

T Mapping, building analysis and image processing in the detection and control of Dengue: A systematic review from 2015 to 2025

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Abstract

Introduction: In recent years, the detection and control of dengue have become more relevant due to the increase in its incidence in tropical and subtropical regions. This study aimed to systematically analyze the use of advanced technologies, such as geospatial mapping, building analysis, and image processing, in the detection and control of dengue between 2015 and 2025.

Methods: Following the PRISM methodology, 148 documents are selected through relevant searches in scientific databases such as Scopus and IEEE Xplore, applying thematic and quality filters.

Results: The results highlight that the United States and Brazil lead research in this field while Latin America, with countries such as Colombia and Mexico, shows a lower representation. In terms of thematic areas, 75% of the studies reviewed correspond to scientific articles, highlighting the academic importance of the topic, while 19.5% come from Environmental Sciences, evidencing the role of sustainability in the fight against dengue.

Discussion: Significant role in evaluating climate data, vegetation indices, and machine learning-based techniques to anticipate the risk of contracting dengue.

Take-home message:

the integration of technologies such as machine learning, remote sensing, and geospatial modeling represents a key tool for dengue prevention and control, highlighting the need for interdisciplinary approaches and data-driven strategies to strengthen the global response to this disease.

Keywords: mapping; buildings; image processing; dengue, review.

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INTRODUCTION

Dengue, a viral disease transmitted by the *Aedes aegypti* mosquito, has affected millions of people around the world [1]. According to data from the World Health Organization (WHO), more than 5.2 million cases were reported globally in 2019, the highest number recorded in the last decade [2]. Countries such as Brazil [3], India [4], Indonesia [5], and the Philippines [6] accumulate many cases, causing health and economic crises due to high treatment costs and loss of productivity. The WHO estimates that the global number of dengue cases could continue to rise due to climate change and unplanned urbanization [7]. Globally, technological advances, including satellite mapping, the use of drones [8,9], and digital image processing [10], have transformed the detection and control of dengue. Countries such as Singapore [11] and Thailand [12] have implemented technologies based on artificial intelligence (AI) to identify areas of high incidence through thermal images and geospatial analysis. Also, the use of international platforms such as GIS (Geographic Information Systems) has proven to be instrumental in predicting the spread of outbreaks and guiding control strategies [13], significantly reducing cases in densely populated urban areas.

In Latin America, the detection and control of dengue face challenges related to socioeconomic and climatic conditions. Brazil, one of the most affected countries, has implemented massive epidemiological surveillance campaigns that combine the use of geospatial technologies and meteorological data [14]. In Mexico, machine learning has been used to detect weather patterns linked to mosquito proliferation [15].

While Colombia and Ecuador have implemented real-time surveillance systems to prevent outbreaks [16,17]. These initiatives reflect a regional commitment to mitigate the impacts of the disease. In Peru, the incidence of dengue has reached exorbitant figures in recent years, with the regions of Piura, Loreto, and Tumbes being the most affected [18]. Health authorities have implemented fumigation campaigns; but efforts have been limited by the lack of adequate technology for mapping and control. According to [19], advances in big geospatial data and AI have facilitated the incorporation of various sources of information and techniques to expect the risk of dengue. In a study based on 53 articles, determining factors such as local climate conditions, human mobility, and vegetation characteristics were identified. Also, techniques such as machine learning and mixed models were used, which have shown significant accuracy in predicting outbreaks. This implementation highlights the importance of satellite data and cloud computing to optimize the prevention of future dengue outbreaks.

Similarly, [20] suggests an approach based on remote sensing and geographic information systems (GIS) to analyze the relationship between landscape factors and urban cases of dengue. In a review of 78 articles, it was shown that land cover variables, type of housing, and infrastructure characteristics have a considerable impact on the incidence of the disease. This methodological framework suggests combining field studies, wildlife observations, and satellite data to build more accurate epidemiological models. Additionally, [21] underscores the importance of machine vision models trained with satellite imagery and urban vision to identify *Aedes aegypti* breeding hotspots in Rio de Janeiro. This analysis, based on data collected between 2019 and 2022, found that microhabitats such as water tanks, tires, and storm drains have a significant correlation with vector expansion, while trash bins showed negative associations. These findings highlight the capacity of high-resolution interpolations in entomological surveillance, optimizing control and mitigation strategies for diseases such as dengue, chikungunya, and Zika.

The main objective of this study is to analyze and test emerging technologies, such as spatial mapping, building analysis, and image processing, in the detection and control of dengue. This research seeks to identify the most relevant trends in research from 2015 to 2025, highlighting their global, regional, and local applications, to contribute to the development of more effective and sustainable strategies to fight this disease.

Systematic reviews are essential tools for synthesizing information, detecting gaps in literature, and guiding future research [22]. In the case of dengue, these reviews ease an understanding of the evolution of detection technologies, highlighting the most significant progress and suggesting evidence-based solutions. This approach is crucial for designing effective strategies that can be adapted to local and global situations. This article will analyze the development of technological innovations, such as geospatial mapping, building analysis, and image processing, in the detection and control of dengue. A detailed analysis of the most prominent cases at the international, regional, and national levels will be presented. Finally, the findings will be discussed within the framework of global public health trends, and suggestions for future research in this field will be determined.

Technologies for Dengue Detection

Dengue

Dengue is a viral disease transmitted by the *Aedes aegypti* mosquito that affects millions of individuals in tropical and subtropical areas [23]. Early detection can prevent serious complications. In this study, accurate detection is essential to install efficient control measures and avoid massive outbreaks in areas of high incidence.

Geo-Mapping

Geographic mapping uses tools such as Geographic Information Systems (GIS) to recognize risk areas and monitor the spread of dengue [24]. These technologies make it possible to locate mosquito breeding sites and vulnerable areas. Mapping is used to optimize control strategies based on real-time geospatial data, as shown in Figure 1 in a Loreto mapping.

Figure 1. Mapping in ArcGIS.



Building analysis

Building analysis assesses the physical and structural characteristics of urban environments where mosquitoes breed [25]. This technology detects places prone to the accumulation of standing water, such as roofs or basements. About dengue, the concentration of preventive actions in affected communities improves.

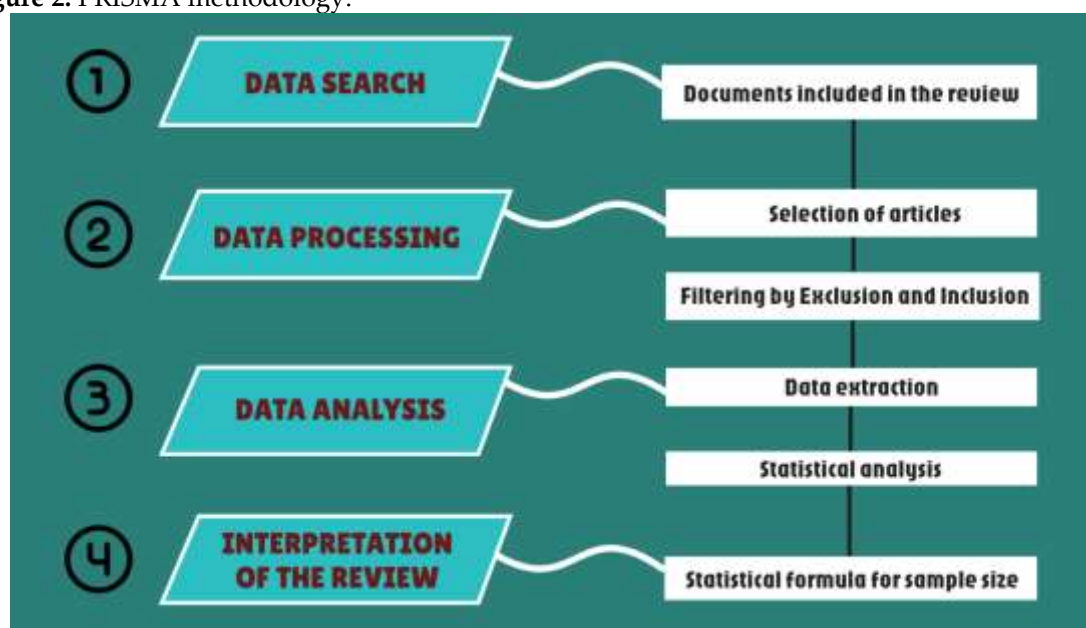
Image Processing

Image processing uses algorithms and Artificial Intelligence techniques to analyze photographs or videos of affected areas [26]. It is used to identify breeding sites, monitor infestations, and identify early signs of outbreaks. This technology contributes to increasing accuracy and agility in healthcare decision-making.

METHODS

This systematic review uses a hybrid approach based on PRISMA to examine the use of advanced technologies in the detection and control of dengue between 2015 and 2025. During the data search phase, a detailed analysis of scientific databases was carried out, optimizing the results using Boolean operators and keywords related to dengue. In the data processing phase, inclusion and exclusion criteria were applied to rule out research not linked to technologies applied to the detection or control of the disease. The data analysis phase included a detailed review of the selected articles, assessing the relevance and scientific validity of each study. Finally, in the data interpretation phase, significant studies were collected on applications of geographic mapping, building analysis, and image processing, highlighting their impact on dengue mitigation.

Figure 2. PRISMA methodology.



Data Search

The data search process focused on the collection of key information on the technologies used in the detection and control of dengue, as well as their effectiveness in different situations. This process aimed to identify technological tools, such as geographic mapping and image processing, related to disease mitigation. Papers were selected that included scientific articles, conference conferences, and systematic reviews, offering a solid basis for analyzing the factors that influence the effective implementation of these technologies.

Data Processing

In this stage, an exhaustive analysis was carried out focused on the technologies applied to the detection and control of dengue. First, the selected studies were classified and organized according to previously established criteria. This was followed by key data extraction, such as the application

of technological tools, advances in geographic mapping, and image processing. Through an analysis of keywords and recurring themes, common patterns were identified that group innovations, challenges, and related solutions. This data was structured to simplify its comparison and analysis. Finally, priority was given to the most effective technologies and areas with the greatest potential for improvement. This approach ensured solid results to synthesize significant applications in dengue control.

Inclusion criteria

This study focused on analyzing documents that met established criteria of quality and relevance. Research obtained from indexed databases such as Scopus, IEEE, and Web of Science was included. The selection gave priority to scientific articles, conferences, and systematic reviews that dealt with the use of advanced technologies, such as AI, geospatial mapping systems, and image processing, related to the monitoring and control of dengue.

Exclusion criteria

Documents that did not meet the established inclusion criteria were excluded from the analysis. This included editorial publications, reviews, commentaries, patents, unpublished theses, and short notes. We also ruled out studies that did not have a direct connection to technologies used for dengue control, such as those with a focus on other diseases or general health issues. Finally, duplicates, incomplete studies, or studies with insufficiently documented methodologies were excluded.

Data Analysis

In this section, the results of the systematic review on the use of advanced technologies in the detection and control of dengue in an organized and understandable way are presented. Line graphs and co-occurrence maps were used. Line graphs showed the evolution of research in technologies such as geographic mapping and image processing over the past decade. Finally, co-occurrence graphs are used to analyze the relationship between terms based on their joint appearance in several texts.

Search Tools

Scopus

Scopus is an academic database that offers access to an extensive set of peer-reviewed articles, books, and lectures [27]. In this study, Scopus was used as the main tool to identify research related to geographic mapping, building analysis, and image processing linked to dengue. Also, it allowed detailed bibliometric analyzes to be carried out, facilitating the identification of technological advances and trends in the detection of this disease.

IEEE

IEEE Xplore is an essential platform for accessing scientific literature in the field of engineering and advanced technology [28]. In the context of this review, it was used to identify research on AI, machine learning, and image processing applied to dengue monitoring. This resource facilitated the analysis of practical solutions, such as the use of smart drones and software, as well as highlighting advances in hardware and software designed for the early detection of mosquito breeding sites.

VOSviewer

VOSviewer is software used to build and visualize bibliographic networks [29]. It was used to examine connections between authors, keywords, and relevant publications on dengue detection technologies. This software made it possible to identify patterns of collaboration between institutions and research areas, highlighting the relationships between technological applications and their influence on dengue prevention. Python's integration with VOSviewer streamlined data extraction and analysis, efficiently generating accurate results.

Interpretation of the Review

To guarantee the representativeness and reliability of the results, a statistical formula was applied for the calculation of finite samples, considering a high degree of confidence and an acceptable margin of error. With the selected sample, key patterns and relevant issues about the technologies used for the detection and control of dengue were identified. This approach made it possible to highlight the most prominent technological trends, the main challenges in their

implementation, and the areas with the greatest potential for development, contributing to a more complete understanding of the overall picture in this sector.

RESULTS

The data collection was based on the main objective of analyzing emerging technologies in geospatial mapping, building analysis, and image processing applied to the detection and control of dengue.

Data Search

In this step, a specific search algorithm was designed and applied to academic databases such as Scopus and IEEE Xplore. This algorithm uses Boolean algebra linked to the research topic, such as "dengue", "map", "geospatial", "image processing," and "analysis." The AND and OR operators were used to merge terms, making it easier to search for relevant documents, while AND NOT was used to exclude terms related to diseases such as malaria, which are not part of the objective of this review. The algorithm also includes a time limitation, selecting only documents available between 2015 and 2025. This ensures that the research examined is current and relevant to current trends. This research represents a solid basis for examining studies that combine geospatial mapping, infrastructure analysis, and advanced image processing techniques, all geared toward dengue mitigation.

The selection criteria for the documents were based on the following algorithm: (TITLE-ABS-KEY (dengue) AND TITLE-ABS-KEY (map*) OR TITLE-ABS-KEY (geospatial) AND NOT TITLE-ABS-KEY (malaria) AND TITLE (detect) OR TITLE-ABS-KEY (control) AND TITLE-ABS-KEY (buildings) OR TITLE-ABS-KEY (infrastructure) AND TITLE-ABS-KEY (imaging) OR TITLE-ABS-KEY (image-processing) AND TITLE-ABS-KEY (analysis)) AND PUBYEAR > 2014 AND PUBYEAR < 2026. This method using Boolean algebra facilitates the accurate identification of relevant studies by combining many keywords related to the topic while excluding irrelevant research and delimiting a specific time range. The use of this algorithm ensures an efficient and exhaustive search, improving the results to meet the objectives of the study. In the initial search, the total number of documents found was 1287.

Data Processing

Exclusion

In the general filter, the initial results include documents from thematic areas not directly related to dengue, such as research focused on other diseases or technology that does not apply to the purpose of the analysis. To prevent deviations from the main purpose, which is to analyze the use of mapping, building analysis, and image processing in the detection and control of dengue, an exclusion was made based on irrelevant thematic areas. This filter is shown in Table 1, as it allowed the analysis to be concentrated on documents with the focus of the study and to prevent its unnecessary extension.

Table 1. Filters by subject area.

<i>Exclusion of Sources by Subject Area</i>	
<i>Excluded areas</i>	<i>N° documents</i>
Medicament	580
Immunology and Microbiology	316
Biochemistry, Genetics and Molecular Biology	240
Mathematics	67
Pharmacology, Toxicology and Pharmacy	51
Chemistry	41
Physics and Astronomy	40
Veterinary	34
Neuroscience	22
Decision Sciences	21
Chemical engineering	18
Materials Science	16

Business, Management and Accounting	14
Energy	12
Infirmity	8
Economics, Econometrics and Finance	6
Arts & Humanities	4
Psychology	1
Dentistry	1

Inclusion

Regarding the inclusion of sources, specific criteria were developed to consider only articles from journals, high-value indexed conferences, and systematic reviews. This approach ensures the quality and relevance of the selected documents, excluding resources such as books or non-indexed materials, which do not usually provide up-to-date and accurate scientific information for this type of research. This filter, detailed in Table 2, guarantees that the sources are scientific and directly linked to the topic studied.

Table 2. Filters by document type.

<i>Exclusion of Sources by Subject Area</i>	
<i>Document Type</i>	<i>N° documents</i>
Article	177
Conference Presentation	54
Revision	5

Finally, a manual exclusion of articles was performed, thoroughly examining the 1287 documents acquired during the initial search. Through discrimination by title and alignment with the defined inclusion criteria, a selection was made only of the most relevant studies. This process narrowed the total to 236 documents, which will be used in later stages of the analysis.

Data analysis

Figure 3 shows the analysis of the documents published on the use of technologies for the detection and control of dengue in the period from 2015 to 2025. During the first years, between 2015 and 2017, the number of publications remained low, with an average of 12 documents per year. But, as of 2018, a notable increase is observed, reaching 36 publications during that year.

This growth remains constant, with minor variations, such as the 28 documents in 2019 and 2021 and 25 in 2020. In 2022, the number of publications decreases slightly to 18, but rises again in 2023 and 2024, with 32 documents published each year. This model indicates a persistent interest in the development of technologies such as geospatial mapping, building analysis, and image processing, likely motivated by the urgent need to control dengue in areas of high incidence.

Figure 3. Document analysis by year.

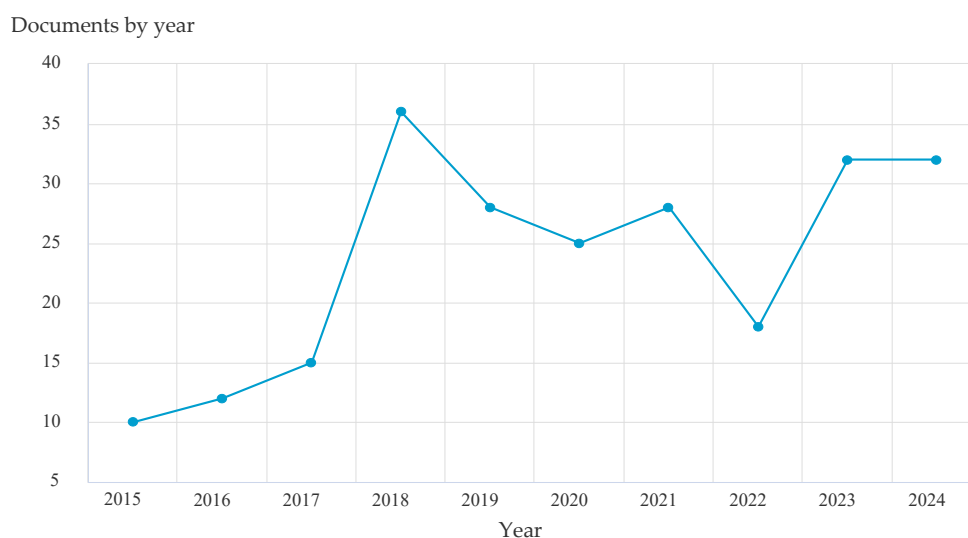


Figure 4. Analysis of documents by type.

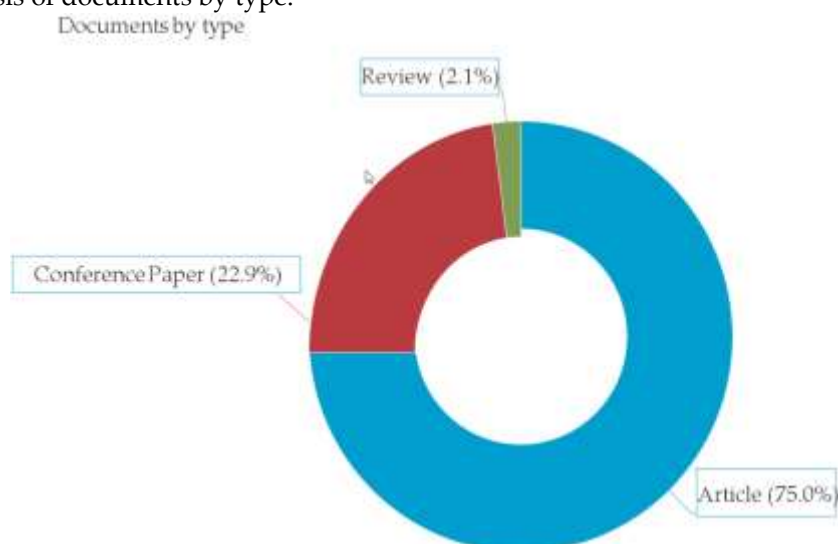


Figure 4 shows the analysis of the documents collected in the Scopus database on technologies applied to geospatial mapping, building analysis, and image processing in the detection and control of dengue, with a diverse representation depending on the type of publication. Scientific articles constitute 75.0% of the total, highlighting their central function in consolidating theoretical and practical knowledge in this field. The works presented at the conferences constitute 22.9%, highlighting the relevance of these spaces to disseminating technological advances and case studies related to dengue control. Finally, the reviews cover 2.1%, evidencing a lower number of critical integrative studies, which suggests the need to carry out more systematic reviews to consolidate knowledge in this constantly evolving field.

Figure 5. Country document analysis.

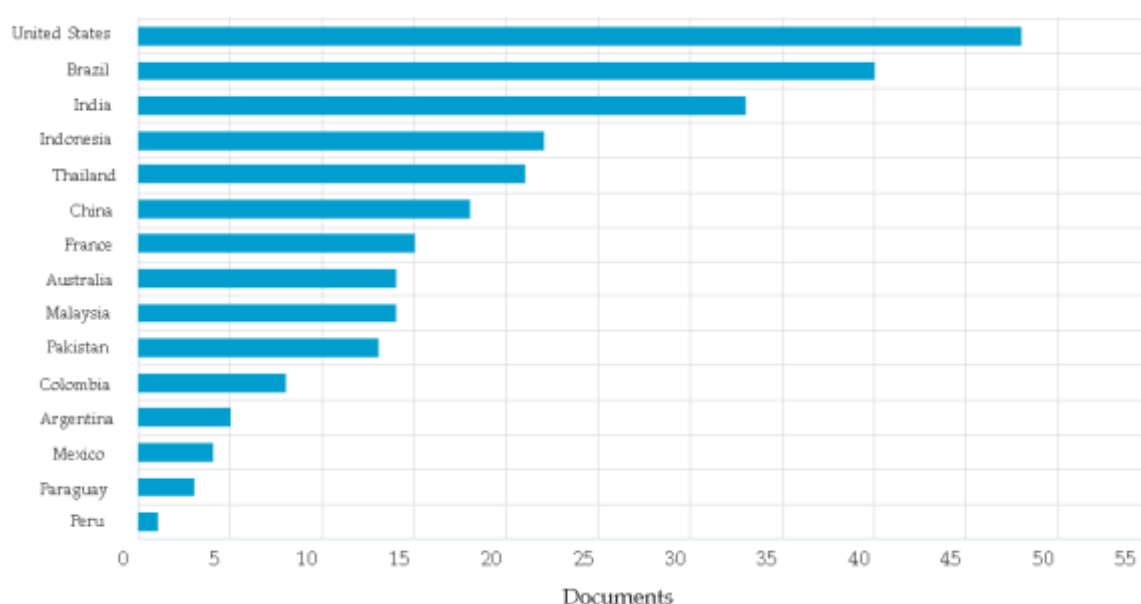


Figure 5 shows the global distribution of publications on technologies applied to geospatial mapping, building analysis, and image processing in the detection and control of dengue. With 48 publications, the United States leads this sector, reflecting a strong investment in technological research and public health. Brazil is in second position with 40 documents, standing out as the Latin American country with the most interest in this field.

The show has 33 publications, and Indonesia follows with 22, both countries with high dengue incidence rates. Thailand (21) and China (18) also contribute significantly, motivated by national programs aimed at combating this disease. Among Latin American countries, Colombia has 8 publications, while Argentina and Mexico have 5 and 4 documents, respectively. Paraguay and Peru present more limited contributions, with 3 and 1, respectively, evidencing an opportunity to expand research in these countries, especially in countries with high vulnerability to dengue.

Figure 6. Analysis of documents by area.

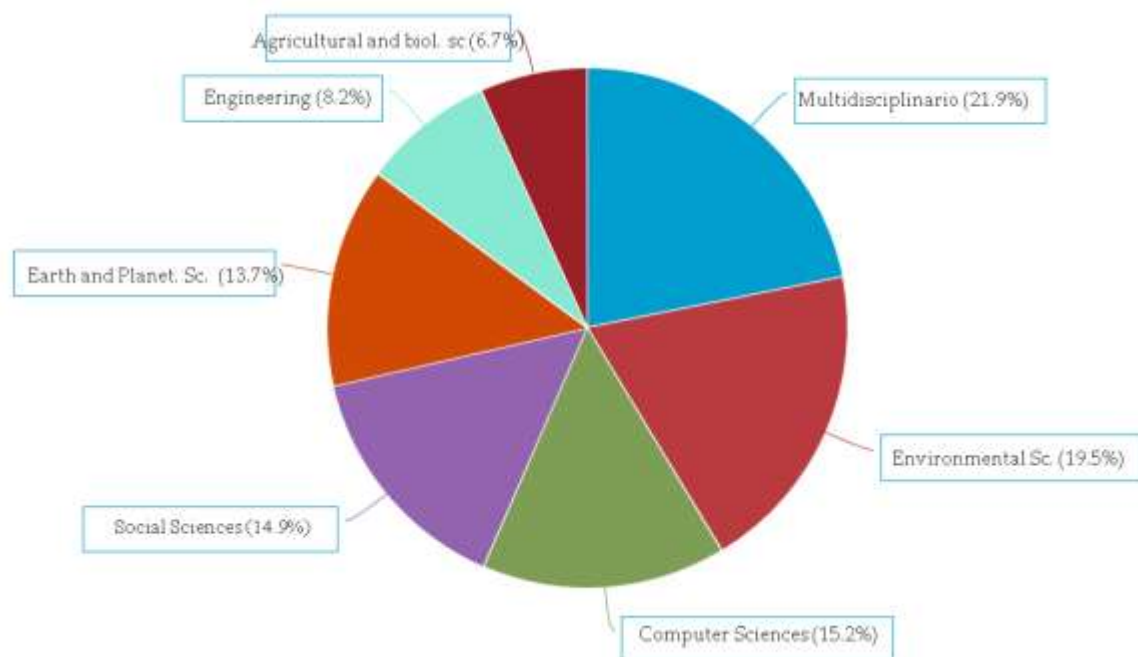


Figure 6 shows the worldwide distribution of publications related to technologies related to geospatial mapping, building analysis, and image processing for the detection and control of dengue. The multidisciplinary category leads with 21.9%, highlighting the integrated approach of various disciplines to address this problem.

Environmental Sciences ranks second with 19.5%, reflecting the relevance of sustainability in dengue control strategies. Computer Science and Social Sciences, with 15.2% and 14.9% respectively, show the crucial role of technology and social factors in the development of innovative solutions. Earth and Planetary Sciences (13.7%) and engineering (8.2%) highlight the importance of technological infrastructure and geospatial analysis, while Agricultural and Biological Sciences (6.7%) underline the focus on ecosystems and their relationship with the spread of dengue, providing a comprehensive vision for the prevention and control of this disease.

Figure 7. Analysis of documents by author.

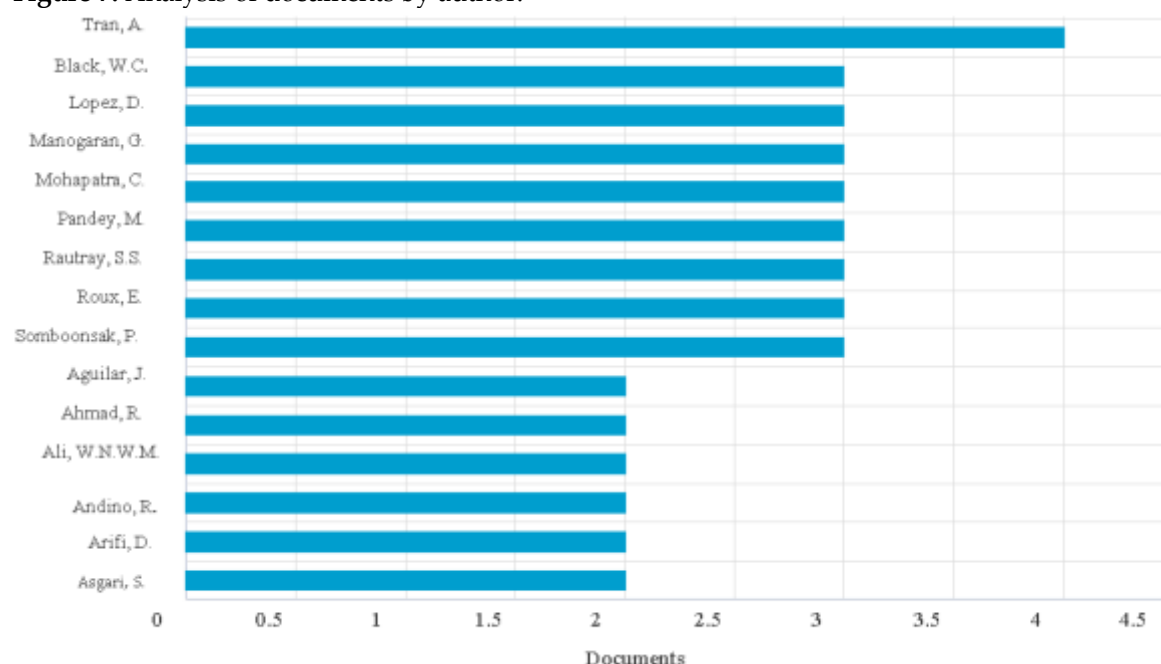


Figure 7 shows an analysis of the most prominent authors in research related to technologies applied in various fields. In this analysis, Tran, A. stands out as the author with the most publications with 4 papers, followed by Black, W.C., Lopez, D., Manogaran, G., Mohapatra, C., Pandey, M., Rautray, S.S., Roux, E. and Somboonsak, P., who have contributed 3 papers each. Also, authors such as Aguilar, J., Ahmad, R., Ali, WNW, Andino, R., Arifi, D. and Asgari, S., have two publications each, reflecting significant participation in this field of research.

Figure 8. Analysis of documents by journal.

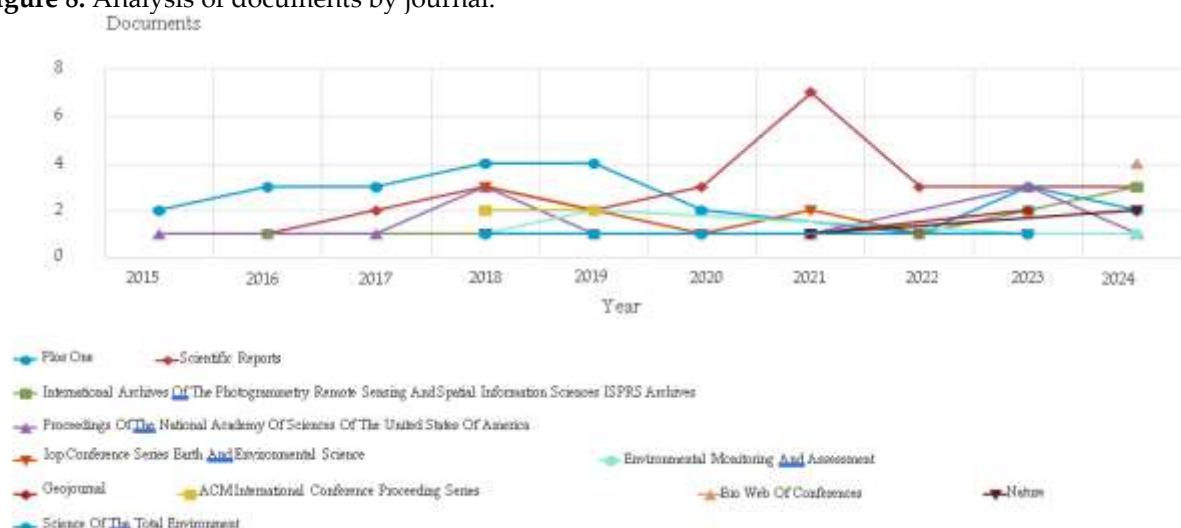


Figure 8 shows the study of documents by Journal over the years, highlighting Plos One and Scientific Reports as the journals with the largest number of publications linked to various technologies, each with 24 documents. They are followed by the Proceedings of the National Academy Of Sciences of the United States of America with 11 publications and the Iop Conference Series Earth and Environmental Science with 10. In addition, sources such as the International Archives of the Photogrammetry Remote Sensing And Spatial Information Sciences ISPRS Archives and Environmental Monitoring and Assessment have contributed with 9 and 5 publications, respectively, establishing themselves as significant references in this field.

Bibliometric analysis by country

Table 3 shows the productivity index of the ten most prominent countries in research related to mapping, building analysis and image processing in the identification and control of dengue, according to the Scopus dataset. On this list, the United States leads with 43 publications. Followed by Brazil with 35 publications and India with 27. In fourth place is Indonesia with 19 publications, followed by Thailand with 17. Finally, the list closes with Malaysia and Pakistan, highlighting the global contribution to the analysis of this issue.

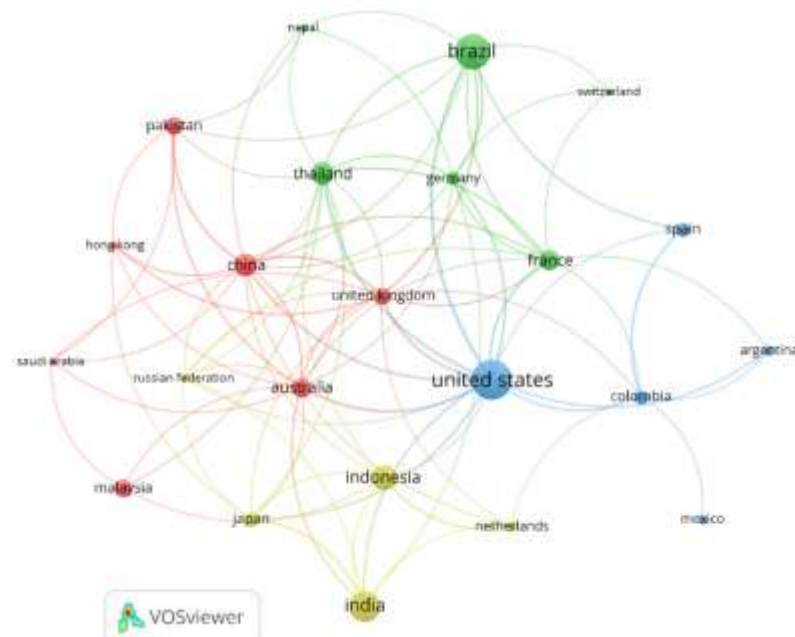
Table 3. Global Research Document Collaboration.

<i>Name of Country</i>	<i>Papers</i>	<i>Citations</i>	<i>Links</i>	<i>Total Link Strength</i>
United States	43	1201	14	39
Brazil	35	254	10	22
India	27	658	7	12
Indonesia	19	137	7	9
Thailand	17	415	13	20
China	16	672	14	23
France	14	496	11	19
Australia	13	536	13	20
Malaysia	11	24	4	4
Pakistan	11	63	7	10

A network of 30 out of 62 countries submitted a least of three documents, while a country with at least five citations in three groups was to be considered, only 23 countries met the requirements placed and are visually mapped using the VOSviewer viewer, as shown in Figure 9. The analysis of the co-authorship of the countries reveals the type and degree of collaboration on this issue, as well as the relationship between the countries involved.

Various colors are used to symbolize each set. Too, the thickness of the link represents the number of collaborations between the two countries, while the size of the node symbolizes the number of publications originating from that country's documents

Figure 9. Co-authored collaboration by country.



This visualization also demonstrates the effectiveness of international cooperation. As far as a few countries are concerned, the United States, Brazil, and India lead in this field. The blue and green clusters are the ones with the largest node size, being led by the United States and Brazil. They are followed by the red group, led by China. The country with the highest number of links was the United States with 43. and 14 links, followed by China with 16 documents and 14 links.

Bibliometric Analysis by Keywords

Figure 10 shows the keyword co-occurrence for 2122 indexed keywords in the reviewed publications. It can be seen that the keyword "dengue" has 77 appearances, followed by "dengue fever" with 45 appearances and "human" with 50 appearances.

Figure 10. Keyword co-occurrence.

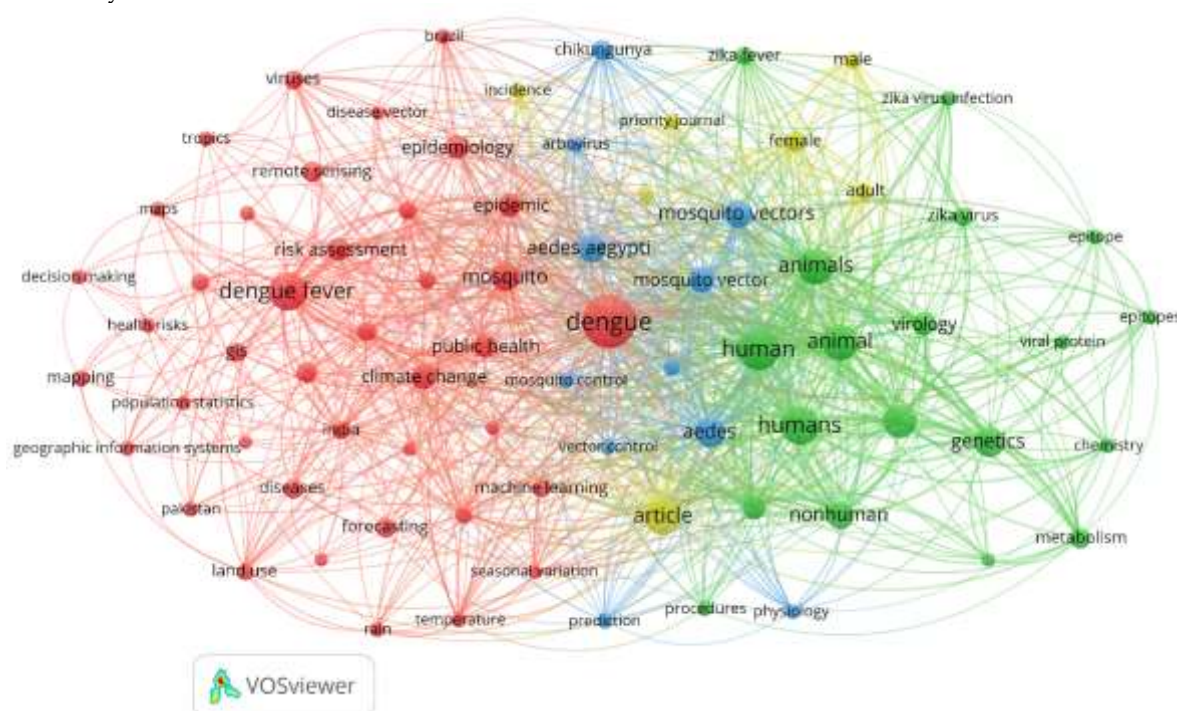


Figure 10 shows the results of this analysis with representations of different sizes and colors, where the size of each node represents the frequency of occurrence of a term. The links between the nodes or show the frequency with which a term is presented, while the distance between two nodes decreases as the co-occurrence between the term increases.

In this sense, 77 occurrences were identified and distributed in four clusters: cluster 1 (40 occurrences), cluster 2 (19 occurrences), cluster 3 (11 occurrences), and cluster 4 (7 occurrences). Each set of keywords was illustrated in different colors through the VOSviewer visualization tool, making it easier to identify thematic patterns. In this analysis, cluster 1 (red) stands out for having "dengue" as the main node, grouping keywords such as "dengue fever" and "mosquito". Cluster 2 (green) stands out with its main node of "human", grouping keywords such as "animals" and "genetics".

These results allow us to differentiate the main topics of each cluster and to understand the dynamics of research on mapping, building analysis, and image processing in the context of dengue control.

Interpretation of the Revision

To determine the representative sample size in this review, the statistical formula for finite sample calculation is used. This formula makes it possible to determine an optimal number of documents to be examined, ensuring the reliability of the results and controlling the margin of error. The equation used was as follows.

$$n = \frac{N * Z^2 * p * q}{e^2 * (N-1) + Z^2 * p * q} \quad \text{Eq. (1)}$$

$$n = 148.44 \approx 148$$

Where:

$$\begin{aligned} N &= \text{tamaño de población} = 236 \\ Z &= \text{nivel de confianza 95\%} = 1.96 \\ p &= \text{proporción de éxito} = 0.5 \\ q &= \text{proporción de fracaso} = 0.5 \\ e &= \text{margen de error} = 0.05 \end{aligned}$$

The estimate indicates a sample size of 148.44, which is like 148 documents for evaluation and study. This procedure ensures that the chosen sample is statistically representative, enabling the characteristics of the total population to be appropriately represented with a degree of confidence of 95% and a margin of error of 5%.

Of the 148 selected papers, a preliminary review was conducted, focusing exclusively on the titles, abstracts, and keywords of each. This method allowed the identification of the main results and the most pertinent conclusions to the study on mapping, building analysis, and image processing in the identification and control of dengue. In addition, the selection of the documents was random, which ensured adequate availability and facilitated an agile analysis without compromising the quality of the review process.

The analysis of the reviewed documents revealed a growing trend in the use of mapping and image processing technologies to detect and control the spread of dengue, applying tools such as satellite imagery, building mapping models, and advanced visual processing techniques.

These advances are aimed at optimizing the early identification of risk areas and the distribution of resources for the control of this disease. But obstacles are also identified, such as the absence of appropriate technological infrastructure in certain areas and the challenge of merging various image processing platforms, which restricts the effectiveness of surveillance systems. It is essential to overcome these technological challenges to improve the effectiveness of dengue detection and control methods, promoting a more agile and precise approach in the fight against this disease.

DISCUSSION AND CONCLUSIONS

The relevance of the findings of this study lies in its ability to prove how booming technologies, such as geospatial mapping, building analysis, and image processing, contribute significantly to the detection and control of dengue. Of the total number of documents reviewed, 75% correspond to scientific articles, reflecting their essential role in the theoretical and practical advancement of these technologies. In addition, the thematic analysis shows that the multidisciplinary (21.9%) and environmental sciences (19.5%) areas lead in research, highlighting the importance of sustainability and digital tools in the fight against this disease. On the other hand, countries such as the United States (43 publications) and Brazil (35 publications) stand out as global leaders, while nations such as Colombia, Mexico, and Peru have significantly less representation, signaling an opportunity to strengthen research in these countries.

In addition, this study determines that disciplines such as social sciences (14.9%) and earth sciences (13.7%) provide an essential interdisciplinary approach to understanding the human and environmental elements in the spread of dengue. These areas complement the development of technological tools by including perspectives on human mobility, social behaviors, and resource management in vulnerable communities. The analysis also reveals the importance of temporal and spatial scale in dengue modeling, highlighting that studies at the urban or neighborhood level are more effective in predicting and controlling localized outbreaks.

Comparing these results with previous studies, [19] underscores the crucial role of climate data, vegetation indices, and machine learning-based models in predicting dengue risk. These findings are consistent with the findings of this study, where the integration of big geospatial data and deep learning techniques emerge as a strategy to avoid outbreaks. But [20] the combination of GIS and remote sensing stands out as fundamental tools for mapping landscape factors related to dengue, which complements the conclusions of this work on the relevance of the analysis of buildings and urban characteristics. Finally, [21] emphasizes the usefulness of computer vision models in the identification of *Aedes aegypti* breeding sites through satellite images, reinforcing the idea that high-resolution technologies are essential to optimize vector control strategies.

This study reaffirms that the use of advanced technologies is essential to address the challenges associated with dengue [30]. While tools such as geospatial mapping and image processing not only improve detection capacity, but also allow for more accurate and informed decision-making. It is also highlighted that leading countries such as the United States and Brazil have made significant progress in the implementation of these strategies, while in Latin America, regions such as Colombia

and Peru have great potential to expand these applications, especially through hybrid models that combine field data and technology.

In future research, it is suggested to carry out case studies in countries with high incidences of dengue, such as Brazil, Paraguay, and Peru, to check the integration of emerging technologies in local health systems for the monitoring and prevention of the disease. It is also recommended to develop research that analyzes the levels of knowledge, attitudes, and practices of the population about dengue, allowing the identification of gaps in health education and the design of more effective strategies for its control and prevention. This approach will not only ease the identification of local best practices, but also the creation of strategies adapted to the needs and resources of each region, promoting more effective and sustainable control of this disease at a global level.

Author Contributions: AHH and CMI led the conceptualization, research strategy, and study design of the systematic review. JMN contributed to data collection, data extraction, and analysis. AAM contributed to data verification and manuscript writing. SRC participated in literature search and data organization. ZDLB contributed to critical revision of the manuscript and supervision of the final version. All authors read and approved the final manuscript.

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