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Environmental impacts caused by urbanization in landslide risk areas: Trends and contributions from the scientific literature.

Impactos ambientais causados pela urbanização em áreas de risco a deslizamento: Tendências e contribuições da literatura científica.

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Abstract: The disorderly growth of cities has contributed to the creation of a scenario of urban unsustainability. This research aims to analyze the results of studies that address the environmental impacts caused by the urbanization process in an landslides risk area through a Systematic Literature Review (SLR). As a methodology, it is an applied research conducted via an RSL without temporal restrictions. The search terms consisted of environmental impacts, urbanization and landslide risk areas. The methodological stages of the study were: database search, meta-analysis, descriptive and bibliographic analysis. The results indicated relevant patterns in the scientific output, with a predominance of methodologies based on geotechnologies. The preliminary dataset consisted of 572 articles, of which 55 (11% of the raw data) met the research objective, revealing a higher concentration of studies in China, Brazil, and Italy, in addition to the predominance of publications in English. In conclusion, the SLR proved to be an effective technique, allowing for the identification of the importance of expanding interdisciplinary investigations regarding lanslide susceptibility analysis, thereby strengthening applied research in tropical contexts and promoting urban and socio-environmental planning strategies aligned with local realities.

Keywords: Urban growth; Landslide; Risk área; Environmental impacts; Natural disasters.

Resumo:O crescimento das cidades de modo desordenado contribuiu para a criação de um cenário de insustentabilidade urbana. Esta pesquisa tem como objetivo analisar os resultados dos trabalhos que abordam os impactos ambientais causados pelo processo de urbanização em uma área de risco a deslizamento por meio de uma Revisão Sistemática de Literatura (RSL). Como metodologia, trata-se de uma pesquisa aplicada por meio de uma RSL sem restrições no espaço temporal, os termos de busca consistem em impactos ambientais, urbanização e áreas de risco a deslizamento. As fases metodológicas de estudo foram: busca em base de dados, meta-análise, análise descritiva e bibliográfica. Os resultados indicaram padrões relevantes na produção científica, com predominância de metodologias baseadas em geotecnologias. O banco preliminar consistiu em 572 artigos, das quais 55 artigos (11% dos dados brutos) estavam de acordo com o objetivo de pesquisa, revelando maior concentração de pesquisas na China, Brasil e Itália, além da predominância de publicações em inglês. Como conclusão, a RSL se mostrou uma técnica eficaz sendo possível observar a importância em ampliar investigações interdisciplinares quanto a análise de suscetibilidade a deslizamento, fortalecendo pesquisas aplicadas em contextos tropicais e promovendo estratégias de planejamento urbano e socioambiental alinhadas às realidades locais.

Palavras-chave: Crescimento urbano; Deslizamento de terra; Áreas de risco; Impactos ambientais; Desastres naturais.

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1. Introduction

It is well known that, because of the Industrial Revolution, the urbanization process expanded throughout the world's cities (ZAZYKI; MARIN; MOURA, 2020). In Brazil, in the mid-20th century, an intense urbanization process occurred through incentives for industrialization, causing a significant portion of the population to migrate from the countryside to the cities, in a phenomenon known as rural exodus (CARVALHO et al., 2022; LIMA et al., 2021).

In this context, the accelerated population growth, and the need for housing and other conveniences, consequently resulted in an intense alteration of natural environments (ARAÚJO et al., 2025; TERFA et al., 2020). From this perspective, the heterogeneity of the distribution of social groups in the territory is related to the availability of urban infrastructure and the difficulty in obtaining land, which contributes to the increase in housing in areas of socio-environmental risk (PFALTZGRAFF; TORRES, 2024; REIS; VÉRAS, 2024; SANTOS et al., 2023).

The disorderly growth of cities has contributed to the creation of a scenario of urban unsustainability, consequently generating adverse impacts, whether through the action of man on nature, such as atmospheric pollution, irregular waste disposal, destruction of natural resources and biodiversity, or through the opposite effect: that is, nature on man in the form of natural disasters such as mass movement in soils with little stability (FERREIRA LEITE; CORTINES, 2024; SEIFOLLAHI-AGHMIUNI et al., 2022).

The accelerated urbanization process, especially in developing countries such as Brazil, has triggered significant transformations in urban territories, often without adequate planning or infrastructure (CAMACHO; MOSCHINI, 2021; LÊU et al., 2024). This unplanned growth has led to the occupation of environmentally fragile areas, such as slopes and riverbanks, increasing community vulnerability to natural hazards, particularly landslides (ANDRADE et al., 2024; FERRAZ et al., 2022). These events, intensified by factors such as soil sealing, deforestation, and the absence of effective public policies, result in severe socio-environmental impacts, including human, material, and ecological losses (SILVA et al., 2024).

Landslides are one of the most frequent and destructive hazards worldwide, and in tropical countries such as Brazil, such geological risks are significant, causing fatalities and economic losses (DIAS; GROHMANN, 2024; SILVA et al., 2025; YU; PRADHAN; WANG, 2025). Thus, according to Bezerra *et al*. (2020), factors such as inadequate occupation of areas highly susceptible to landslides are the main cause of accidents on Brazilian slopes, especially those occupied by subnormal clusters.

Although several studies address the relationship between urbanization and landslides, many remain limited to localized analyses or strictly technical approaches, leaving gaps in the integrated understanding of environmental, social, and spatial factors involved (NAKANO; MARU, 2024; OLIVEIRA et al., 2024; PORTO et al., 2025). In this regard, the Systematic Literature Review (SLR) distinguishes itself by offering a broad and critical synthesis of the scientific output of the theme, identifying methodological patterns, the most affected regions, applied approaches, and persistent gaps in the field. By synthesizing evidence from different contexts, the study contributes to expanding the understanding of the impacts of urbanization in landslide risk areas, considering both applied technological advances and the social dimensions of the issue.

Articles that use the Systematic Literature Review (SLR) mechanism are essential for scientific development, given that they play a critical role in academic research, in addition to seeking to collect information and analyze the data extracted within a specific field of study (LINNENLUECKE; MARRONE; SINGH, 2020; PICOLLI; STECANELA, 2023).

With the exponential growth of scientific publications through various journals, SLR is used as a tool that allows research to be investigated in an efficient, transparent and reproducible manner, analyzing its contribution and quality following a standard for inclusion and exclusion to facilitate the synthesis of research results (CHENG et al., 2025; SOLÓRZANO; MORANTE-CARBALHO; CARRIÓN-MERO, 2022).

The scientific contribution of this review lies in the organization of a structured database that allows no only visualization of the current state of research but also the identification of strategic directions for future investigations and public policies. By compiling, comparing, and critically analyzing studies, it is expected to provide support for sustainable urban planning, risk management, and the use of technologies. Furthermore, by considering the role of social inequalities and urban governance, the study seeks to promote a more integrated and interdisciplinary view of one of the most urgent challenges os contemporary cities.

Thus, this research aims to analyze the results of studies that address the environmental impacts caused by the urbanization process in areas at risk of landslides, contributing to the creation of a database through an RSL. Furthermore, the analysis aims to answer the following questions: (1) What are the losses of the urbanization process for the population

in areas at risk of landslides? (2) What study mechanisms are applied to analyze urbanization in risk areas? (3) What is the relationship between urbanization and areas at risk of landslides?

2. Characterization of the study área

The municipality of Recife, capital of the state of Pernambuco, is in the coastal region of northeastern Brazil, with an estimated population of 1,488,920 inhabitants in 218.843 km² of extension (IBGE, 2022). Recife is bordered to the north by the municipalities of Paulista and Olinda, to the south by the municipality of Jaboatão dos Guararapes, to the west by the municipalities of São Lourenço da Mata and Camaragibe, and to the east by the Atlantic Ocean.

According to the characterization of the territory, prepared by the City Hall of Recife (2023), the territorial area of the city consists of 67.43% hills, 23.26% plains, 9.31% aquatic areas, and 5.58% Special Environmental Preservation Zone. In addition, the city is divided into 94 neighborhoods and six administrative regions (RPAs). The study area is in RPA 3, in the neighborhood of Alto José Bonifácio, with latitude 8º00''6.0" S and longitude 34º54''9.2"W of Greenwich (Figure 1).

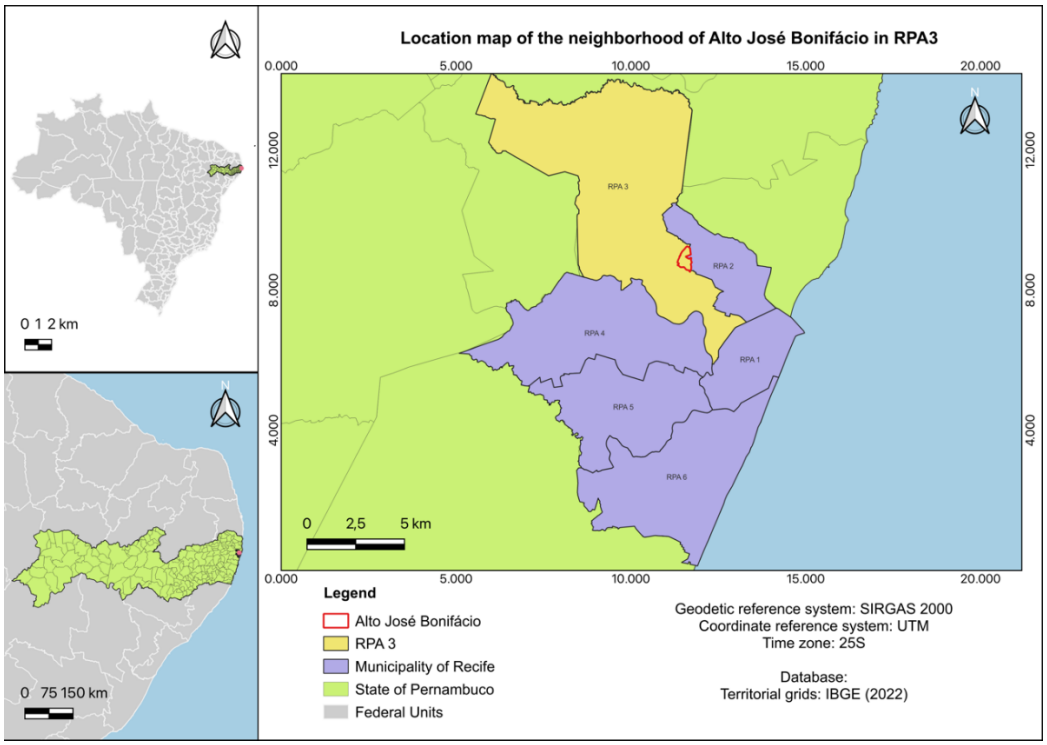

Figure 1 – Location of RPA 3 of the Municipality of Recife-PE.
Source: Authors (2025).

According to the Pernambuco Water and Climate Agency – APAC (2023), the region that covers the study area has a hot and humid tropical climate influenced by tropical maritime air masses, with the highest rainfall recorded in the months of May, June, and July. The geomorphology of the neighborhood is characterized by the presence of eastern plateaus in the northeast, composed of sedimentary plateaus, narrow valleys, and steep slopes.

The Alto José Bonifácio neighborhood is predominantly urban. According to the Geographic Information System (ESIG, 2021), the neighborhood is in the Special Zone of Social Interest (ZEIS) with the presence of housing settlements occupied by a low-income population. There is possibility for land regulation, which emerged spontaneously and are subject to mass movement on slopes.

In this context, the Systematic Literature Review will be a tool to help understand the consequences that urbanization can cause in such areas, as well as provide knowledge about the tools that, in recent years, have been used to minimize such impacts in areas subject to landslides.

3. Methodology

This study consists of applied research through an exploratory literature review, focusing on analyzing the environmental impacts caused by the urbanization process in risk areas, from various perspectives, through a descriptive bibliographic survey to investigate this topic qualitatively and quantitatively.

From this perspective, a Systematic Literature Review was adopted as a methodological instrument, following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. As for the PICo strategy, whose steps are suggested by Okoli (2019), the urbanization process was chosen as the population; the interest consisted of environmental impacts; and the context was the areas at risk of landslides. From this perspective, the present investigation was divided into 4 phases, as shown in Figure 2, which defined the systematic research method: (1) Database search, (2) Metadata, (3) Bibliometric analysis, and (4) Systematic analysis.

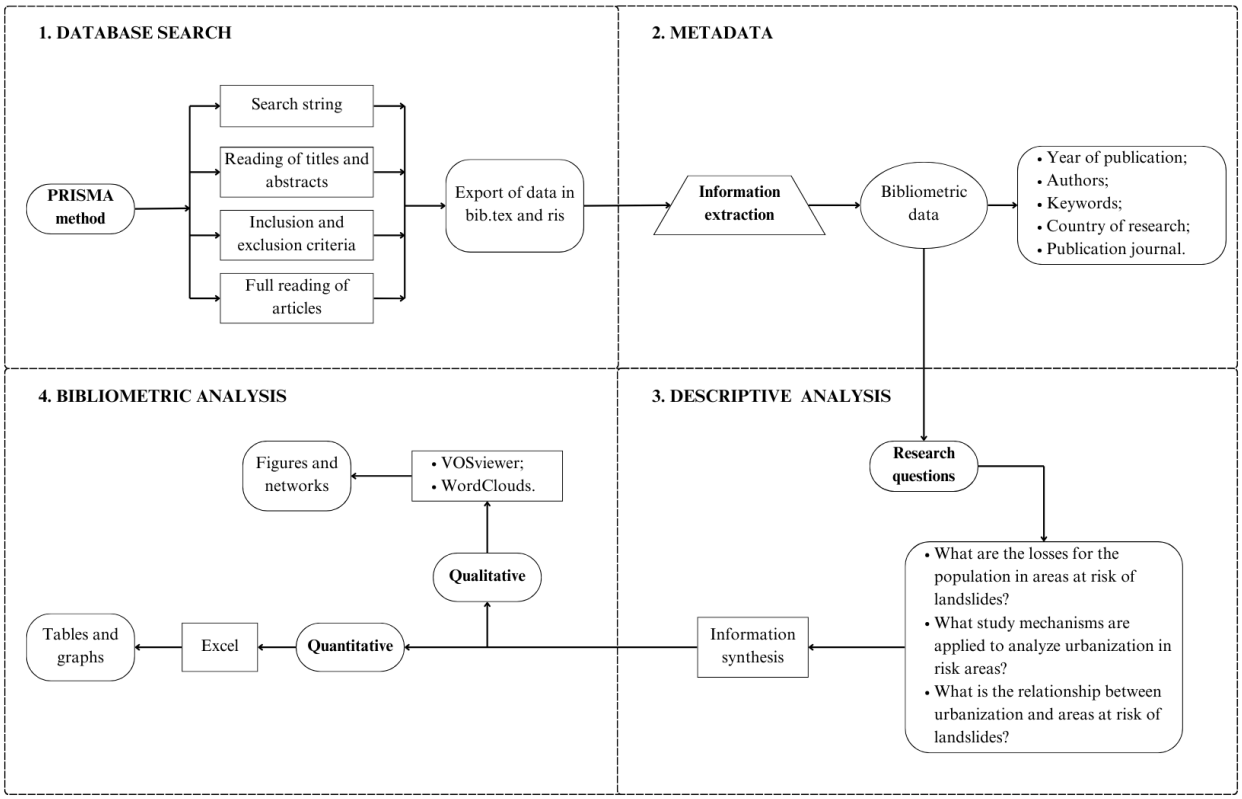

Figure 2 – Sistematic research flowchart.
Source: Authors (2025).

The works used for this study were acquired from the EBSCO host, ASCE library, Engineering Village, and Web of Science databases, as they have a collection of international publications, in addition to their multidisciplinarity and relevance with a wide scientific scope of credibility and quality in research. Access to the databases occurred through the Journal Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES), to identify studies published on the theme of environmental impacts caused by the urbanization process in areas at risk of landslides.

The search process was carried out in October 2024. As for the search strings, the keywords and Boolean operators (OR, AND) were chosen: (“environmental impacts” AND “urbanization” OR “urban Growth” OR “urban expansion”) AND (“risk areas” OR “landslide” OR “slope instability”). Some limitations/ filters were applied in the research process, such as: selection of studies in which the keywords were found only in the titles, abstracts, and keywords of each; selection of articles published in scientific journals; open access; research written in English, Spanish, French, or Portuguese; and no restrictions were adopted regarding the time frame.

Regarding the inclusion criteria, the research studies were selected according to their publication in journal with full-text availability, in addition to mentioning the urbanization process and the environmental impacts caused in areas at risk of landslides. Exclusion criteria encompassed duplicate articles; absence of search terms in the title, abstract, or keywords; studies not published in journals; works written in languages other than English, Spanish, French, or Portuguese; articles lacking well-detailed methodology and results; studies unrelated to urbanization in risk areas; and analyses not addressing landslides. Next, a selection of the titles was carried out including the year of publication, authors, keywords, country of research, and journal of publication, in order to perform the descriptive and bibliometric analysis of the selected articles.

4. Results and discussions

4.1 Descriptive analysis

Due to the consequences of urbanization in risk areas and, consequently, landslides, a descriptive analysis was carried out on the methods of landslide risk analysis studies, as well as the losses of such a natural disaster for the population.

4.1.1 Urbanization in risk áreas

According to Guo et al. (2022), approximately one-third to one-half of Earth's surface transforms due to the influence of anthropogenic activities. From this perspective, adequate land use management and landscape control, supported by the analysis of future scenarios, become an essential guide for the social and economic development of cities (SALAZAR et al., 2020; ZENG et al., 2022).

In a study carried out by Garcia et al. (2024) and Zevallos; Consuelo (2021), it is possible to verify that the urbanization model, particularly in developing countries, is guided by a territorial configuration that follows the emergence of economic activities together with the lack of planning to guide this growth process. Unplanned urban development has been occurring for a long time; the lack of planning combined with factors such as climate, geology, geomorphology, and vegetation suppression has demonstrated society's vulnerability to natural disasters (CANTARINO et al., 2021; HAMZA et al., 2020).

The accelerated and disorderly urbanization process has caused vast social inequality and environmental degradation, which manifests itself in problems such as housing shortages, ecosystem vulnerability, lack of public services and economic opportunities, as well as in the growth of settlements in areas at risk of landslides (PUENTE-SOTOMAYOR; EGAS; TELLER, 2021; SAEIDI et al., 2019).

In this scenario, according to Sestras et al. (2021), several factors can make an area prone to landslides, including predisposing factors that generate suitable conditions for landslides, such as slope, geology, land use, and triggering factors, i.e., heavy rainfall, deforestation, cutting of slopes, and construction in unsuitable locations.

Duarte et al. (2024) state that the increase in the number of people impacted by landslides in Brazil is linked to the intense urbanization process that the country has undergone over the last 2 decades. Landslides are one of the most dangerous natural disasters in terms of the frequency and severity of the damage they cause, leading to loss of life and the disruption of social infrastructure virtually across the entire world (HETTELINGH; PUZRIN, 2023; ROHAN; SHELEF, 2024; SOLÍS; ROSADO; VERA, 2024).

Cui et al. (2019) point out that a contributing factor to the greater severity of the impacts generated by landslides is also related to the lack of identification of the risk and the response to such a natural disaster, which should be provided to the community at various levels of education so that there is greater investment in improving the population's awareness and reducing risks.

The reviewed literature indicates that urban vulnerability does not stem solely from geological and geomorphological conditions, but above all from socioeconomic inequality, informal settlements, and the absence of public policies (AI et al*.,* 2022; GARCIA et al*.,* 2024; SAEIDI et al*.,* 2019). From this perspective, there is an academic consensus regarding the negative impacts of unregulated urbanization, with the current challenge lying in understanding the interaction between social and environmental factors, as well as their role in amplifying landslide risks, an aspect still underexplored in the reviewed studies.

4.1.2 Landslides risk analysis

Natural hazards have become more destructive in recent times due to rapid urban development, resulting in significant loss of human life, damage to property and infrastructure, and environmental collapse, drawing the attention of

geoscientists to the search for controlling the consequences and carrying out geological risk management (BOZZOLAN et al., 2024; REHMAN et al., 2022).

Cantarino et al. (2021) highlight the need to determine the extent to which residential areas may be at risk of landslides, understand the causes of these risks and improve planning for them; therefore, risk maps are necessary for this. Landslide susceptibility mapping and zoning is one of the most effective research methods for providing a forecast of the occurrence of natural disasters (XIONG et al., 2023; ZUMPANO et al., 2021).

Research carried out by Daoudi; Niang (2021), Peethambaran; Leshchinsky (2023), Rehman et al. (2022), Ai et al. (2022) was conducted using remote sensing technologies, Geographic Information System (GIS), as well as tools such as the Analytical Hierarchy Process (AHP) and Multi-Criteria Decision Analysis (GIS-MCDA) to produce landslide risk maps.

In the last decade, a new method has been introduced in the landslide monitoring process, consisting of the use of unmanned aerial vehicles (UAVs), geometric tools, and georadar investigations for use in complex photogrammetry and geometric techniques, as a subsidy in the preparation of landslide susceptibility maps (SESTRAS et al., 2022).

The expansion in the use of technological tools for landslide risk analysis, such as GIS, remote sensing, and UAVs, has proven effective in developed countries and temperate regions, where long-term high-resolution datasets are available for validation (REHMAN et al., 2022; SESTRAS et al., 2022; XIONG et al., 2023). In contrast, tropical and developing countries, although adopting the same methods, face a scarcity of systematized information and field surveys (DUARTE; COUTINHO, 2024; SALAZAR et al., 2020).

Paliaga et al. (2019) highlight the importance of collecting documents, analyzing data, and implementing field research to assess active dynamic processes about the possibility of landslides. Sim et al. (2023), in their research on community perceptions of landslides in Malaysia, applied a questionnaire survey method that proved to be very useful in determining the public's psychological responses and mental anticipations related to natural disasters.

These findings highlight the need to overcome current challenges by broadening the interdisciplinary scope of studies, aiming at the inclusion of social veriables in modeling, and promoting greater field validation, thereby transforming academic tools into affective instruments for urban and risk management.

4.2 Bibliometric analysis

To carry out the Systematic Literature Review, a preliminary raw database was created with 572 articles, covering the period between 1962 and 2024. To ensure a portfolio aligned with the theme, the Rayyan AI software, developed by the Qatar Computing Research Institute (QCRI), was used to find duplicate files and apply the exclusion and inclusion criteria. Thus, the PRISMA model flowchart (Figure 3) presents the results after this screening process.

The refinement process adopted in this research not only highlights the abundance of studies on urbanization and landslides but also underscores the need to apply rigorous filters to distinguish works of a tangential nature from those that effectively address the environmental issues under analysis.

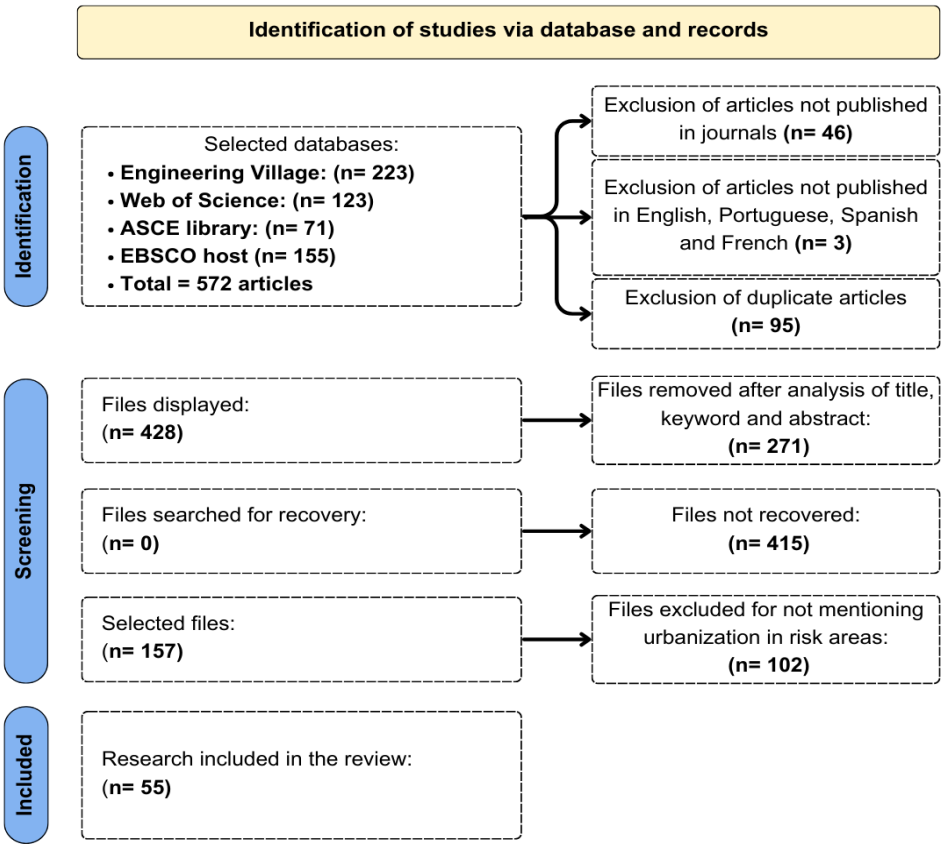

Figure 3 – Flowchart of study identification using the PRISMA method.
Source: Authors (2025).

Figure 4 presents, numerically and in percentage, the articles found in each selected journal database. Thus, Engineering Village was responsible for 223 articles, generating a percentage of 38.99%, followed by EBSCO host with 155 articles, that is, 27.10%, Web of Science with 123 articles, equivalent to 21.50% and ASCE library with 71 articles, thus, 12.41%.

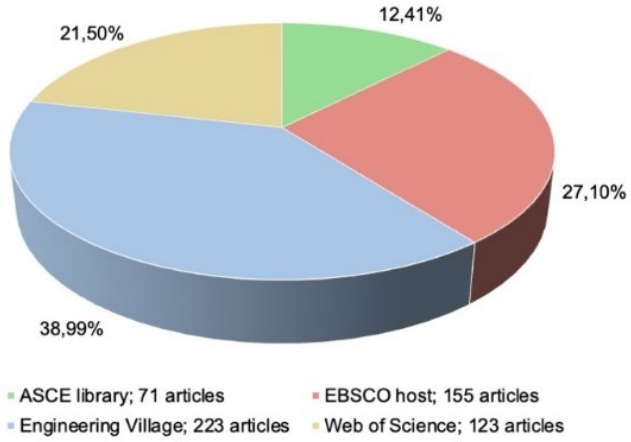

Figure 4 – Articles selected through the databases.
Source: Authors (2025).

It was found that 55 articles were in line with the research objective, that is, approximately 11% of the previously selected raw articles. Figure 5 shows the result of the number of research studies by countries that published the most about environmental impacts caused by urbanization in areas at risk of landslides.

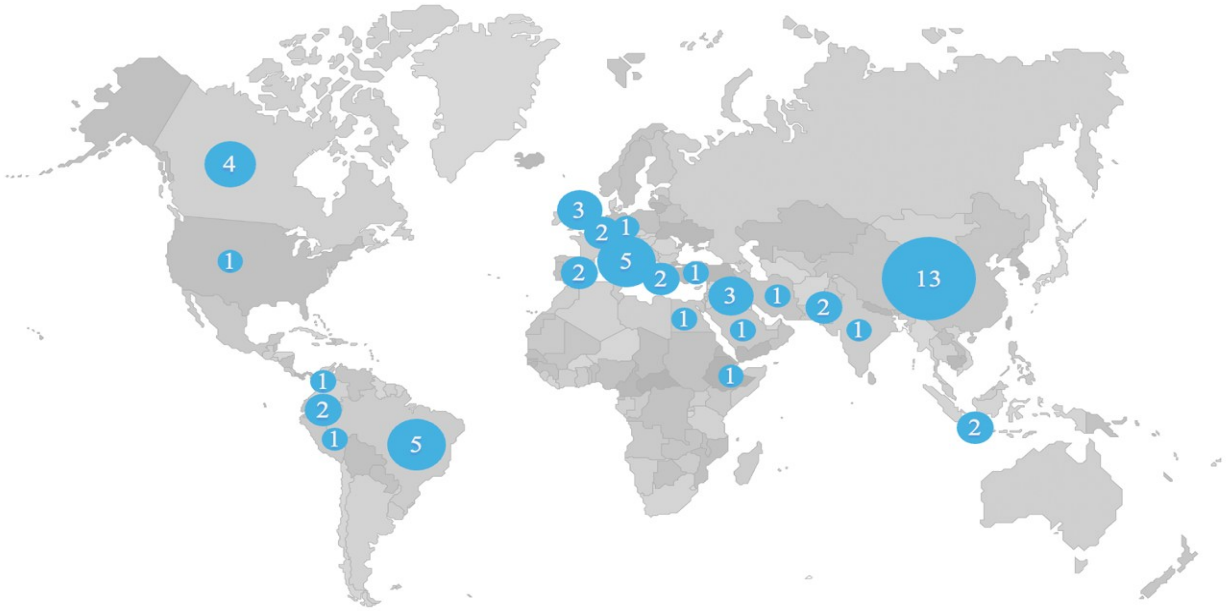

Figure 5 – Number of publications of articles found by country.
Source: Authors (2025).

China stands out with 13 publications, followed by Brazil and Italy with 5 published articles; the United States with 4 articles; the United Kingdom and Romania with 3 articles; Ecuador, Spain, Greece, Indonesia, Switzerland and Pakistan with 2 publications; and Saudi Arabia, Germany, Colombia, Egypt, Ethiopia, India, Iran, Mexico, Peru and Turkey with 1 article.

China's leadership in the field stems from the combination of rapid urban expansion in geologically fragile areas and the occurrence of extreme events, which generate both social demand and research opportunities. In Brazil, the relevance of publications is linked to the socio-environmental vulnerability of urban areas, particularly on densely populated slopes. Italy, in turn, stands out due to it is history of disasters and mountainous geology. Thus, the distribution of scientific production reflects the contexts of exposure to natural hazards in each country.

Among all 55 selected articles, 51 were written in English, reinforcing the centrality of this language in global scientific dissemination, 2 in Portuguese and 2 in Spanish. The articles were published between 2010 and 2024 (Figure 6). The year with the most significant publications was 2023, with 9 articles, followed by 2021, with 7 articles; 2024 and 2019, with 6 articles; 2022, with 5 articles published; 2016, with 4 articles; 2010, 2013, 2017, and 2018, with 3 publications; 2020, with 2 articles; and 2011, 2012, 2014, and 2015, with 1 article.

The increase in publicatios observed in 2023 can be attributed to the intensification of extreme events, advances in remote sensing and artificial intelligence methodologies that expand analytical capacity, as well as the strengthening of international agendas, such as the United Nations Climate Change Conference (COP 28). Therefore, 2023 can be seen as a reflection of the convergence of climatic, social, and technological factors.

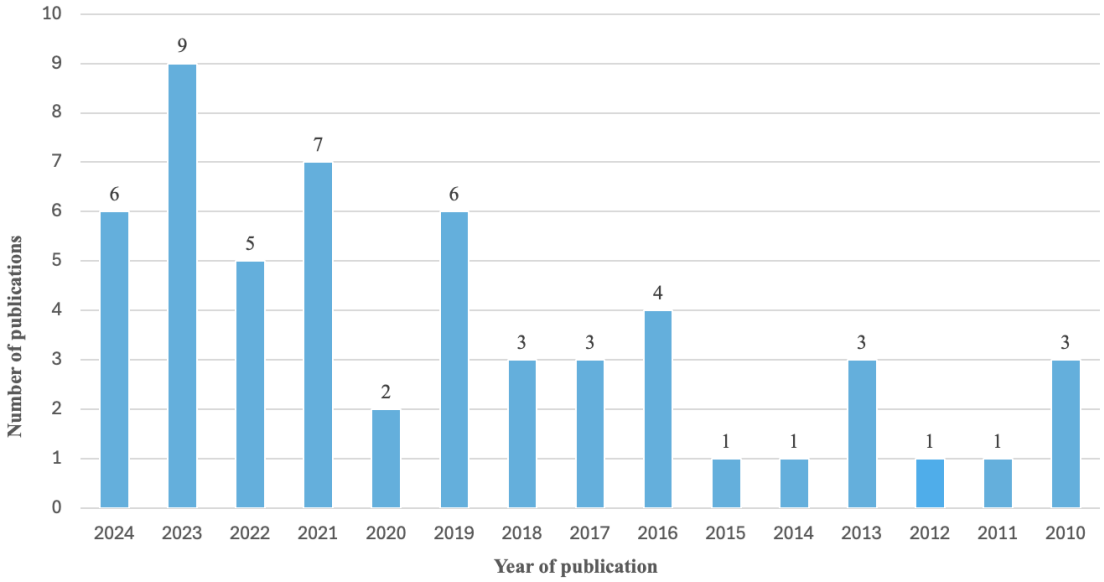

Figure 6 – Number of articles vs. Year of publication – number of publications.
Source: Authors (2025).

The keywords were analyzed using a correlation network map (Figure 7), with the sizes of the points proportional to the frequency of these words, namely, “landslides”, “urban growth”, “land subdivision”; as for the thickness of the lines, these represent the connections between the related terms.

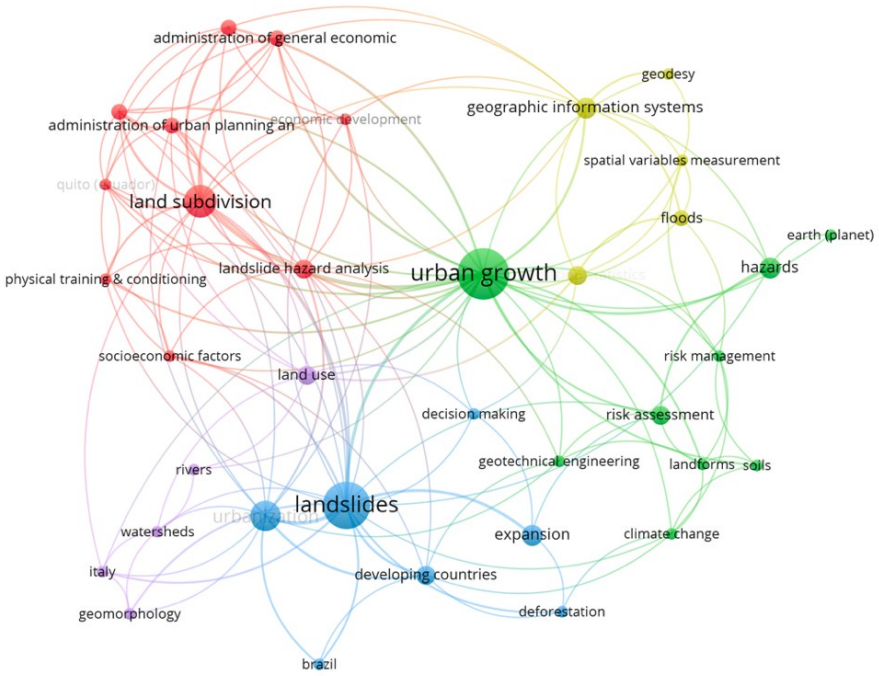

Figure 7 – Correlations of keywords.
Source: Authors (2025).

In addition, a word cloud was created (Figure 8) with the names of the journals that appeared most frequently. Among them, the journals "Remote Sensing", "Landslides" and "Science of The Total Environment" are in a larger font size, indicating that these journals were the ones that published the most articles related to the urbanization process and its environmental impacts caused in risk areas. This pattern reveals the interdisciplinary nature of such research, given the dialogue established among geosciences, technology, and the environment.

Figure 8 – Word cloud: Frequency of publication by journal.
Source: Authors (2025).

In Table 1, it is possible to verify that 5 articles address the use of the Hierarchical Analysis Process together with the Geographic Information System; 2 work with landslide monitoring using unmanned aerial vehicles; 11 carried out landslide susceptibility mapping; 5 use urban modeling methods; 4 carried out a space-time analysis to understand land use and its relationship with natural disasters; 8 used remote sensing; 6 carried out landslide simulations, in addition to the use of Artificial Intelligence and statistical applications; 8 articles worked with the questionnaire survey method, information collection through documents and data analysis; 6 analyzed risk management, mitigation and adaptations.

Table 1 – Analysis of articles selected in the systematic review.

Study mechanisms used	**Authors**
Use of the AHP hierarchical analysis process in conjunction with the GIS geographic information system mechanism	Peethambaran; Leshchinsky (2023) AI et al. (2022) Daoudi; Niang (2021) Rehman et al. (2022) Bathrellos et al. (2017)
Landslide monitoring using unmnned aerial vehicles (UAVs)	Sestras et al. (2021) Sestras et al. (2022)
Use of urban modeling methods	Saeidi et al. (2019) Zeng et al. (2022) Hettelingh; Puzrin (2023) Salazar et al. (2020) Yao; Huang; Chen (2023)

Source: Authors (2025).

Table 2 – Analysis of articles selected in the systematic review – Continued.

Study mechanisms used	Authors
Spatiotemporal analysis	Froude; Petley (2018) Quintana; Carlos (2011) Pratesi et al. (2016) Zhu et al. (2024)
Mapping of landslide susceptibility	Florence; Frankie (2018) Bozzolan et al. (2023) Guo et al. (2022) Zevallos; Consuelo (2021) Cantarino et al. (2021) Xiong et al. (2023) Yanar; Kocaman; Gokceoglu (2019) Rohan et al. (2023) Huqqani et al. (2023) Zumpano et al. (2021) Young (2013)
Use of remote sensing	Maithani; Arora; Jain (2010) Garcia et al. (2024) Wang et al. (2023) Duarte; Coutinho (2021) Zeng et al. (2023) Cui et al. (2019) Hamdy et al. (2014) Gizzi et al. (2019)
Development of simulations, use of artificial intelligence and statistical applications	Zhao et al. (2024) Kerekes; Poszet; Gál (2018) He et al. (2024) Bozzolan et al. (2024) Gerui et al. (2017) Holcombe et al. (2016)
Questionnaire survey method, document collection and data analysis	Paliaga et al. (2019) Notti et al. (2015) Puente-Sotomayor; Egas; Teller (2021) Alimohammadlou; Najafi; Yalcin (2013) Abebe et al. (2010) Filho (2012) Sim et al. (2023) Kong (2017)
Development of urban growth projections, landslide risk management	Wulandari; Supriatna; Latif (2019) Harrison; Williams (2016) Hamza et al. (2020) Ho et al. (2016) Solis et al. (2024) Filho; Caceres (2010)

Source: Authors (2025).

5. Final considerations

The main scientific contribution of this study lies in the investigation of the urbanization process, particularly in landslide risk areas, and its direct influence on their environmental impacts. The Systematic Literature Review proved to be an effective method in analyzing and understanding the main influences of the urbanization process and its environmental impacts in areas at risk of landslides, serving as a guide for future research. Through filtering in the research and application of inclusion and exclusion criteria, it was possible to perform a qualitative and quantitative analysis of the selected articles, explore publications trends, and assess their global contributions.

The literature database consisted of 55 articles, it was possible to identify methodological trends (use of geotechnologies, remote sensing, and lanslide susceptibility modeling) and relevant gaps, such as disorderly growth of cities, the lack of interdisciplinary social and technological approaches, the limited community participation in prevention strategies, and the absence of studies addressing the cumulative affects of urbanization in risk areas. These findings provide a solid foundation for researchers and decision-makers.

It was found that scientific studies have been present in a discontinuous manner over the years; however, it is possible to observe that the year 2023 marked an increase in this theme. Through the bibliographic analysis, it was also possible to observe that urbanization in risk areas is a factor that has been widely studied in Brazil (with 5 publications) and that it stands out in China (with 13 published articles), given its accelerated urbanization process and great vulnerability to natural disasters combined with intense rainfall. This is a global theme with research spread across 22 countries.

Therefore, future scenarios of susceptibility to landslides resulting from population growth and the advancement of cities into risk areas can provide useful information for managing landslide risks, minimizing such impacts, and assisting in strategic planning regarding urban expansion and socio-environmental planning.

As for the limitations of the review, it is important to highlight the restriction to publications available in indexed databases, which may have excluded technical reports and studies with relevant information. Furthermore, the methodological diversity among the analyzed articles posed challenges for direct comparison of quantitative results.

Within this context, greater integration between emerging technologies and early warning systems in predictive models is recommended. From a social perspective, it is essential that future research explores the role of local communities, considering factors such as socioeconomic vulnerability, acess to information, an participation in urban panning.

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