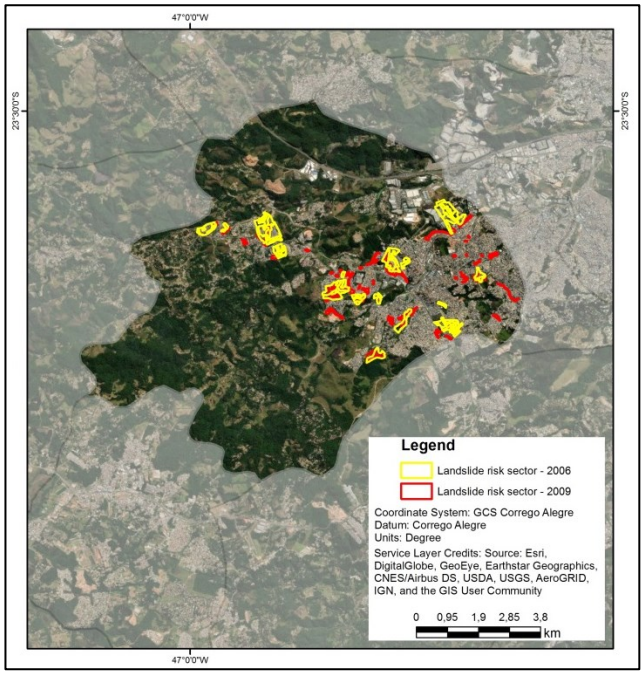

Figure 4. Landslide risk map for Itapevi count.

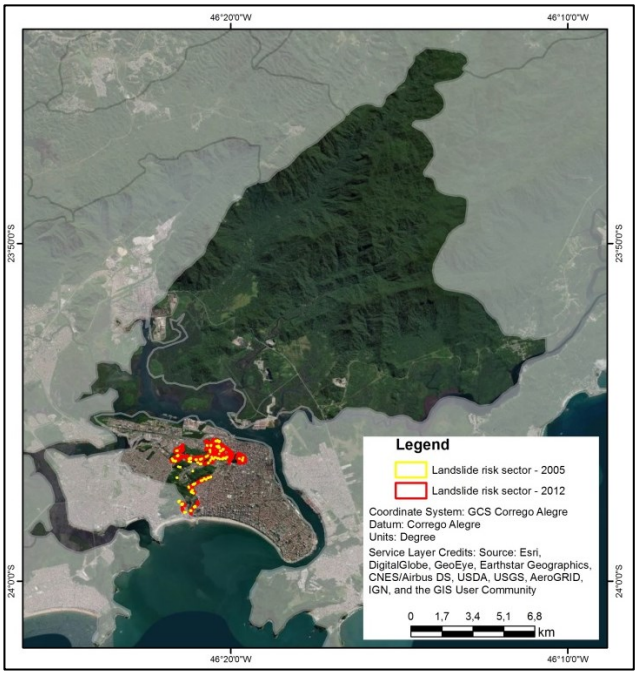

Figure 6. Landslide risk map for Santos count.

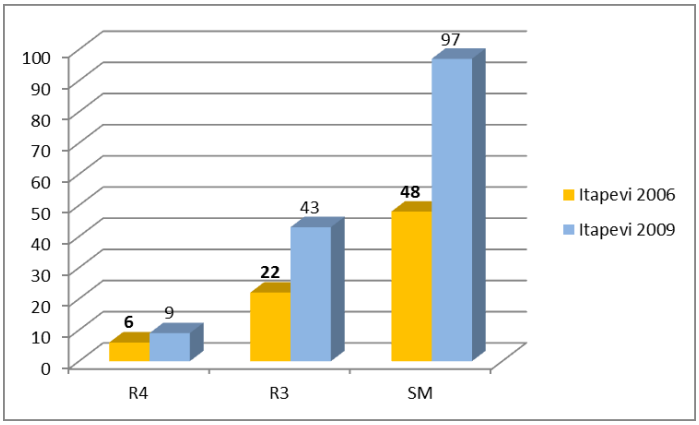

Figure 5. Results of risk mapping for the Itapevi municipality.
Note: Very high risk – R4; High risk – R3 e SM – Low or Medium risk sector

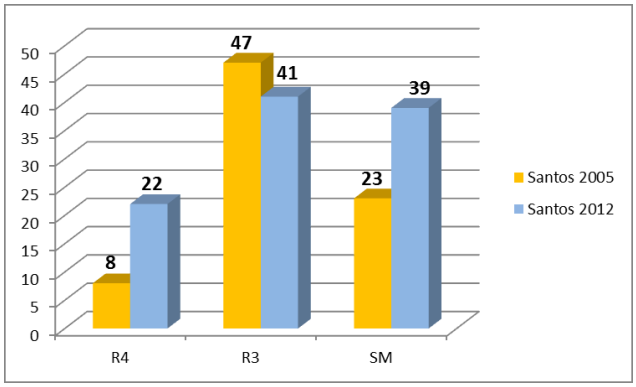

Figure 7 Results of risk mapping for the Santos municipality.
Note: Very high risk – R4; High risk – R3 e SM – Low or Medium risk sector

In the Santos municipality, in 2005, 76 sectors were mapped and in 2012 a total of 102 sectors. Thus, there is an increase in the number of very high risk sectors, but as for high risk, there was a decrease in the number of sectors (Figures 6 and 7).

In the city of São Paulo in 2003, 533 risk sectors were mapped. In 2010, the number of sectors mapped was 1179 (Figure 8). Figure 9 shows that there was an increase in the number of high and very high risk sectors.

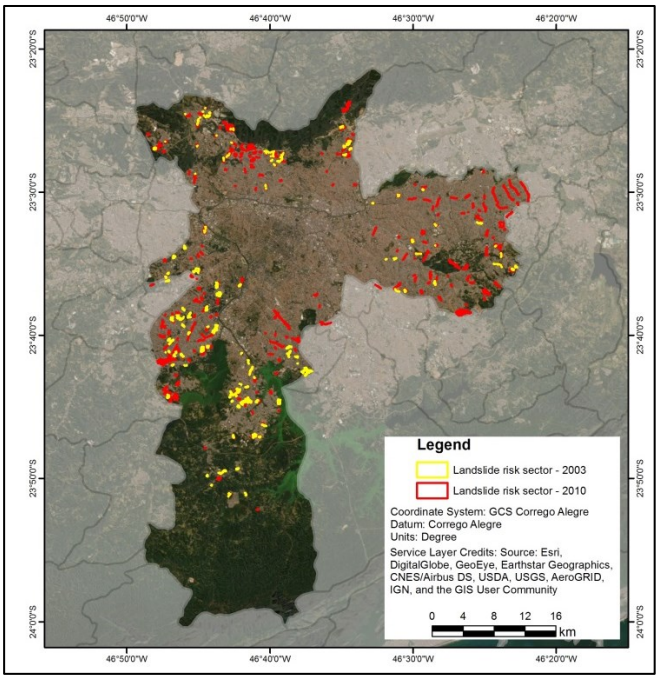

Figure 8. Landslide risk map for São Paulo count.

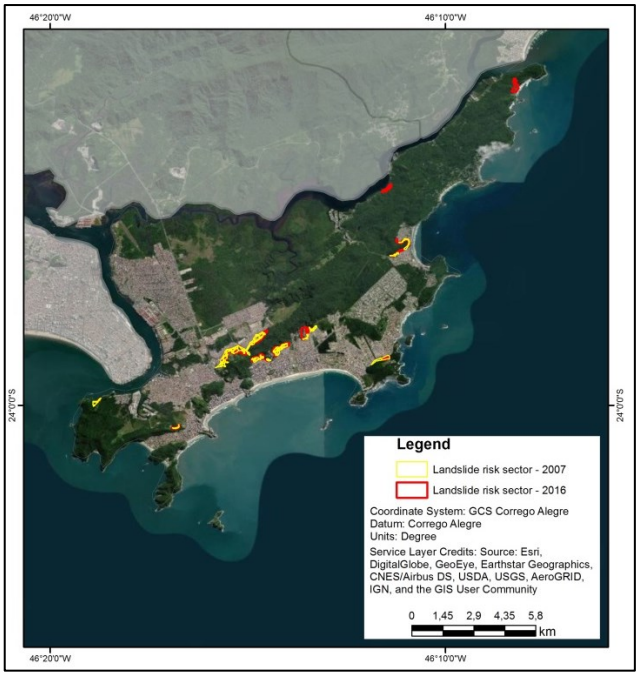

Figure 10. Landslide risk map for Guarujá count.

In the city of Guarujá, there was also a reduction in the number of high-risk sectors from 22 to 14 (Figure 10). And the 17 very high-risk sectors were reclassified to high-risk sectors or to monitoring sectors due to increased occupation or structural works. The comparison between the two mappings allows us to observe that a reduction in the number of Very High (R4) and High (R3) risk sectors occurred (Figure 11).

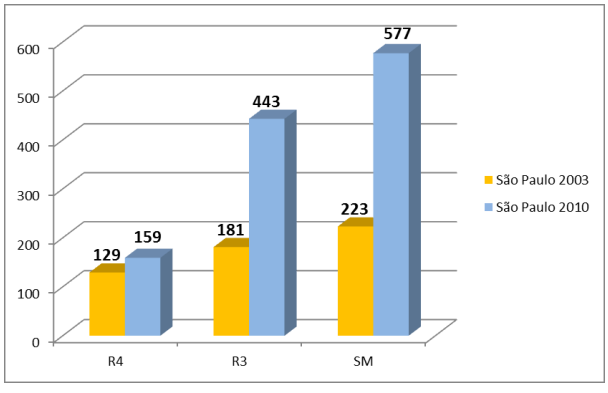

Figure 9. Results of risk mapping for the São Paulo municipality.
Note: Very high risk – R4; High risk – R3 e SM – Low or Medium risk sector

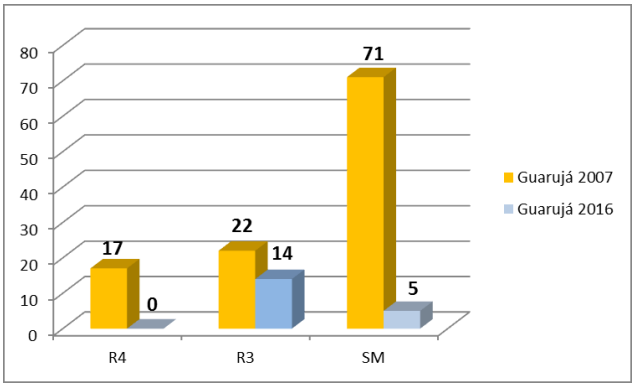

Figure 11. Results of risk mapping for the Guarujá municipality.
Note: Very high risk – R4; High risk – R3 e SM – Low or Medium risk sector

4 CONCLUSION

In municipalities with an increase in high and very high risk sectors between one mapping and another may be associated with the absence of public policies and implementation of structural interventions to reduce the risk degree. However, depending on the period of one mapping and another, one can also consider a worsening of economic conditions with an increase in the number of unemployed people and consequently an increase in the number of informal settlements.

In cases where a reduction in the number of high and very high risk sectors occurred, the factors that caused this may be: implementation of the proposed structural interventions, increase in the number of dwellings in the sector reducing empty spaces.

5 REFERENCE

BRASIL b Lei nº 12.608, de 10 de abril de 2012. Institui a Política Nacional de Proteção e Defesa Civil - PNPDEC; dispõe sobre o Sistema Nacional de Proteção e Defesa Civil - SINPDEC e o Conselho Nacional de Proteção e Defesa Civil - CONPDEC; autoriza a criação de sistema de informações e monitoramento de desastres; altera as Leis nºs 12.340, de 1º de dezembro de 2010, 10.257, de 10 de julho de 2001, 6.766, de 19 de dezembro de 1979, 8.239, de 4 de outubro de 1991, e 9.394, de 20 de dezembro de 1996; e dá outras providências.

Macedo E. S, Canil, K., Silva, F. C., Mirandola, F. A., Gramani, M. F., Ogura, A. T., Corsi, A. C., Santos, L. P. (2011). *"Methodological procedures to landslide risk mapping in Brazilian slums"*. Proceedings of the Second World Landslide Forum, Rome.

Ministério das Cidades, Instituto de Pesquisas Tecnológicas do Estado de São Paulo – IPT (2007). *"Mapeamento de riscos em encostas e margem de rios"*. Org. Celso Santos Carvalho, Eduardo Soares de Macedo, Agostinho Tadashi Ogura. Brasília: Ministério das Cidades; Instituto de Pesquisas Tecnológicas – IPT, 2007.