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METHODOLOGIES FOR IDENTIFICATION OF NATURAL DISASTERS - THEORETICAL METHODOLOGICAL POSTULATE

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Abstract: This work is the result of part of a study on identifying areas at risk of natural disasters, proposed by the postgraduate program in geography at UEM - `` Universidade Estadual de Maringá``, with the aim of theoretically discussing the various methodologies applied to monitoring and planning areas with possibilities of disasters, which could cause losses of human and economic lives, both natural and anthropogenic. It is a theoretical study from a methodological point of view. Thus, giving the possibility for different professionals to study and understand the dynamics of natural causes, with those promoted by human action.
Keywords: Natural events, Fragility, Susceptibility, Planning

INTRODUCTION

Over time, cities grew and became a complex place for planners, cities, the cradle of the civilization process, began to present planning problems, and therefore, the importance of mapping, cartography and surveying areas that may suggest signs of risks, vulnerabilities and weaknesses, thus identifying geological and geomorphological characteristics, may point out guiding planning parameters.

Geological-geomorphological models can represent components of the geological environment of significance for planning land use, for engineering projects, as well as providing support for the environmental planning of urban sites. However, the urbanization of areas does not only follow geological and geotechnical criteria, but also several other factors, including their history, political decisions and economic interests (Filho, 1990). This way, the way in which spaces are occupied in urban areas does not necessarily comply with physical limits such as: occupation of steep or floodable areas on the banks of rivers. Souza (1996) demonstrates that the increasing development of human activities generates, in most cases, the triggering of flooding processes, landslides and erosion.

In this sense, the concern of this work, from a theoretical point of view, will be to highlight evaluation criteria that take lithology into account; geomorphology, type of soil and its physical parameters to map and delimit areas suitable for housing, or guide the form of occupation of areas that undergo an occupation process within cities.

THEORETICAL FOUNDATION

METHODOLOGIES APPLIED TO MAPPING RISKS TO OCCUPATION/ FRAGILITY

In the production of cartographic material, in the area of mapping, there is a very wide range of methodologies discussed and applied in the most diverse countries and with the most varied lithological and climatic differences, many of which are not applicable in countries with a tropical climate, but are adaptable to them, in this context are methodologies used by SANEJOAUND (1972), MATHEWSON & FONT (1973), IAEG (1976) and GRANT, (1975). These are the ones that stood out most in their countries of origin and internationally. The methodologies under discussion in national schools used by HARBERLEHNER (1966), HEINE (1966) and CABRAL et al. (1976) in Rio de Janeiro, COLON (1973) and MACIEL FILHO (1978) in Rio Grande do Sul. Among other authors who stand out most in the application of methodologies in Brazil in the research carried out were: SEIGMARTIN & FULFARO (1981), PEJON (1987), ZUQUETTE (1981), in the state of São Paulo, CARVALHO (1982) in (MG). But with information technology and new software there was a huge advance in the area of mapping, and those that stood out the most were: FERRANTE (1990), VEDOVELLO

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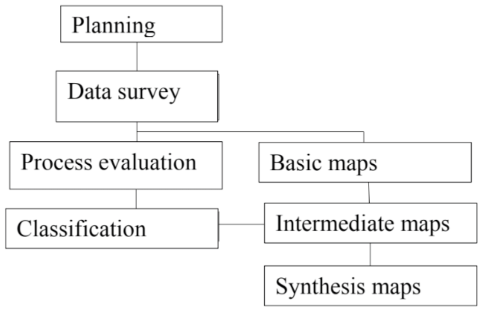

Given the large number of existing methodological proposals, some steps to be followed were outlined according to Flowchart 1. (1997)

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MAIN METHODOLOGIES

In Brazil, several comprehensive methodologies are currently being developed, but only a few were selected considering that for this study we will not delve into them in depth, so only methodologies for regional and urban mapping were selected: SANEJOAUND (1972), MATHEWSON & FONT (1973), IAEG (1976), (PUCE, in GRANT, 1975) and ZUQUETTE (1987), as shown in Table 1.

SANEJOAUND (1972)

For this methodological mapping proposal, the most frequent aspects of which are geology, geomorphology and geotechnics, concerned both with the spatial position of terrain units and morphometric units. Cartographic materials can be generated for use in the most diverse areas of knowledge in specific functions for each scale:

- On a general scale: 1: 100,000 and 1:500,000

- Regional scale - 1:25,000 to 1:10,000

- Planning zones - 1:10,000 to 1:2000

MATHEWSON & FONT (1973)

For this methodology, the main attributes to be considered are geological parameters, where the generated product will be a map of land use and urban planning and **classified according to an order:**

1st order, which show technical results of general studies.

2nd order, which directly deal with the types of soil materials.

3rd order, shows the suitability of an area for a specific purpose of land use, susceptibility or risk.

4th order, land use for engineering geology.

INTERNATIONAL ASSOCIATION OF ENGINEERING GEOLOGY, IAEG (1976)

In this methodology the most relevant factors are: rock and soil, water, geomorphology where the geological features presented on the maps are: hydrology, geomorphology. According to Aguiar (1994), it must meet objective information regarding regional planning and suitability of areas and predict variations in the physical environment, providing data that can facilitate use and application by the most varied professionals and specialists.

PATTERNS, UNITS, COMPONENTS AND EVALUATION PUCE. APUD GRANT (1975)

This methodology takes into consideration, the following aspects for mapping: geology, relief, drainage, soil, vegetation and topography, which classifies the land for use in regional and urban development. According to Aguiar (1994), land assessment cannot replace a field investigation, but rather provide rational bases for the procedure.

ZUQUETTE (1987)

Classifies the mapping according to scale, into: General Scales smaller than 1:100,000; Regional Scales - from 1:100,000 to 1:25,000; and Semi-detailed Scales - from 1:25,000 to 1:10,000. It does not recommend the use of scales greater than 1/10,000, as it considers that the volume of information would exceed that necessary for local investigation, therefore mischaracterizing the purpose of mapping.

For the Regional and Semi-detailed Scale, the purpose is to help with the occupation and the best way to carry it out. The difference between the regional and semi-detailed scales lies in the greater detail of the latter, maintaining the same attributes. These are: unconsolidated and/or rocky materials,

Methodology	Characteristics of the physical environment addressed	Scale: 103	Charter	Goal
SANEJOAUND (1972)	Rocks Covering materials Geomorphology Hydrogeology	< 100 100 – 50 25 – 10 5 – 1 > 1	Data Factors Synthetics	General (territorial and urban planning) Specifics
MATHEWSON & FONT (1973)	Rocks Soils Geomorphology Topography		1st Order (observation) 2nd Order (engineering) 3rd Order (Interpretative) 4th Order (Planning)	Suitability (planning and Interpretive)
IAEG ((1976)	Rocks Soils Geomorphology Hydrogeology	< 200 10 – 20 5 – 10 > 5	General and Specific	General Use (multispecific) Special (Specific use)
PUCE, (in GRANT, 1975)	Rocks Soils Geomorphology Topography (slope)	> 250 >250 – 100 >25 >2,5	General and Specific	Zoning (taxonomic classes)
ZUQUETTE (1987)	Rocks Soils Topography Slope Hydrogeology	< 100 100 – 25 25 – 10	Fundamental Basic Optional Assistant Derivative	Geotechnical conditions. Geotechnical zoning and specific

Table 1. Shows the methodologies discussed at national and international levels adapted: ZUQUETTE de (1987) AGUIAR (1994) and SOUZA (1996)

AUTHORS	HAZARD	RISK
VARNES (1984)	Probability of occurrence of a potentially dangerous phenomenon, in a given period of time and in a given area.	Expected degree of loss, related to a particular natural phenomenon.
BUSTAMANTE (1992)	It is defined as the latent danger posed to a city by the possible occurrence of a catastrophic event of natural or technological origin, within a period of time, with a determined magnitude.	It is a probative function that involves the concepts of "hazard" and vulnerability
ZUQUETTE (1993)	Dangerous events, external action that is exposed to a subject or a system, representing a (latent) danger that is associated with a phenomenon of natural or man-made origin, which manifests itself in a specific place, at a specific time, producing adverse effects on people, goods and/or the environment.	It is the probability that economic, social and environmental losses will occur, beyond a limit value considered normal or acceptable, for a specific place during a determined period of time. It is considered the result of the relationship between a "hazard" and the vulnerability of the exposed elements (human beings), which can be of natural origin (geological, hydrographic, atmospheric) or also of technological origin and, therefore, caused by man or resulting from his failures. elements of the occupation.

Table 3. Different definitions of natural risks and hazards organized by Souza (1994)

geomorphology, hydrogeological and hydrological conditions, form of occupation, climatic data and anthropogenic action.

ZERMOS: SEGUNDO ANTOINE (1977) AND RODRIGUES ET. AL. (1997)

Developed in France for soil risks, on scales 1:25000, 1:20000 and 1:5000, the latter being called the Zermos plant, designed for regions with mass movement, erosion, subsidence, seismic problems, whose representation to the rich using a color scale. Where:

Green, for areas without problems; Orange, indicating the potential, but without specifying the level, nature and extent of the risk; Red indicates unstable areas with real chances of risk and black is used for situations that reflect the dynamics of the observed instability. The analysis of land instability is carried out through surveys of permanent natural factors (lithology, structural, drainage) and temporal factors, and the work is divided into three phases:

10 - Bibliographic and oral survey on the existence or not of ground movements.

20 - Geomorphological studies and carried out by photo interpretation.

30 - The study and control of the main factors that affect stability.

The explanatory notes must contain comments essential for a good understanding and interpretation of the charter, with general indications on the geographical, morphological, geological, typological situation of movements, definition of zoning adopted and its consequences. Rodrigues et. al. (1997).

HINOJOSA & LEON (1978)

This proposal was developed in Spain and applies predominantly to transport routes and aims to classify land into morphodynamic units (Table 2). The map must provide complementary data reporting the degree of risk and the type of movement involved and must also provide complementary data on the structure, climate, contour and hydrological conditions of the subsurface and surface.

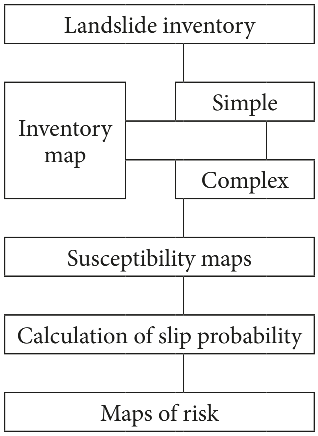
Units	Basic characteristics	Representation	Scale
Lithogroups.	Homogeneous materials from a lithostratigraphic and structural point of view	1 número	1:100000
Morph area.	Morphological differentiation within the lithogroup with typical terrain profile	Capital charter	1:50000
Morphody-namic unit.	Instability that exists in the units	Geokinetic group: By charters: One for movement and one for erosion	<1:50000

Table 2. Classify the morphodynamic units according to Zuquette, Gandolfi (1988). Rodrigues, et. Al. (1997)

BRABB IN RODRIGUES, *ET. AL* (1997)

This proposal presents a study of the landslide processes that occurred in the past and that continue to occur, and the classification of the types of mass movement (slides) and other information such as the impact of landslides on people and buildings.

To apply this methodology, cartographic material such as: basic topographic map, photointerpretation; past, present and future landslide maps showing the depth and occurrence of the event, land use for the period, analyzing the type of process involved (surface flow and landslide) and, laminar erosion map and debris fan. Steps involved in the methodology in Flowchart 2.

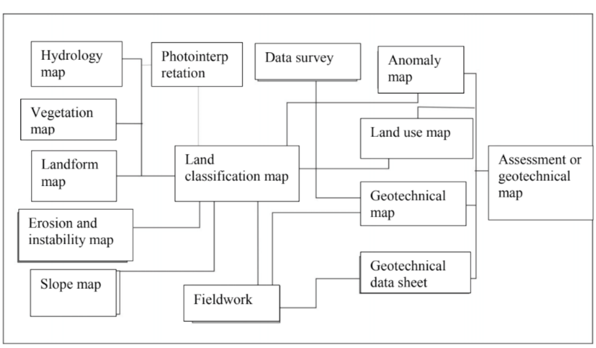


Flowchart 2. Data collection and processing steps, modified from Rodrigues, et. Al. (1997)

GEOTECHNICAL AREA STUDIES PROGRAMME (GASP) IN RODRIGUES (1997)

THIS METHODOLOGY CLASSIFIES ON TWO SCALES: REGIONAL (1:20000) AND DISTRICT (1:2500)

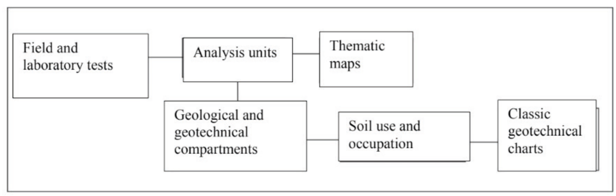
At the Regional scale, the attributes considered are: slope classes, terrain components and instability features. In the district scale, in addition to the attributes previously described, the following are considered: the morphology of the terrain; the map of landforms used for planning and field studies (landform map) and more interpretative, (Flowchart 3).



Flowchart 3. Steps for implementing this methodology According to Rodrigues et. al (1997)

CERRI (1990)

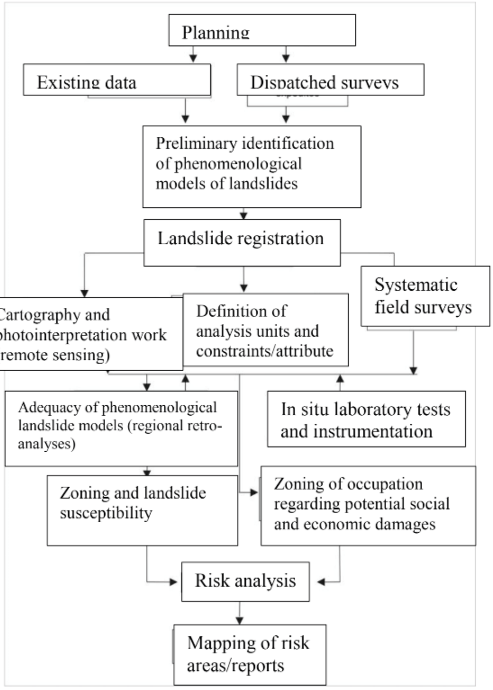
This proposal was developed in Brazil, and analyzes the distribution of different types of soil and rocks, geological properties, relief forms, active processes and changes arising from the forms of land use and occupation and the consequences of the occurrence of processes (natural and induced). The charter defines the correction and prognosis of the relationships between the physical environment and occupation. (Flowchart 4)



Flowchart 4. Mapping steps adapted from Cerri (1990)

AUGUSTO FILHO (1994)

This methodology presents the geological and geotechnical characterization of slopes where there is evidence of movement or destabilization. According to (Flowchart 5) it can be subdivided into four parts: Inventory, which consists of planning, data collection, preliminary identification of phenomenological models. Research: Definition of units of analysis and constraints, cartography work and systematic field surveys. Analysis: Zoning of occupation and susceptibility and risk analysis. Summary: Mapping of risk areas and report. An advantage of this methodology is that digital cartography and remote sensing techniques can be used in all phases of the work.



Flowchart 5. Mapping steps Proposed by Augusto Filho (1994) adapted from Souza (1996)

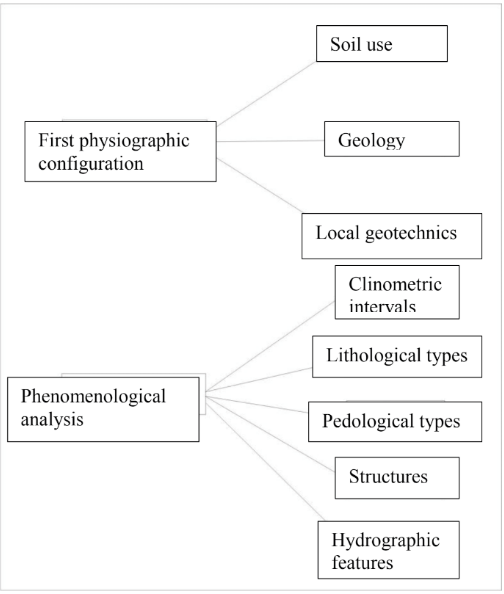
PRANDINI (1991)

In the context of this methodology, geomorphological (relief shapes and dynamics), geological (lithological types, modes of occurrence, structures, external and internal geodynamic processes) and geotechnical (terrain characteristics, soil and rock properties) aspects are considered, following steps (Flowchart 6). The results of this methodology are the geotechnical maps:

Risk charter (geological): When assessment of potential damage to the occupation prevails;

Susceptibility chart: when you want to highlight one or more undesirable phenomena or behaviors;

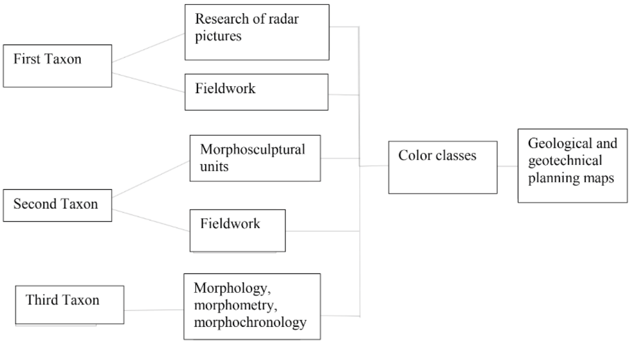
Attribute or parameter charts: They are restricted to presenting the geographic distribution to one or more forms of land use and occupation.



Flowchart 6. Modified methodological proposal from Prandini et. al. (1991)

ROSS, (1996)

This methodology was used in the Radam Brasil project (1990 and 1992) with the main purpose of using it in environmental planning, where it is associated with cartographic data combined with field and laboratory work at scales of 1:250000, 1:100000, 1:25000 and 1:10000, whose results are: morphological, morphometric and morphochronological maps. And they can be divided into taxa, as can be seen in Flowchart 7.



Flowchart 7. Methodological scheme by Ross, (1995)

GEOTECHNICAL CARTOGRAPHY

In Brazil, much has been discussed about environmental issues, mainly due to the multiplicities and variations of the physical environment (climate, vegetation, relief), having access to information of cartographic origin and accessible economic methodologies is a key factor for research scientific, however this information is not always available, especially due to political intervention in micro-regions and/or small cities.

According to Zuquette and Gandolfi (1990), they present a methodology that contributes to the development of mapping, analyzing cost-benefit:

- Present the lowest possible cost, so as not to compete with scientific research.

- Apply to the diversity of the physical environment and the large territorial extension

- Provide useful data (lithological typology)

- Allow addition of information

Geotechnical cartography is the practical expression of geological knowledge applied to tackling problems imposed by land use, which can predict the interaction between the physical environment, combining preventive and correlative measures with land use and occupation projects.

Therefore, in all stages of territorial or local planning, a prior study of the general conditions of the enterprise is necessary, whether it be the interaction of the units, or just a sketch of the physical characteristics, which will contribute to the information.

NATURAL RISKS OR MISFORTUNES

When mapping susceptible areas, methodologies are used to evaluate (natural risks or hazards) such as: geological, landslides, erosion, groundwater contamination and floods. Recent work carried out by Rodrigues et. al. (1997) aimed, mapping is the recognition of the potential for the outbreak, the types and processes involved, as well as the factors and agents responsible.

In the matter of natural risks and hazards there is a range of terminology where there is agreement and disagreement of concepts depending on the school of use and/or the methodology adopted. For RODRIGUES et. al. (1997), there is an interdependence of terms related to risks. Analyzing the general terminology, it can be considered that it classifies natural risks and hazards as having greater or lesser effect, or the conditions under which the event occurred, and the characteristics that could generate the impact, it can be said that the terms are pragmatic and controversial Souza (1994). In table 3 some concepts are grouped, defined by Varnes (1994), Bustamante (1992) and Zuquette (1993).

SHAPES AND EVOLUTION OF THE STRANDS

According to an integrative vision, the contributions of geomorphological studies and their interrelationship with other elements of the environmental system are significant, in addition to being relevant to human activities. The relief forms explain the constraints of the lithology, the results of endogenous and exogenous processes and their evolution. Morphogenetic processes are responsible for the sculpture of the relief, representing the action of external dynamics on the slopes. (Christofoletti - 1974).

At first glance, the topographic landscape appears immutable on the time scale of thousands of years. But on a local and specific scale, it presents significant changes over the course of years and decades. These changes are caused by landslides, opening and evolution of gullies, transport of debris from slopes, which are indicators of imbalances occurring in a given territory.

MASS MOVEMENT

Mass movements are defined as: those that are directly acted upon by gravity or whose material is carried by a means of transport that can be water, ice or snow. For Penteado (1983) mass movements are caused by biological activities, physical processes resulting from climatic conditions and the action of gravity.

According to Lopes (1995), there are three basic types, verticals (heaves), slips (slides), and flows (flows). Vertical movements are due to contraction and expansion processes (wet and dry) and do not transport material directly, but provide basic mechanisms for other types of movement, such as crawling. Landslides are easily characterized and occur in places where the soil moves as a mass, with the material below remaining unchanged. In flow, there is no clear surface, but rather shear throughout the material.

FLOWS

Simple runs are generally associated with the excessive concentration of surface water flows at some point on the slope and the triggering of a continuous flow process of earthen material. (Fernandes and Amaral, 1996)

SLIPS

Rapid downward movement of the material making up the slope, which may even include movements in the form of runs. Landslides are generally divided based on the shape of the rupture plane and the type of material in motion. As for the form of the movement, it can be made up of soil, rock, and a mixture of soil, rock and domestic waste. Fernandes and Amaral (op. cit.)

ROTATIONAL LANDSLIDES (SLUMPS)

In generating this movement, the existence of thick and homogeneous soils stands out, being common on slopes composed of alteration material originating from clayey rocks such as mudstones and shales. (Fernandes e Amaral -1996)

TRANSLATIONAL SLIPS

They have a planar rupture surface which accompanies mechanical and hydrological discontinuities. Such planes of weakness can be the result of the activity of geological, geomorphological and pedological processes and are generally shallow. (Fernandes and Amaral op. Cit.).

BLOCK DROPS

They occur on the steep slopes of rock walls and contribute to the formation of talus deposits, and are favored by rock discontinuity, such as fractures, compositional banding and physical and chemical weathering processes. (Table 4), classification of mass movement organized by Fernandes and Amaral (1996.) According to Freire (1965), Guidini and Nieble (1984) and the Institute for Technological Research (1991).

Freire (1965)	Guidini and Nieble (1984)	IPT (1991)
Runoffs:	**Runoffs:**	**Crawls**
CRAVES AND RUN	Crawls and runs	Mass Races
SLIPS:	**SLIPS:**	Slips
ROTATIONAL AND	**ROTATIONAL AND**	
TRANSLATIONAL	**TRANSLATIONAL**	
	Block Falls and Debris	Falls/tips
	Subsidence:	
Subsidence and	Subsidence,	
	Repressions and	
Collapse	Landslides	
	Transition Forms	
	Movements	
	Complexes	

Table 4. Classification of types of mass movements according to Freire (1965), Guidini and Nieble (1984) and the IPT (1991)

Christofoletti (1974), classifies all gravitational movements that promote the movement of particles or parts of the regolith down the slope, as:

Creeping (creep or reptation): These are displacements of particles, promoting slow and imperceptible movement of the various soil horizons.

Solifluction and mudflows: It corresponds to the collective movements of the regolith when it is saturated with water, which can move a few centimeters or decimeters. It occurs when the presence of an impermeable layer of regolith prevents water penetration, causing saturation of the overlying layer.

Avalanche: It is the fastest regolith flow known, moving enormous amounts of materials, the composition of which can be either ice or snow or rock fragments.

Slipping: Movement of a mass of regolith over an ordinary basement saturated with water, which may be through a healthy rock or through a regolith horizon with a large quantity of fine elements (silts, clays), thus reaching a very rapid limit of plasticity.

Collapse: Rapid displacement of a block of earth, when undermining creates a void at the bottom of the slope.

RISK ASSESSMENT METHODOLOGY INTEGRATING HAZARD, RISK AND VULNERABILITY

Varnes (1984), Bustamante (1992), and Zuquette (1993), a methodology for risk assessment can be developed that encompasses the concepts of "hazard", "risk", and vulnerability. This methodology can be used by teachers and authors in teaching and research related to risk management. Here is a description of this methodology:

DEFINITION OF KEY CONCEPTS

- **Hazard:** This concept refers to the probability of occurrence of a potentially dangerous phenomenon in a certain period of time and in a specific area. It can be of natural origin, such as geological, hydrographic or atmospheric events, or of technological origin related to human actions.

- **Risk:** Risk is related to the expected degree of loss associated with a particular natural or technological phenomenon. It involves the combination of hazard (probability) and vulnerability (impact) to determine the level of risk in a specific location during a determined period of time.

- **Vulnerability:** Vulnerability is the measure of the susceptibility of elements (such as human beings, goods and the environment) exposed to a hazard. It reflects the potential for economic, social and environmental losses and is influenced by factors such as infrastructure, response capacity and planning.

METHODOLOGY STEPS

- **Hazard Identification:** In this phase, potential hazardous events are identified. This includes determining which natural or technological phenomena may pose a latent danger to a specific area.

- **Probability Assessment:** Here, the probability of occurrence of each identified hazard is assessed. This involves historical analysis of past events, statistical modeling, and geographic considerations to determine probability.

- **Vulnerability Assessment:** The vulnerability of the elements exposed to each hazard is assessed. This may include analyzing infrastructure quality, community responsiveness, and other factors that influence resilience.

- **Hazard and Vulnerability Integration:** In this step, the results of the hazard and vulnerability assessment are combined to determine the level of risk associated with each hazard. This involves applying statistical methods or mathematical models.

- **Risk Communication:** Risk assessment results are communicated in a clear and accessible way to stakeholders, including local authorities, affected communities and decision makers.

- **Risk Management:** Based on risk information, risk management strategies are developed, such as disaster preparedness, mitigation and response plans, aiming to reduce global risk.

FINAL CONSIDERATIONS

The methodology must be dynamic and subject to updates as new information and data become available. Continuous monitoring of hazard, vulnerability and risk is essential to ensure that risk management strategies remain effective over time.

The integrated methodologies, based on the concepts of hazard, risk and vulnerabilities described, offer different approaches, because they are comprehensive for the assessment and management of risks related to natural, technological and anthropogenic events. They present themselves as valuable tools and can be used by various professionals, researchers including teachers, involved in the area of risk and vulnerability management.

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