THEMATIC CONTRIBUTION

# Municipal plan for the reduction of risks of landslides in areas with precarious habitation: a methodological approach

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**Abstract** This article presents a methodology developed by the Institute for Technological Research of São Paulo, sponsored by the World Bank – International Bank for Reconstruction and Development – International Development Association, as a tool to elaborate the Plan Municipal Risk Reduction, which is inserted in the Program of Urbanization, Regularization and Integration of Precarious Settlements. This Plan consist in a document to guide states and municipalities on the assessment and management of landslides risk areas, in order to implement interventions related to the land regularization, security, and habitability for population who lives in precarious areas.

**Keywords** Risk plan, government, landslides, slums, Brazil

## Introduction

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Program of Urbanization to precarious habitations (Program of Urbanization, Regularization and Integration of Precarious settlements), implemented by the Brazilian Government since 2002, has been applied in several cities in Brazil.

It is coordinated by the Federal Government, which provides funds to states and municipalities, in order to implement interventions related to the land regularization, security, salubrity and inhabitation of population who lives in precarious areas.

One of the actions related to prevention and control of hazards in slums, under this program, is the "Action in support of prevention and eradication of risks in poor housing", which the main task is the development of a Municipal Plan for the Reduction of Risks, focused on the processes of landslides.

This article aims to present the methodology that had been developed by the Institute for Technological Research of São Paulo, sponsored by the World Bank - International Bank for Reconstruction and Development - International Development Association, as a tool to elaborate the Municipal Plan for Risk Reduction.

That methodology was applied for Municipal Plans in several cities in Brazil. In the State of São Paulo, some cities like Embu, Guarulhos, Itapecerica da Serra, Jundiaí, Osasco, Guarujá, Santos, Cubatão, Caraguatatuba, Jacareí and Taboão da Serra have already the Plan done.

The main purpose of the plan is to present the hazard mapping of landslides, discussing the role of federal, state and municipal levels in a search for solutions, considering the availability of resources, knowledge and counting with community participation in order to prevent and diminish landslide risks.

#### **Theory Approaches**

The theory approach concerned to Municipality Plan for Risks Reduction reveals the importance to consider and understand the basis of landscape ecology, regeneration and environmental justice.

In the various aspects of a landscape (components, processes, relations), landscape ecology

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should be regarded as a multidisciplinary, better a transdisciplinary, science where different views and approaches are involved in a holistic manner. The principle of complementarily is helpful to understand and describe the landscape. As a crucial step, the transformation of natural science categories to categories of the human society is brought out. This is realized by land(scape) evaluation and by the elaboration of goals (visions) of landscape development.

Considering communities who live in risk areas, the aim of Plan of Risks Reduction is also based on regeneration approaches, because it is applied to land-use planning, deregulation and financial incentives to improve, give quality and security to the citizens. It means that it is a welfare-based social project, as well as considers community participation as social inclusion in the plan, is perceived to be a key component of regeneration and policy makers seek to ingrate social inclusion and sustainable development, in spite of perceived tensions between environmental and social concerns.

Nowadays environmental justice means equal access to a clean environment and equal protection from possible environmental harm irrespective of race, income, class or any other differentiating feature of socioeconomic status. Thus environmental justice research seeks to determine whether marginal and/or minority groups bear a disproportionate burden of environmental problems, and whether planning policy and practice affecting the environment are equitable and fair.

So, people who believe that they have been treated fairly are more likely to accept a decision, even where the outcome has gone against them. Tyler (2001) says that people are most likely to accept decisions when they acknowledge both the moral basis of the judgement and the legitimacy of the decision-making body.

Then, according to the IUGS (1997) the concepts of risk are:

- *Risk Estimation:* the process used to produce a measure of the level of health, property, or environmental risks being analyzed. Risk estimation contains the following steps: frequency analysis, consequences analysis and their integration.
- *Risk Analysis:* the use of available information to estimate the risk to individuals or populations,

property, or the environment, from hazards. Risk analysis generally contains the following steps: scope definition, hazard identification, and risk estimation.

- *Risk Evaluation:* the stage which values and judgments consider the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.
- *Risk Assessment:* the process of risk analysis and risk evaluation.
- *Risk Control or Risk Treatment:* the process of decision making for managing risks, and the implementation or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.
- *Risk Management:* the complete process of risk assessment and risk control (or risk treatment).

All these concepts somehow are considered in the elaboration of Municipality Plan for Risks Reduction.

#### Steps for the Elaboration of Risk Reduction Plan

The plan should be developed by well-trained technicians, who have experienced this issue, besides the essential participation of experts from local government. The mainly activities to elaborate the plan are:

- a) Develop risk areas mapping, indicating the level risk sectors, including householders in dangerous area;
- b) Give alternatives that can be implemented in order to control and/or reduce risks in those communities;
- c) Indicate an estimative of the cost / budget of interventions (structural and non structural);
- d) Support and be part of the legislation;
- e) Provide criteria for priority interventions; and
- f) Provide training landslides courses for technicians of local governments focused on risk management in order to assist them in planning and implementing practices to improve the quality of life of people living in communities affected by these risks.

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## **Methodological Proceedings**

This work has to do with environmental issues, considering the dynamic process (landslides) and the population who is affected. The methodology chosen and applied involves the geoindicators of geological-geotechnical processes on landslides and social contexts related to risks.

The products will be: map of the risk zones of landslides, the number of householders in each level of risk, the actions to prevent and control the risks in these areas, and an estimative of costs/ budgets for recovery investments.

To map risk areas is important to know the causes of landslides. In the broadest and most general sense, *landslide* is simply the down slope movement (sliding or falling) of soil, rock, or some mixture of the two, under the influence of gravity (Figures 1-6). Landslides are natural processes, but can be triggered or accelerated by one or more of the factors listed below, especially when the factors occur in combination, such as:



Figure 1 – Garbage dump landslide in a slum of São Paulo, Brazil.



Figure 2 – Precarious inhabitation next to a garbage dump landslide, São Paulo, Brazil



Figure 3 – Landslide in slope cutting, Campos do Jordão, Brazil, 2000



Figure 4 – Landslide in landfill caused the death of seven people, São Paulo, Brazil, 2001

- a) Intense or prolonged rainfall, or rapid snow melt, that cause sharp changes in groundwater levels;
- b) Undercutting of a slope or cliff by erosion or excavation;
- c) Shocks or vibrations from construction;
- d) Vegetation removal; and
- e) Placing fill (weight) on steep slopes.

The main criteria used on mapping these areas are:

- a) Area characteristics: tipology of inhabitation (masonry, wood, mixed);
- b) Terrain characteristics: natural slope (high and inclination); slope cutting (high and inclination; distance of inhabitations – top and base);
- c) Deposits existence on natural slopes or slope cutting (garbage, rubble, landfill);
- d) Movement evidences (presence of fissures in inhabitation and in the terrain; steps of subsidence; curved walls; trees, poles, walls inclined; scars of landslides);
- e) Water Action: rainfall concentration in surface;



Figure 5 – Landslide in slope cutting affected several wood inhabitation, São Paulo, Brazil, 2003



Figure 6 – Landslide in slope cutting, São Bernardo, Brazil, 2005

release of wastewater into surface, leaking pipes, sump, piping / stream head; surface drainage system (enough, precarious or satisfactory);

f) Land cover vegetation (presence of trees,

underbrush, cultivation area, or deforestation area);

g) Kind of instabilization processes expected (landslides in natural slope, landslides in slope cutting; landslides in landfill deposits, erosion, debris flow, falling and rolling block).

After identify these indicators, it is possible to evaluate the risk degree, which is based on the probability of landslides occurrence (Low risk, Medium risk, High Risk and Very High risk). It is important to know that this mapping is valid for a period of one year because of the constant changes caused by

tropical rain periods and human interventions.

a) Low Risk: concerning to evaluated indicators, the area shows low risk to develop landslides processes;

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- b) Medium Risk: concerning to evaluated indicators, the area shows medium risk to develop landslides processes. It can be observed just some indicators of instability processes;
- c) High Risk: concerning to evaluated indicators, the area shows high risk to develop landslides processes. It can be observed significative indicators of instability processes; for instance (Figure 7).



Figure 7 - Risk mapping of landslides, pointing the sector risk degree, São Paulo, Brazil

d) Very High Risk: concerning to evaluated indicators, the area shows very high risk to develop landslides processes. It can be observed almost all those indicators of instability processes; for instance: (Figure 8). It is the most critical condition found.

Concerning the risk map, it is also pointed the mainly structural interventions that can be implemented in the area (Figures 9-12):

- a) Services of cleaning the area and path recuperation;
- b) Drainage works and superficial protection;



Figure 8 - Risk mapping of landslides, pointing the sector risk degree, São Paulo, Brazil

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Figure 9 - Precarious pathway, Figure 10 - Stepped spillway for São Paulo, Brazil, 2003



energy dissipation, São Paulo, Brazil, 2003



Figure 11 - Re-urbanized slum in a flood risk area, São Paulo, Brazil



Figure 12 - Re-urbanized slum in a flood risk area, São Paulo, Brazil

c) Stabilize work in the slopes;

d) Habitation removal.

It is also planned a social work, which consists in visiting the areas to identify the community leader and the population, to distribute folders to explain the importance of the Plan and how the population can work together (Figures 13 - 16). Meetings with the communities have the proposal of:

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- a) Inform about the plan;
- b) Prepare the community to participate in the Public Meeting to discuss the Plan;
- c) Prepare the community leader to be the contact with the entirely community; and



Figure 13 – Capacity course for technicians whom work in risk management, Santos, Brazil



Figure 14 – Fieldtrip to capacity technicians to elaborate risk maps, Jundiaí, Brazil

d) Attending capacity courses.

After all, the criteria for priority interventions have to consider:

- a) Degree of geological risk;
- b) Characteristics of impacted areas;
- c) Number of householders that will be grantee;
- d) Community participation;
- e) Technical and executive parameters;
- f) Costs to implement the measures of infrastructure;
- g) Indication of Governamental Programs that can afford these measures;
- h) Public Hearing/Meeting (Federal Government, State Government, Local Government, Communities) to present the results and approve the Plan.



Figure 16 – Exercise to elaborate the risk map after the fieldtrip, Osasco, Brazil



Figure 15 - Fieldtrip to capacity technicians to elaborate risk maps, Jundiaí, Brazil

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The expected results of municipality plan for risks reduction are:

- a) Control the growth of householders in risk areas;
- b) Keep mapping and monitoring the risk areas to avoid new habitation constructions;
- c) Indicate the areas that must be prioritized to receive interventions;
- d) Elaborate a Preventive Plan of Civil Defense, considering: previous assessment before the rainy season; accomplish meeting with the communities to inform about the risks of landslides and the preventive and emergency measures supposed to be adopted; creation of an institution organization to monitory the risk areas during the rainy season; and attending emergency occurrence;
- e) Create a centre of Civil Defense composed by inhabitants of communities and volunteers and prepare capacity courses in risk management to work together with the local government.

### **Conclusions And General Proposals**

The Municipal Plan for Risk Reduction was based on a zoning methodology of landslides risk areas used in order to help on the assessment of risk areas, aiming to provide immediate, medium and long term solutions for the slums in critical situations. Considering the synthesis of the mapping of risk areas, one must establish a plan for management of mapped areas, structured from each municipality.

The installation of a monitoring program in the areas of risk based on data gathered constitutes a first application of this mapping. It is very important to bring local communities next to technicians in order to develop easy going works on the areas. To understand the potential influences on hazard risk concern, it is useful to trace the history of the hazard in the local context(s).

Some others considerations can be also outlined:

- a) Inhabitation Policy should consider and include the actions and measures of the Municipality Plan for Risks Reduction;
- b) During the process of elaboration Plan, the local government should discuss with the

communities the deadline to eradicate the risks situation;

- c) Financial resources to prevent and control risks should be included in the Annual Budget Plan of the Municipality;
- d) Federal Government through State Government and other institutions of the government should cooperate with financial resources and technical knowledge to help Local Government execute the measures to prevent and control risk situation.

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