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Review Article

Review of Technologies for Mitigating Traffic Accidents in Foggy Conditions

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Abstract *- Traffic accidents in foggy conditions represent a significant risk in countries such as Peru, where topography and weather conditions vary considerably. In 2023, the Tax Administration Service of Lima (SAT) reported around 43,000 accidents, with 4% deaths, 66% injuries and 30% runovers. This study employed the PRISMA methodology and bibliometric analysis in Scopus, using Boolean algorithms to filter scientific articles on devices and methods to mitigate accidents in fog between 2002 and 2025. 387 documents were analyzed and processed with RStudio and Google Collaboratory. Of the total, 73.7% corresponded to articles, 24.5% to conference papers and 1.8% to reviews. China led production with 179 documents, followed by the United States with 68. The most relevant advances include adaptive lighting systems and driver assistance devices, such as cameras and radars, which improve visibility and reduce the risk of collisions. Despite the progress, the study recommends developing more accessible and efficient technologies adapted to Peruvian conditions. The use of real-time monitoring and artificial intelligence algorithms is transforming road safety, but more research and collaboration between scientists and engineers is needed to improve road safety, especially in regions with high incidences of fog.*

Keywords *- Traffic accidents, Fog mitigation, Road safety, Accident prevention, Traffic safety.*

1. Introduction

Car accidents are catastrophic events that occur when a moving vehicle collides with another vehicle, object, or pedestrian [1]. These incidents are one of the leading causes of injuries and deaths worldwide [2]. Currently, the World Health Organization (WHO) estimates that approximately 1.35 million people die each year due to road accidents, and between 20 and 50 million are injured [3]. These figures are alarming and underscore the urgency of addressing this problem effectively. Road accidents have a wide range of causes, from human error to unfavourable weather conditions and mechanical failures [4]. In addition to the human cost, these accidents also represent a huge economic cost to society in terms of medical care, vehicle repairs, and lost productivity. In Peru, traffic accidents are a significant problem that affects road safety and takes a heavy human toll. According to data provided by the Superintendence of Land Transport of People, Cargo and Goods (SUTRAN), in 2020, 27,613 traffic accidents were registered throughout the country [5]. For the year 2023, the Tax Administration Service of Lima (SAT) estimated close to 43,000 traffic accidents nationwide, of which 4% of people died, 66% were injured, and 30% were run over [6]. Science is key in preventing and mitigating road accidents [7], [8]. Thanks to research in vehicle engineering, advanced technologies such as automatic braking systems, stability control, and collision detection are being developed to help avoid accidents and reduce their severity [9]. In addition, science contributes to the design of safer road infrastructure through studies on traffic flow and analysis of driver behaviours patterns [10]. On the other hand, forensic medicine and traumatology research provide knowledge to improve medical care for victims, increasing their chances of survival and recovery [11]. Fog is a meteorological phenomenon that can have dangerous consequences on the roads, especially in relation to road accidents [12]. When visibility is reduced due to fog, drivers face a significant challenge in navigating safely [13]. Decreased visibility makes it difficult to perceive other vehicles, road signs, and obstacles on the road, increasing the risk of collisions [14]. Drivers must slow down and increase the distance between vehicles to adapt to these adverse conditions. Unfortunately, some drivers do not take the necessary precautions, which can lead to serious accidents. In addition to reducing visibility, fog can contribute to slippery roads due to the moisture it deposits on the surface [15]. This can increase the risk of skidding and loss of vehicle control, especially if drivers are not prepared to deal with these conditions [16]. Therefore, drivers must be alert and aware of the dangers associated with fog, take extra

precautionary measures, and adjust their driving style to maintain road safety during these times of low visibility [17]. In Peru, it can be an important factor in traffic accidents. In regions such as the highlands and jungle, fog can be especially dense, reducing visibility and making driving difficult [18]. Drivers should be prepared to deal with these adverse conditions by reducing speed, using appropriate lights and maintaining a safe distance between vehicles [19]. However, there is often a lack of awareness about the dangers associated with fog, which can lead to serious accidents. Technology has played a crucial role in improving road safety in the fight against adverse road weather conditions, such as fog. Various devices have been developed to help drivers have better vision in low-visibility situations [20]. One of the most significant advancements is adaptive lighting systems that use LED technology and sensors to adjust the vehicle's light beam automatically, allowing for a better road view even in dense fog conditions.

These systems can detect the presence of fog and adapt the intensity and angle of the headlights to minimize glare and improve visibility for both the driver and other vehicles [21]. In addition to adaptive lighting systems, driver assistance devices have also been developed that use cameras and radars to detect objects and vehicles on the road, even in foggy conditions [22]. These devices can provide visual or audible alerts to the driver of the presence of obstacles, pedestrians, or other vehicles that might not be visible due to fog. Some systems can even automatically intervene in driving, such as braking or correcting the vehicle's trajectory, to avoid collisions in low-visibility conditions [23]. These technological advances contribute significantly to improved driving safety, especially when faced with difficult conditions such as fog on the road. These devices help drivers by providing enhanced vision and early warnings of potential road hazards.

Their usefulness is amplified when fog can severely hinder visibility, allowing drivers to anticipate and react more effectively to any obstacles or unforeseen situations. In short, these advances represent a step forward in road safety by providing tools that help mitigate the risks associated with driving in unfavourable weather conditions. That is why the present research presents knowledge of the current situation of electronic devices and accident prevention methods for frequently fogged roads in PERU. A hybrid methodology based on PRISMA and its own will be used that is suitable for using the Scopus database and information processing algorithms such as Biblioshiny and the R programming language. In Section 2, the related works will be seen. In Section 3, the methods used in the review. In Section 4, the results and discussion. Finally, the conclusion in Section 5.

2. Literature Review

Various studies are analysed to understand the effectiveness of emerging technologies in road safety. According to [11], an advanced classification model was developed that employs a real-time monitoring system through social networks, integrating technologies such as ontology and Dirichlet latent assignment with Bidirectional Long-Short-Term Memory (Bi-LSTM), reaching an accuracy of 97% in the detection of traffic accidents. This implementation represents a significant advance over previous methods. In a similar context, [12] describes a methodological framework that uses sentiment analysis and topic modelling to improve the characterization of traffic conditions while maintaining equal accuracy.In addition, [16] it addresses the impact of adverse weather conditions on road safety, proposing advanced techniques within Intelligent Transport Systems to optimize the response to reduced visibility.

In parallel, [18] discusses the use of fog collectors in marginalized areas of Lima, highlighting their potential as a scalable solution to the lack of water resources, suggesting a revaluation of the concept of "smallness" in social projects.Related to reviews in [19], it is crucial to analyse the importance of studying fog for human and environmental systems. Research from 1976 to 2021 is reviewed, highlighting advances in the last twenty years by analysing 250 research articles and other resources. Techniques for investigating fog formation, including air-surface interactions, and advances in detection and prediction technologies, such as microwave communication links, are being examined.

The influence of smog-related fog in India and China is also being discussed, as well as the potential of harnessing fog to reduce water scarcity, suggesting more widespread implementation in the identified areas.Similarly, the fog has been thoroughly researched in [24] due to its impact on everyday aspects of life and sectors such as aviation and transport. Despite having published around 4700 articles in the American Meteorological Society journals, it is still complex to predict fog due to the interaction of factors such as droplet microphysics, aerosol chemistry and surface conditions.Likewise, in [25], the incidence of weather-related air accidents is approximately 25 times higher than the national average for Canada, increasing to 31 times when reduced visibility incidents are considered. Ice fog occurs 25% of the time in these regions, significantly contributing to reduced visibility.

As this review highlights, improving the prediction and detection of ice fog in northern latitudes is important. They propose to summarize the current knowledge about ice fog microphysics obtained from observations and numerical weather prediction models, as well as to address challenges in measuring properties and discuss advances in remote sensing and simulation within the Ice Mist Survey. Finally, in [26], they analysed the composition of fogs and clouds previously focused on inorganic species and acidity. However, recently, it has pivoted towards organic matter in its aqueous phase, examining its origin, reactivity and fate. During the last

decade, global observational studies have analysed this matter's occurrence, solubility and molecular characterization, noting variations in organic carbon concentrations and how it is transformed within the droplets by biological processes. The review concludes by discussing the impact of fog on the atmospheric deposition and persistence of organic material. Additionally, in [27], studies since 2000 have investigated dew and mist harvesting as a sustainable solution to the global water challenge of climate change. Despite its connection to architectural science, scholars and architecture practitioners know little about this field. A systematic review revealed a predominance of studies on flat mist nets and dew condensers. The exploration of combined harvesting systems in three-dimensional formats and the use of traditional architecture and local materials in Indonesia are suggested, highlighting the possibilities in urban and rural areas.

3. Materials and Methods

The methodology of this study is based on the exhaustive review of articles collected from the Scopus database. A bibliometric analysis is carried out, taking advantage of the ability of this platform to filter information using Boolean algorithms, which makes it an extremely versatile and effective tool for the search of journals and scientific articles. Scopus offers a wide range of publications, which enriches the research and analysis process.

3.1. Flowchart

The research will follow the path in the provided flowchart (Figure 1). During the information search phase, it is crucial to ensure the quality of the results [28], [29]. That is why limiting our searches to precise keywords and clearly defining our objectives is essential. The second section details the information gathering process, focusing on the Boolean search facilitated by Scopus. The data will be filtered according to the document type and the year of publication, using specific criteria [30]. This data will then be organized in a CSV storage format for further analysis. Finally, we will present the results clearly and in an understandable way through tables and graphs, highlighting relevant characteristics such as novelty, citations, year, and impact.

3.1.1. Data Search

Scopus is one of the most prominent platforms for exploring information in scientific and academic research [31]. This tool offers streamlined access to a wide variety of documents, including articles, journals, conferences, patents, and books, making it easier to find relevant information. Its interface, renowned for being dynamic and easy to navigate, makes it a must-have option for researchers. In addition, Scopus allows advanced searches to be carried out using specific filters, such as subject areas, authors and affiliations [32], improving the accuracy and efficiency of scientific literature searches. The platform also offers bibliometric analyses that allow citations to be tracked and the impact of publications to be measured, consolidating itself as a key tool for managing, evaluating and developing high-quality research in various disciplines.

3.1.2. Data Processing

In the second section, we will describe in detail the information selection process using Scopus' specialized search and its Boolean algorithms [33]. Although the information obtained will be targeted by the filters and keywords we provide, it will also be manually filtered to ensure its relevance to the study's objective. Likewise, we will limit the types of documents considered for this paper to Conference Papers, Reviews, Conference Reviews, Book Chapters, Editorials, Letters, Short Notes, and Books if their content is aligned with our research objectives.

During the data processing phase, various documents were used, focusing on devices for mitigating traffic accidents in foggy conditions and offering solutions and methods to address this problem [30]. No restriction was imposed on the language of the papers, which were selected from various fields of study and disciplines if they addressed solutions and methods to mitigate traffic accidents in foggy conditions. For the development of this work, a time interval from 1950 to May 2024 was considered with respect to the documents collected. An analysis was made of the number of documents per year, data on the most cited authors, the research activity of different countries, the number of documents by country or territory, publications per author and the journals with the highest number of publications in that interval.

When previewing an incomplete result in Scopus, a Boolean criterion can be added or excluded in the Boolean formula described. In addition, some information may be lost, so it is necessary to save some manually [34]. Afterwards, the extracted files .csv and. bib will be sorted according to their order of priority, year, journal, citations, and other information necessary for processing.

3.1.3. Data Presentation

To carry out the data processing in this study, RStudio will be used using the R language, as well as Google Colaboratory, which uses Python for data analysis.

3.2. Bibliometrics with RStudio

It is an open and free source program called RStudio, based on the R programming language. Its primary purpose is to carry out statistical and data analysis. With this tool, it is possible to make predictions from the data provided, analyze it, model it, and represent it in graphs.

RStudio Desktop is a desktop application, unlike RStudio Server, which can be accessed through a web browser. On the other hand, Biblioshiny, a web interface for Bibliometrix, is integrated as a package in RStudio, simplifying data conversion to the R programming language.

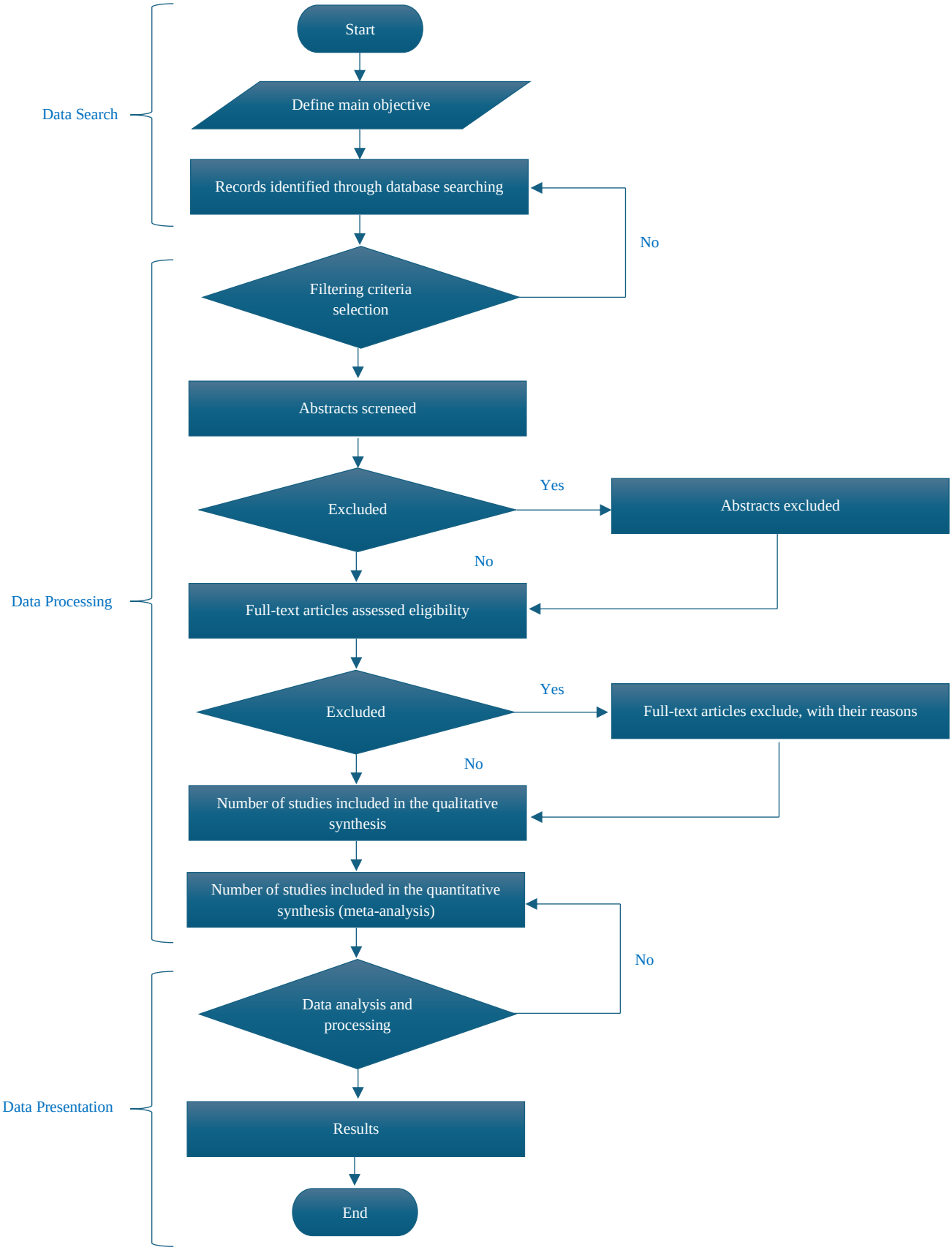

Fig. 1 Methodology flowchart

Bibliometrix is responsible for analysing data extracted from the main bibliographic databases, including Scopus, and allows for the carrying out of the exhaustive bibliometric analysis, generating various graphs.

3.3. Bibliometrics with Google Collaborate

Python, being a general-purpose programming language, could perform a wide variety of functions, including data processing and analysis. Google Collaboratory uses Python as a programming language. This tool is based on machine learning and allows users to edit and execute code for data analysis and graphs, as well as combine it with images, HTML, and LaTeX. The Matplotlib library can also be added to Python using the package manager and is used to render histograms, scatter plots, and other interactive visualizations. Pandas is a Python library for data analysis and numerical computation [35], [36]. It is free, one of the most popular Python libraries, and can process large datasets efficiently. For this work, various aspects such as scientific production, authors and journals were compared using bibliometric data. The findings of this analysis will be presented in. SVG or other image formats are an integral part of the results obtained in this research.

4. Results and Discussion

As part of the methodology, indexed articles of higher scientific quality were obtained by searching and validating bibliographic data using Scopus. In addition, to complement this search, RStudio was used to obtain and process more detailed graphed data, obtaining more precise and specific data essential for the study. The process for data collection is structured in three stages: data search, data processing, and data presentation, which involves selecting the best research articles available.

4.1. Data Search

Regarding the search for scientific articles, a clearly defined and structured research objective guarantees that the results are more precise and detailed because a clear answer is obtained in the search for information on the systematic review of devices for mitigating traffic accidents in foggy conditions.

4.2. Data Processing

Data processing follows a sequence for item selection analysis. It is important to mention that when selecting the keywords and obtaining the search results, given a result, more filtering criteria were selected to obtain more accurate data. For the selection criteria of documents, filters available on the Scopus website were used, such as keywords, author, and year of publication, language, subject area and type of document. This was based on the following algorithm:

(TITLE (fog) AND TITLE (device) OR TITLE-ABS-KEY (technology) OR TITLE-ABS-KEY (iot) OR TITLE-ABS-KEY (3d) OR TITLE-ABS-KEY (raspberry) OR TITLE-ABS-KEY (arduino) OR TITLE-ABS-KEY (esp32) OR TITLE-ABS-KEY (atmega) OR TITLE-ABS-KEY (weather) OR TITLE-ABS-KEY (humidity) OR TITLE-ABS-KEY (atmospheric) OR TITLE-ABS-KEY (gps) OR TITLE-ABS-KEY (location) OR TITLE-ABS-KEY (detection) OR TITLE-ABS-KEY (sensor) OR TITLE-ABS-KEY (bluetooth) OR TITLE-ABS-KEY (display) OR TITLE-ABS-KEY (led) OR TITLE-ABS-KEY (oled) OR TITLE-ABS-KEY (battery) OR TITLE-ABS-KEY (supervised AND learning) OR TITLE-ABS-KEY (unsupervised AND clustering) OR TITLE-ABS-KEY (deep AND network) OR TITLE-ABS-KEY (neural AND networks AND model) OR TITLE-ABS-KEY (convolution) OR TITLE-ABS-KEY (automat) OR TITLE-ABS-KEY (automatic) OR TITLE-ABS-KEY (big AND data) OR TITLE-ABS-KEY (expert AND system) OR TITLE-ABS-KEY (hybrid AND intelligent AND system) OR TITLE-ABS-KEY (diffuse AND logic) OR TITLE-ABS-KEY (artificial AND intelligence) OR TITLE-ABS-KEY (traffic) OR TITLE-ABS-KEY (safety) OR TITLE-ABS-KEY (devices) OR TITLE-ABS-KEY (automobiles) OR TITLE-ABS-KEY (roads) OR TITLE-ABS-KEY (car AND safety) OR TITLE-ABS-KEY (driver AND assistance) OR TITLE-ABS-KEY (autonomous AND vehicles) OR TITLE-ABS-KEY (control) OR TITLE-ABS-KEY (Visibility) OR TITLE-ABS-KEY (headlights) OR TITLE-ABS-KEY (low AND visibility) OR TITLE-ABS-KEY (night AND driving) OR TITLE-ABS-KEY (alerts) OR TITLE{{-ABS-KEY (warnings) OR TITLE-ABS-KEY (mist) OR TITLE-ABS-KEY (haze) OR TITLE-ABS-KEY (rural) OR TITLE-ABS-KEY (engineering) OR TITLE-ABS-KEY (design) OR TITLE-ABS-KEY (implementation) OR TITLE-ABS-KEY (modeling) OR TITLE-ABS-KEY (prototype) OR TITLE-ABS-KEY (low AND cost) OR TITLE-ABS-KEY (prevention) OR TITLE-ABS-KEY (adaptation) OR TITLE-ABS-KEY (monitoring) AND NOT TITLE-ABS-KEY (system) AND NOT TITLE-ABS-KEY (algorithm) AND NOT TITLE-ABS-KEY (computing) AND NOT TITLE-ABS-KEY (chemistry)) AND PUBYEAR > 2002 AND PUBYEAR < 2025 AND (EXCLUDE (SUBJAREA , "EART") OR EXCLUDE (SUBJAREA , "COMP") OR EXCLUDE (SUBJAREA , "PHYS") OR EXCLUDE (SUBJAREA , "MATE") OR EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "AGRI") OR EXCLUDE(SUBJAREA, "SOCI") OR EXCLUDE(SUBJAREA, "CHEM") OR EXCLUDE(SUBJAREA, "DENT") OR EXCLUDE(SUBJAREA, "HEAL") OR EXCLUDE(SUBJAREA, "NURS") OR EXCLUDE(SUBJAREA, "VETE") OR EXCLUDE(SUBJAREA, "PSYC") OR EXCLUDE(SUBJAREA, "PHAR") OR EXCLUDE(SUBJAREA, "ECON") OR EXCLUDE(SUBJAREA, "DECI") OR EXCLUDE(SUBJAREA, "NEUR") OR EXCLUDE(SUBJAREA, "IMMU") OR

EXCLUDE(SUBJAREA, "BUSI") OR EXCLUDE(SUBJAREA, "ARTS") OR EXCLUDE(SUBJAREA, "MULT") OR EXCLUDE(SUBJAREA, "BIOC") OR EXCLUDE(SUBJAREA, "ENER") OR EXCLUDE(SUBJAREA, "CENG") OR EXCLUDE(SUBJAREA, "MATH") AND (EXCLUDE(DOCTYPE, "NO") OR EXCLUDE(DOCTYPE, "CH") OR EXCLUDE(DOCTYPE, "tb") OR EXCLUDE(DOCTYPE, "rp") OR EXCLUDE(DOCTYPE, "ED")).

The records of the previously identified scientific articles result from applying filters in the database. This process has provided a list of valuable results for the study, allowing us to advance to research with a solid and reliable basis. Subsequently, abstracts of each article were obtained. Once done, those that were unnecessary were excluded, and the most important ones were selected; full-text articles evaluated for readability were also chosen. In this step, an exclusion was made by several studies included in the qualitative synthesis and full-text articles were included according to their problems. Discarding some of the articles was necessary since they did not meet the type of information sought according to this research work's objective, such as the Arduino or Raspberry Pi devices. Finally, one study was carried out on the number of studies included in the quantitative synthesis.

This metadata was stored in. CSV and processed using the software mentioned in the methodology section. All this metadata was useful for collecting filtered information by manual selection and using the tools provided by the Scopus interface. Initially, it resulted in offline themes. Therefore, exclusion was made in this case, as shown in Figure 2. After applying the filter, 387 of the 2,327 found documents were obtained as search results. This result is attributed to the algorithm proposed and to the one that excludes other types of scientific documents with erratic information.

Table 1. Filter by document type

Type of Documents	N of results
Article	285
Conference paper	95
Review	7
Editorial	Exclude
Report	Exclude
Retracted	Exclude
Book chapter	Exclude
Note	Exclude

Table 2. Documents per year

Type of Documents	N of results
Article	287
Conference paper	95
Review	7
Book chapter	2
Retracted	1
Editorial	1

4.3. Data Presentation

A thorough analysis of the results obtained from the collected research papers was carried out at the data presentation stage. An important data collection of 9610 articles was obtained and processed using Python and its Pandas. lib and matplotlib libraries, taking advantage of the Google Collaboratory platform for more efficient analysis and visualization of results. During the analysis of the scientific documents reviewed, we observed a variation in the frequency of publication, with articles being published weekly, semi-annually, monthly or annually. The Scopus database provides a valuable source of data for our study. Since its initial records in 1950 with only 2 papers, we have observed a steady evolution in the number of publications over the decades.

Between 1957 and 1984, the number of publications increased to 61, reaching its peak in 1983 with a total of 18 published documents. This increase in scientific production indicates a growing interest in the subject we are investigating. As we move forward, publications continue to increase, with notable increases from 2002 onwards. In 2020, we recorded the highest number so far, ranging between 30 and 35 publications. This data reveals a clear trend: the topic of our traffic safety and fog research is gaining relevance over time, attracting continued interest from the scientific community. This historical context provides us with an important perspective to understand the evolution of the topic and the need for updated and relevant research in this field. According to data collected from the Scopus database, there has been an increasing trend in the number of articles related to devices for mitigating traffic accidents in foggy conditions in Peru in recent years.

As of 2017, there was a significant increase in the number of publications, reaching a peak in 2021 with 31 articles. However, in 2024, there was a decrease in the number of publications, with a total of only 4 articles. This decline could be attributed to several factors, such as changes in research priorities, the resolution of specific problems, or the emergence of new technologies that may have reduced the need for research in this field. Despite this fluctuation, the total number of publications during this period is considerable, suggesting a continued interest in developing and implementing accident prevention devices and methods on roads frequently affected by fog in Peru. This interest reflects the scientific community's commitment to improving road safety and adapting to the country's specific climatic conditions. The analysis of the Scopus database reveals a clear focus on the intersection between Engineering and Environmental Science in research on devices to mitigate traffic accidents in foggy conditions, with 212 and 189 papers, respectively. This approach suggests a recognition of the complexity of the problem, which not only involves technical engineering aspects to develop effective devices and environmental considerations related to the nature and intensity of the haze in different regions.

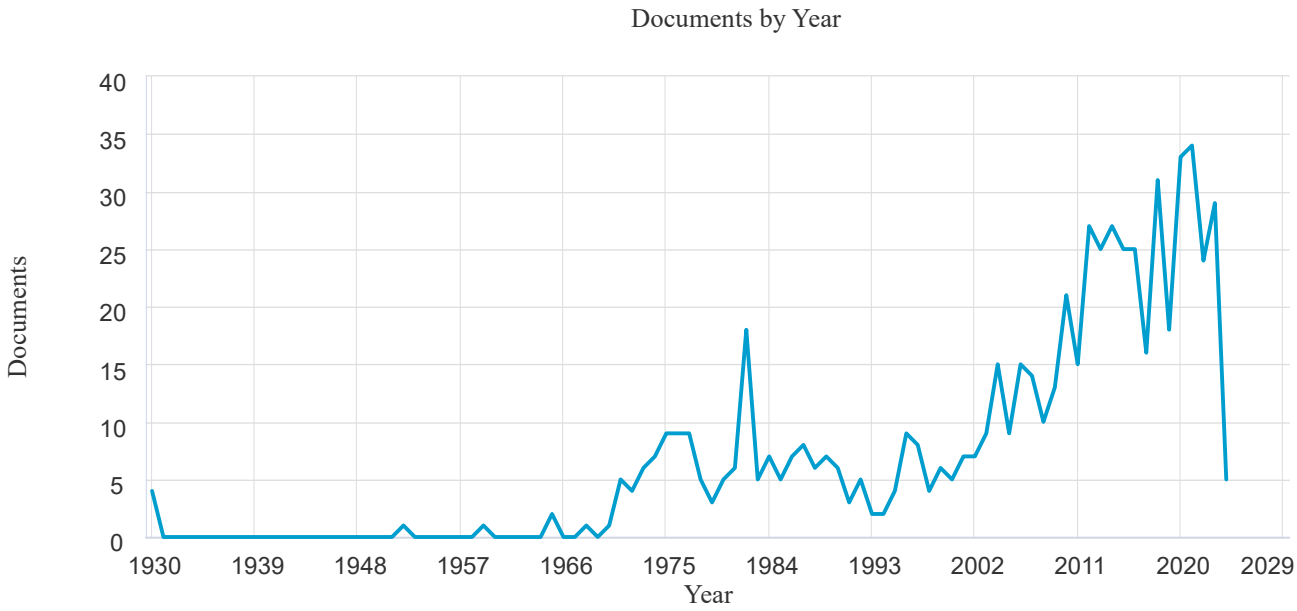

Fig. 2 Document per year

It is essential to highlight that research in this area is crucial given the significant impact of traffic accidents in foggy conditions on road safety, especially in a country like Peru, where varied topography and weather conditions can exacerbate this risk. Combining engineering and environmental science efforts is vital to create comprehensive and sustainable solutions that address the devices' technical effectiveness and their adaptation to local environmental conditions.

This underscores the importance of a multidisciplinary and collaborative approach in researching and developing road traffic accident mitigation measures in foggy conditions.

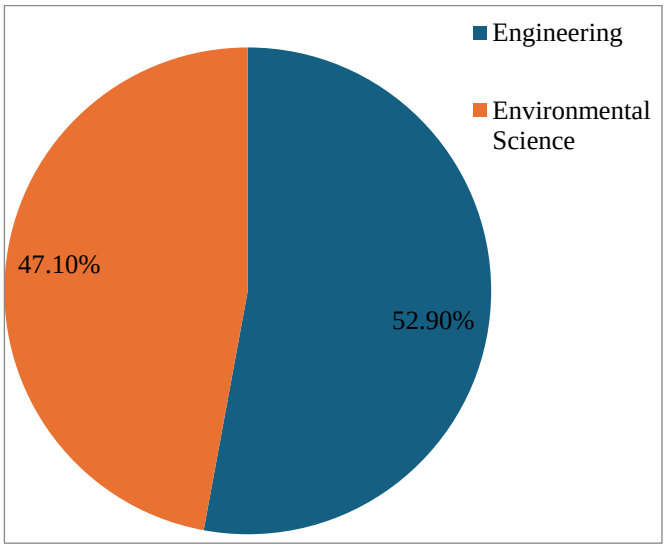

Fig. 3 Document by subject area

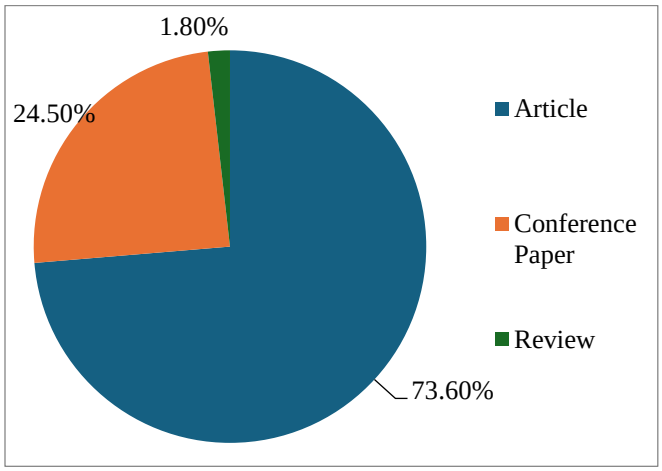

Fig. 4 Filter by document type

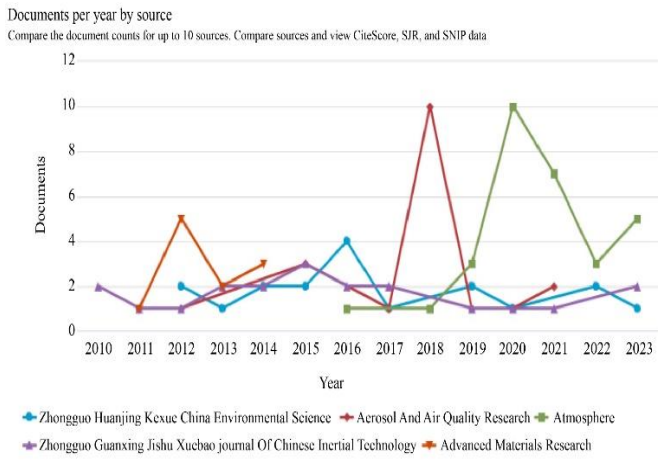

Fig. 5 Filter per year by source

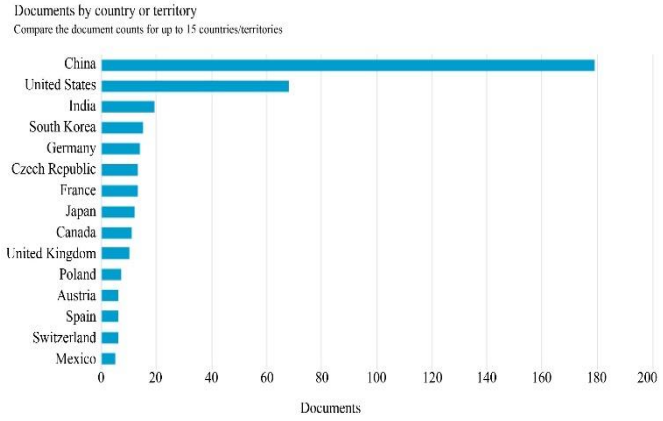

Fig. 6 Filter by country

Of the 387 documents identified in Scopus on the mitigation of traffic accidents in foggy conditions on Peruvian roads, the majority are articles (73.7%), followed by conference papers (24.5%) and reviews (1.8%). This suggests a predominantly academic approach to research on this topic. Many articles indicate a continued interest in developing devices and methods to address this challenge in Peru's specific context. The presence of conference papers also signals active activity in presenting and discussing advances in this field, possibly driving innovation and collaboration between academic and industry professionals. This panorama highlights the commitment of the Peruvian scientific community to the search for effective and sustainable solutions to improve road safety under low visibility conditions. After analyzing Scopus' search results on traffic accident mitigation devices in foggy conditions in Peru, a wide variety of sources are observed, with a significant concentration in journals related to atmospheric sciences and materials technology. Atmosphere magazine leads with 30 articles, followed by Aerosol and Air Quality Research and Journal of Chinese Inertial Technology, each with 20 articles. This diverse set reflects a multidisciplinary approach to addressing the problem, incorporating aspects of engineering, environmental science, and technology. In addition, the presence of journals such as Science of the Total Environment and Environmental Science and Pollution Research suggests a concern about the environmental impacts of the proposed solutions. This indicates an active search for innovative and sustainable solutions to mitigate traffic accidents in foggy conditions in the Peruvian context. China leads with 179 documents on accident mitigation devices in foggy conditions, followed by the United States with 68 documents and India with 19. This analysis reveals a significant concentration of research in these countries, possibly due to their high population density and extensive road infrastructure.

However, other countries such as South Korea, Germany, and the Czech Republic among the top ten highlight the geographical diversity of interest and research in this field. In addition, countries such as Mexico, Spain, and Brazil have suggested a global concern for road safety in foggy conditions. This geographical dispersion of research underscores the importance of addressing the challenges of reduced visibility on roads internationally, thereby promoting global collaboration and knowledge sharing to improve road safety. A notable number of authors have contributed to developing devices to mitigate traffic accidents in foggy conditions. The most prolific authors in this field are Lee, Y.L., Nakashima, Y., and Takamatsu, M., each with 6 publications, followed by Kurniawan, B.A., Yin, Y., and Chen, K., with 5 and 4 publications respectively. The author's distribution of the number of publications demonstrates a wide variety of contributors, suggesting a significant and diversified interest in developing accident prevention devices and methods on fog-affected roads.

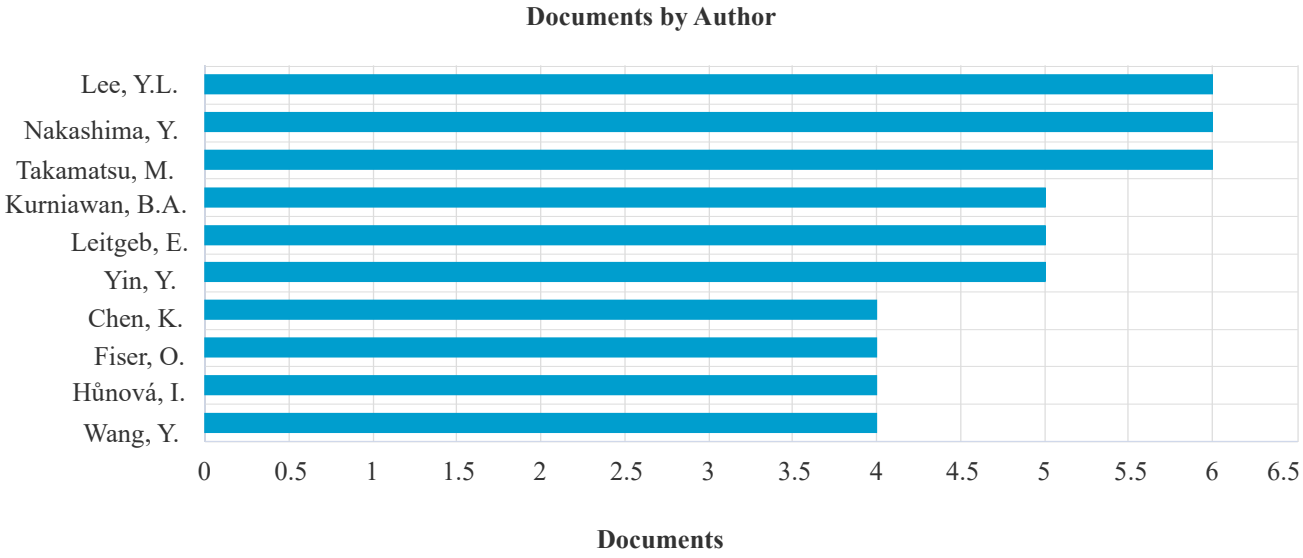

Fig. 7 Filter by authors

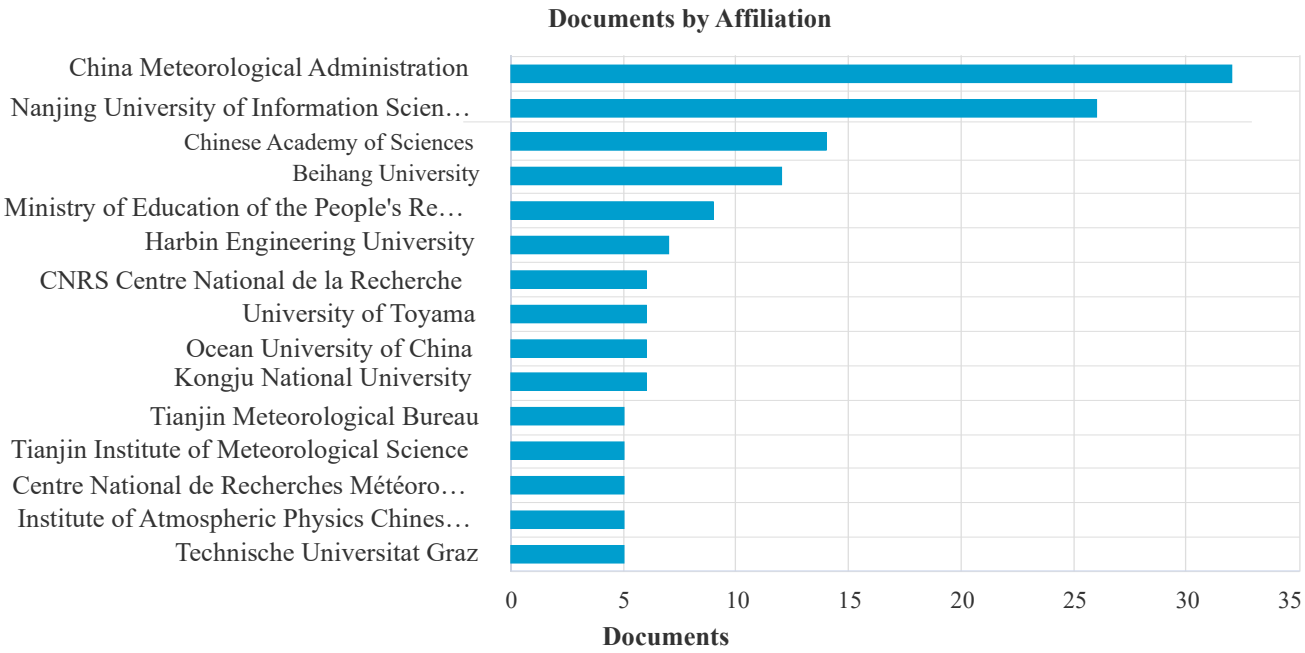

Fig. 8 Filter by affiliation

This diversity indicates a multidisciplinary approach that incorporates engineering knowledge, sensor technology, and data analytics, facilitating the creation of innovative solutions.In addition, the frequency and distribution of the publications reflect a collaborative effort within the scientific community to share advances and best practices. A predominance of Chinese affiliations and universities is observed in the research of devices to mitigate traffic accidents in foggy conditions, with the China Meteorological Administration and the Nanjing University of Science and Information Technology standing out. In addition, research institutions from various countries in meteorology and atmospheric sciences also play an important role, such as the Academy of Sciences of the Czech Republic and the Indian Institute of Tropical Meteorology. Chinese affiliations account for most studies, with the China Meteorological Administration leading with 32 studies, followed by Nanjing University of Information Science and Technology with 26. This geographic and academic concentration suggests a robust approach to China's foggy road accident mitigation research and significant international collaboration in this field.

5. Conclusion

The relationship between technological advances in managing adverse weather conditions, such as fog, and innovations in road safety highlights the importance of emerging technologies in improving public and environmental safety. Both fields advance thanks to accurate and rapid methods to identify and address critical problems. On the other hand, [19] and [28] extensively review the relevance of fog in environmental contexts and its influence on visibility in sectors such as aviation. Meanwhile, [25] emphasizes the need to improve the detection and prediction of ice fog in northern latitudes, highlighting advances in simulation and remote sensing. In fog management, implementing nanocomposite-based devices and advanced testing to detect and manage dense fog represents a step towards efficient and accessible solutions, crucial in vulnerable communities. At the same time, developing advanced models that use real-time monitoring technologies to detect accidents shows high accuracy in road safety. In addition, algorithms based on meteorological data to predict and mitigate the impact of fog demonstrate how artificial intelligence is transforming both meteorology and road safety, enabling early and effective interventions. Finally, [26] and [27] examine the role of organic matter in fogs and clouds, highlighting their impact on the atmosphere and proposing dew and fog harvesting as innovative responses to the climate change-induced water challenge.

These studies provide a comprehensive perspective on the application of technologies in mitigating environmental and social problems. Emerging technologies in road safety improve the response to adverse conditions such as fog and prevent accidents, using real-time monitoring systems and advanced techniques such as ontology and sentiment analysis. These methodologies increase accuracy in detecting hazardous conditions and improve real-time traffic characterization. Research on fog and its impact on visibility highlights the need to address complex natural phenomena, reflected in studies on the influence of fog on visibility in aviation and transport. The study of fog microphysics and its numerical model prediction exemplifies how advanced science contributes to practical solutions that affect public

safety. In conclusion, this review highlights the importance of technological advances in reducing traffic accidents in foggy conditions, emphasizing the need to implement advanced devices to improve road safety. Technologies such as adaptive lighting systems, real-time monitoring, and advanced algorithms offer effective solutions to minimize the risk of collisions in low-visibility situations. These developments address the constraints imposed by fog and integrate innovations such as artificial intelligence and weather data analysis. Although important advances have been made, there is still much to be done to implement and adapt these technologies in specific contexts, such as Peruvian roads. Collaboration between the scientific community and emerging technological advances will be key to further improving road safety. It is recommended that future research focus on developing more accessible and efficient devices to meet the challenges of driving in adverse weather conditions. For this reason, it is recommended that future research be developed regarding the production of devices to mitigate traffic accidents with fog detection. In addition, this work is left as a new line of research in treating climatic conditions for subsequent study.

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