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# Geo-Informatics for the Future: A Systematic Literature Review on the Role of WebGIS in Infrastructure Planning and Development

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**Abstract**

The crucial role of geographic information in contemporary transportation infrastructure planning underscores the need for efficient and practical tools. This systematic literature review aims to provide a comprehensive overview of the current evidence concerning Web Geographic Information Systems (WebGIS) application in infrastructure planning. It further identifies potential avenues for future research. The study leverages digital libraries to source peer-reviewed papers and published journals, evaluating the characteristics and applications of WebGIS. The review offers an in-depth analysis of WebGIS implementation, focusing on flexibility, location, utilized sectors, and environmental impacts.

The methodology involves identifying research topics, developing a search plan, and selecting relevant articles using rigorous search techniques. The selected articles undergo a thorough quality assessment before data extraction. This review seeks to answer key research questions: How does WebGIS aid infrastructure management in agricultural settings? Can WebGIS be implemented free of charge? Is it flexible and user-friendly? Can WebGIS address the issue of declining seawater quality? Has WebGIS been successfully implemented for infrastructure planning globally? This review aims to shed light on the potential of WebGIS in shaping future infrastructure planning and to encourage further exploration in this field.

 

## A. Introduction

Mobility across regions is hindered by physical barriers such as geographical separation, travel time, and transportation costs [1]-[2]. An efficient transportation system is instrumental in connecting locations and facilitating activities, thereby eliminating regional barriers. This connectivity hinges significantly on adequate road networks. Optimal urban economic and social environments, stimulated by well-developed road infrastructure, can promote growth in these areas. As socioeconomic activities necessitate geographical dispersion, transportation becomes essential.

Accessible data and Geographical Information Technology (Geo-ICT) are fundamental in the development of smart cities, as highlighted by Aina [3] and Kim et al. [4]. Geo-ICT provides a rich geographical perspective and enhances our understanding of urban challenges [5], [6]. WebGIS, while not the only component, is integral to the feasibility of smart cities [3], [7]-[8].

WebGIS is an internet-based tool that enables users to share geographic data over the World Wide Web [9]. It facilitates comprehensive and multi-temporal analysis by querying, downloading, and overlaying visual and geometric datasets. Its architecture comprises hardware and software elements, including a web server, Database Management System (DBMS), computer languages, web browsers, and operating systems [10].

The Systematic Literature Review (SLR) method employed in this study is modeled on those used by Inayat et al. [11] and Kitchenham et al. [12]. This method offers an overview of the existing evidence regarding the implementation of WebGIS for infrastructure planning and outlines pertinent background information for future research initiatives. The study evaluates previously published papers and journals to understand WebGIS characteristics, providing a detailed analysis of WebGIS implementation concerning flexibility, location, sectors utilized, and environmental impacts.

This systematic literature review aims to provide a comprehensive description of existing research on the use of Web Geographic Information Systems (WebGIS) in infrastructure development. It also identifies potential study directions for the future.

The following is the paper's layout: Section 2 describes the approach used for the review. Section 3 compiles and examines the selected studies. Section 4 discusses the findings and answers the research question presented by this systematic review. Finally, Section 5 offers the SLR's conclusions, including its benefits, limitations, and implications for future research.

## B. Research Method

The research strategy used in this article was created following recommendations made by Kitchenham et al. [12]. The author first determined the research topics to determine the paper's involvement. Second, a search plan was developed. Third, articles were chosen, which entailed evaluating their quality. Then, data was extracted.

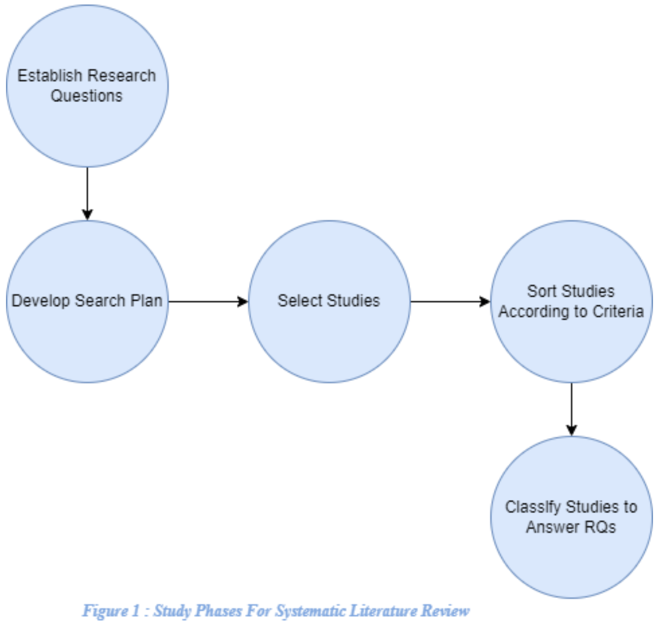


**Figure 1.** Study Phases for Systematic Literature Review

**Research Questions**

The paper addresses four research questions related to the use and implementation of WebGIS in the management of infrastructure, particularly in agricultural locations. Here are the responses to each question:

**Research Question 01:**

What is the role of WebGIS in managing infrastructure within agricultural settings?

**Research Question 02**:

Is it feasible to implement WebGIS without incurring any costs, and if so, does it retain its flexibility and user-friendly interface??

**Research Question 03**:

How does WebGIS contribute to addressing the issue of declining seawater quality and what implications does this have for infrastructural development?

**Research Question 04**:

What is the extent of successful implementation of WebGIS in infrastructure planning on a global scale?

**Search technique**

This systematic literature review (SLR) aims to investigate the role of WebGIS in infrastructure planning and development within the context of Geo-Informatics for the Future. The search process involved the utilization of academic databases such as IEEE Xplore, ACM Digital Library, ScienceDirect, and Google Scholar. Relevant keywords, including "Geo-Informatics," "WebGIS," "Infrastructure Planning," and "Infrastructure Development," were combined using Boolean operators to create effective search queries. The search results were filtered based on relevance, with careful consideration given to the scope and focus of the articles. Reference lists of selected articles were examined, and citation tracking was performed to identify additional relevant sources. The forward and backward snowballing technique was also applied to expand the search. The search process resulted in a collection of articles that will be further evaluated for quality and relevance to the research objectives.

The following steps in this SLR will involve evaluating the quality and relevance of the selected articles using predefined inclusion and exclusion criteria. The evaluation process will consider factors such as research methodology, sample size, data sources, and author credibility. Relevant information will be extracted from the selected articles, including key findings, methodologies, and insights related to the role of WebGIS in infrastructure planning and development. This information will be organized and synthesized in a structured manner. The findings will then be analyzed to identify common themes, trends, and patterns. The final output of this SLR will be a systematic and structured report presenting the findings, adhering to the guidelines and requirements of the research project, and ensuring transparency and reproducibility in the search process.

**Table 1.** Study Selection Process

| | | |
|---|---|---|
| Phase 1 | Online Library Search | 73 Publications |
| Phase 2 | Screening Process | 64 Publications |
| Phase 3 | Exclusion Criteria | 55 Publications |
| Phase 4 | Similarity to RQ1 | 50 Publications |

*Exclusion standards*

The papers were analyzed and ranked according to exclusion criteria to establish the parameters for this particular systematic review in order to omit irrelevant research. The following is a list of the exclusion criteria (EC):

1. Disqualifying factors
   a. One of the exclusion criteria is that the paper has nothing to do with WebGIS.
   b. English is not the primary language of the publication
   c. Duplicate publications or publications that have previously been obtained from another database are excluded
   d. The publication's full text isn't available
   e. The publication was released before to 2000

There were only 77 studies left after the initial three criteria for exclusion were used. A total of 50 papers were chosen for additional analysis after the aforementioned six exclusion criteria were applied.

Below figure shows the types of published sources chosen for this systematic literature review:

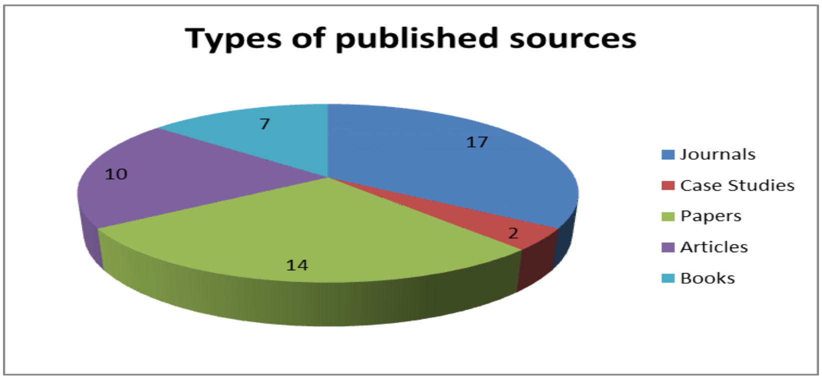


**Figure 2.** Types of published sources

Below figure shows the years in which the chosen sources were published:

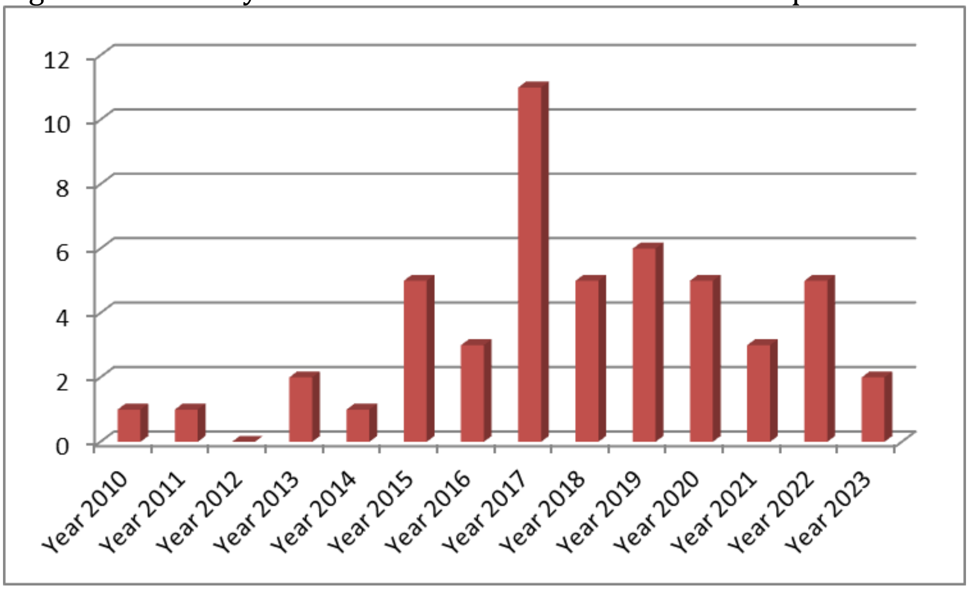


**Figure 3:** Years of published sources

## C. Result and Discussion

This section presents and examines the findings in the context of the study questions. A full summary of the findings is offered to explore the Role of WebGIS in Infrastructure Planning and Development. The diversity of correspondent/first-author articles was evenly distributed across Europe, Asia, America, and Africa. To assess authorship per geographical distribution, we considered the location of the first author affiliation country. China, India, Indonesia, the United States, Finland, England, Denmark, Estonia, Italy, Malaysia, Portugal, and Sweden are among the countries represented. China was the most productive country. Some papers were written or cowritten by the same person, demonstrating the presence of an active research group on this topic.

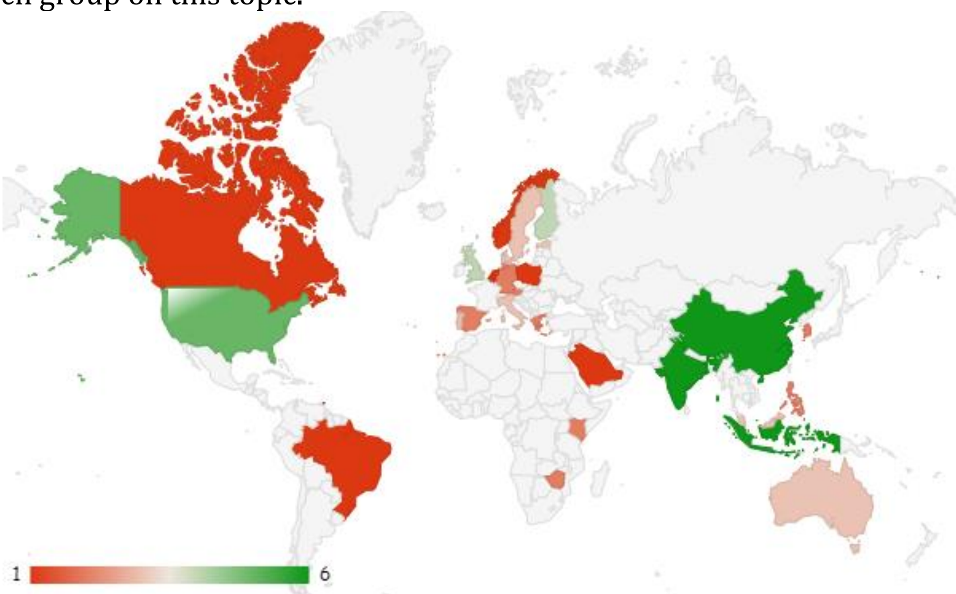


**Figure 4:** Years of published sources

**RQ 01: What is the role of WebGIS in managing infrastructure within agricultural settings?**

Agriculture, utility management, environment monitoring, disaster management, urban planning, road network, forest management, and fish farming are just a few of the programs that benefit tremendously from web-based GIS [13], [14], [15]. Numerous GIS-based SDSSs have been developed for various other applications, including scheduling urban transportation, arranging the distribution of forest goods, managing healthcare in rural areas and associated services, and developing and evaluating environmental resources [16].

The agriculture industry will profit immensely as user understanding of information and communication technology (ICT) grows in emerging nations such as India. Employing online technology and spatial science in agricultural mapping and monitoring will improve decision-making, especially during disaster response and policy formulation [17].

Kumar and Babu's study [18] presents the recommended development framework for a web-based GIS application for supervising and managing agricultural services. The research shows the practicality and design of a computerized system that could provide important data to managers, decision-makers, and agricultural laborers in Punjab, India. Because it ensures continuous exposure to the most recent data, academics, government, employees, administrators, and planners can use the established framework as an efficient decision-making tool. This paper also discusses the usage of online GIS for constructing spatial systems that assist decisions using free technology. Implementing these technologies in agricultural management and planning is beneficial [18].

The GIS-based AMMS site, designed with a simple structure, will help individuals with more technical abilities access the data and take the necessary actions to boost crop output. Such user-friendly platforms aim to promote scientific discovery to the general audience. The program's need to be user-friendly, simple to understand, and cost-effective has been considered. It also emphasizes how GIS spatial data is used in everyday life and how this improves the Punjab government's agriculture industry through increased crop observation and management.

Meanwhile, the Council for Agricultural Research and Economics (CARE) Centre for Politics and Bioeconomics (CREA-PB) built and oversaw the online GIS platform SIGRIAN and the Countrywide IS for Agriculture Water Management. The Agricultural Italian Ministry created this GEO database as a reference library for collecting national irrigation statistics. It has been in operation since 1998. SIGRIAN collects geographical data regarding state water departments' hydraulic infrastructure plans and technical and financial data regarding agricultural water supply administration.

SIGRIAN will be used as a financial assessment database to address policies related to agricultural water supplies and to allow the evaluation of the optimal water supply distribution [19].

Furthermore, the transition from hand drawing to Computer-Aided Design (CAD) and now to GIS has enabled the development of Planning Assistance Systems to provide real-time quantitative feedback regarding visualization, experimentation, and impact evaluation. Some PSS is designed to foster systems thinking by supporting engineers in better understanding the implications of a design decision in a certain framework, not only within that system but also across all other related systems.

These studies illustrate that webGIS may greatly aid in managing infrastructure in agricultural settings.

**RQ 02: Is it feasible to implement WebGIS without incurring any costs, and if so, does it retain its flexibility and user-friendly interface?**

Numerous readily accessible online GIS has increased in popularity among consumers and the geospatial industry as a more economical and practical method of disseminating geographic data. Customers are not required to invest in software resources.

According to Thiebes et al. [20], Buchori et al. [21], and Sejati, et al. [22], the concept behind Web GIS is the ability to present a summary of geographical details along with statistical data that aids in decision-making. Web GIS may be developed using open-source software in underdeveloped nations to save money and achieve the objective of open data, particularly in public policy provision.

Huang et al. [23] have conceptualized a method for constructing an online GIS application using Open Source and free software to utilize publicly available GIS applications in a study. Due to the use of an open-source platform that does not require a commercial subscription, the produced app is cost-effective. The data exchange is cost-free and straightforward to implement. Using this online GIS tool, policymakers, decision-makers, and agricultural laborers can exchange agricultural data more quickly.

In the study by Kuria et al. [24], the open-layers library resources used as the primary mapping client are utilized to construct the dynamic online user interaction using CSS and HTML elements. Free, simple-to-use Desktop Internet GIS (uDig) software generates an adaptive SLD or Styled Layer Descriptor to provide a flexible and user-centric mapping style. In addition, the development of AMMS adds quantitative and geographical analytical components to WebGIS, concluding the platform. The Internet-based geographic information system has a flexible and user-friendly interface that allows users to interact with geographical data and software. The online GIS-focused AMMS approach, which integrates all components into a single system using open-source software, could bridge the gap [24].

The concept of smart cities is frequently a modified version of 'ecologically sustainable metropolitan areas' with increased creativity and innovation. In a broader context, smart cities promote sustainable urban development [25], [26], and [27]. Therefore, technological advancement is crucial for developing intelligent, sustainable cities.

Consequently, defining how the structure is formed based on actual behaviors and problems with effective leadership in property management and urban infrastructure has been challenging. This is because research has yet to focus on evaluating the implementation of urban infrastructure and land use policies. In order to augment previous research, it is essential to describe the development of Web GIS to formulate policies following the characteristics of emerging nations. In light of this, the objective of the study presented by Sejati et al. [27] is to give a paradigm for how Open-Source Web GIS applications may assist in decision-making, particularly for analyzing the implementation of land use policies in emergent economies, particularly Indonesia.

In the interim, a prototype of the open-source web application was recently developed. In the past, costly, licensed software such as ArcSDE and ESRI ArcIMS have been utilized for projects. The ArcSDE 8 Package (which includes a system license) costs $10,000, while the ArcIMS Regular Version Server/CPU License costs $7,500. For the purpose of this investigation, open-source, online-accessible software was used. Whether they are accustomed to working on large or small initiatives, this aids in cost reduction. The online tool will support effective road management and decision-making by detecting promptly damaged road intersections, laybys, bridges, and signs [17].

These studies demonstrate that open-source, flexible, and user-friendly webGIS software is being implemented for free.

**RQ 03: How does WebGIS contribute to addressing the issue of declining seawater quality and what implications does this have for infrastructural development?**

The population's difficulty locating fish growers in Tulungagung District is an issue covered in research by Rahmanto and Hotijah [28]. A computerized infrastructure for controlling, studying, and preserving data about geography known as web GIS, or Website-based Geographic Information System, was created successfully. Consequently, a geographical information system that presents data regarding fish growers in Tulungagung District was developed to address the abovementioned issues [28].

This study employs fish cultivator location information to create maps showing the precise positions of fish breeders so that anyone interested in discovering where Tulungagung, a region known for its numerous fish cultivators, both farmed and ornamental fish, may do so. However, it's still difficult for consumers to locate fish farmers because so many individuals still need to know their existence. Therefore, in this study, a method was developed to use library leaflets and geographic information systems to present the locations of fish farmers. When library leaflets were examined compared to Google Maps API, it was discovered that leaflets loaded more quickly. Thanks to this approach, the local population will find it simpler to locate fish farmers in the Tulungagung region. And recommendations for the following study include developing this platform with online sales capabilities like internet shopping [28].

In another study, the authors explain that anthropogenic impacts impact the marine-coastal ecology in the coastal regions, which causes a profound coastline evolution. A particular fact-finding technique should be created to identify the possible qualitative and quantitative harms sustained by such an environment. An ideal approach to meet those objectives is WebGIS, designed to store, handle, and distribute extensive geographic data and information produced by processing raw data. As a result, this project aims to provide a WebGIS prototype created to analyze and display data on seawater quality in the Puglia area in Southern Italy.

Tides, surges, and waves can result in floods, erosion, dunes, and construction overtopping in many coastal places. Specific initiatives and immediate information that assess all relevant phenomena and may be utilized to create thorough monitoring platforms are needed to address catastrophe and risk mitigation in these areas. In Rocha et al.'s study [29], the WebGIS system's capabilities and features were created with a focus on the needs of future users, and its infrastructure was created using open-source and free applications for GISs in line with the Open Geospatial Consortium and the European legislation INSPIRE. The created WebGIS enables multi-temporal and multiple-sized analysis to assess and track saltwater quality, enabling local authorities to schedule the necessary corrective steps.

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These surveillance systems can aid in the creation of forecasting algorithms that take into account all dangers together. In the article, the authors provide a technique for assessing multi-hazard coastal warning and risk and how it may be applied to a specific WebGIS platform [29].

This article aims to provide an overview of the WebGIS platform's development process to help the formulation of adaption strategies for the Italian municipality of Chiomonte [30]. Since they can bring together the various stakeholders, visualize alternative methods on the ground, and consider both quantitative and qualitative data, GIS is acknowledged as a key player in managing multifaceted and complex decision-making procedures regarding coastal infrastructure [31].

Another crucial problem is the evaluation of seawater quality among the coastlines since it affects the health of coastal ecosystems, which is necessary for the delivery of the ecological services associated with it [32]. Due to a spike in nutrient imports over the past few decades, marine pollution in coastal waterways has grown to be a severe issue. In order to assess the pollution status of seawater, it is necessary to develop user-friendly techniques and instruments for coastal supervisors while encouraging successful plans for the preservation and long-term growth of coastal ecosystems [33].

These studies show that webGIS are solving the issue of declining seawater quality, which helps keep the coastal infrastructure safe and updated.

**RQ 04: What is the extent of successful implementation of WebGIS in infrastructure planning on a global scale?**

In Patel et al’s study [34], a web-based GIS-based system that supports decisions for farming management and scheduling is being developed. Yet, there is room for additional improvements in its features through including result-driven satellite-obtained parameters, thematic dynamic maps, and metrics, which promote the growth of agriculture, and by improving temporal and spatial precision [34].

For an improved understanding of the farming circumstances and practices throughout the state of Punjab, the created system is intended to deliver geographical information to academics, decision-makers, organizers, public and commercial organizations, societies, and even basic and nontechnical consumers.
Additionally, a WebGIS tool has been developed for Serang City's transportation administration. The app is a multitier client-server structure comprised of the data directory, server-side, and the client-side information which is found in the Virtual Private Server. HTML-5, which is supported by the APIs of various open-source web mapping projects, powers the client-side. Each menu works as intended according to the standard performance test of the app, which has been established. The results of this work will inform upcoming studies on WebGIS validation. Multiple instruments such as Web Apps like Selenium Testing and Geoserver's Jmeter [35] must be used to carry out the Playback/Record or Scripting process [36].

Balikpapan Web GIS's system focuses more on infrastructure support that may help the state in a participative approach. Administration and society may successfully track even broad regions with the correct communication strategy using Web GIS. Smart governance will be made possible by an efficient surveillance function and effective technology assistance, allowing for the joint protection of the execution of progress goals. According to the philosophy of the smart city, a smart city is not merely an idealized idea but also one that benefits its inhabitants, which can lead to better governance and higher standards of living [4], [26], [37], [38], [39], [40].

To oversee road asset infrastructure, including rest places, animal grids, bridges, and roadway markings in Zimbabwe, a web-GIS was created. Web-GIS has made it possible to consolidate disparate data sources into a single interface, select assets based on their present state and visualize them, and calculate the distance between each item and the closest departmental camp. According to Ajwaliya, et al. [41], online GIS may be utilized for the design, upkeep, and enhancement of data standards and decision-making procedures. As a result, our research makes it possible for lawmakers and other decision-makers in underdeveloped nations like Zimbabwe to employ affordable solutions for managing roads. Because it was created using open-source, free software, the project appeals to economically constrained nations like Zimbabwe. Furthermore, the app is capable of performing the intended job with proper commercial tools [17].

The purpose of Santillan et al's article [42] was to discuss the creation and implementation of a web geographic information system called "Near-real time Flood Event Visualization and Damage Estimations", which can display comprehensive visualizations of present and projected flood features as well as the capacity to analyze and offer maps and statistics regarding the effects of flooding on different infrastructures, such as bridges, roads, and buildings.
Using a web GIS system, the multiple flood layers depicting present and predicted flood occurrences as well as other geographical layers such as infrastructures including administrative boundaries, bridges, roads, and constructions are then rendered accessible in almost real-time.

The user may do spatial overlay examination for effect evaluation as well as flood features visualization using a mix of online mapping data management, visualization, and evaluation resources [42].

In this respect, the Turin (Italy) municipality's "Albera.TO" online tool, which was introduced in 2017 and continues to be under expansion, provides an intriguing illustration by enabling the administration and scheduling of the entire town's green spaces, including its historic gardens and parkland . This research's ultimate objective is to examine, using a few case studies, the relationship between Strategic Plans and GIS/WebGIS solutions that are at present being created.

Throughout the world, WebGIS services may handle all data about historic public gardens, their elements and characteristics such as pavements, plants, water network, trails, hedges, lawn areas, and trees. They can register and schedule maintenance and care, such as mowing the greenery, trimming shrubs, applying fertilizer and pesticide, and performing technical assessments on monumental trees. The aforementioned WebGIS services are particularly well-liked by municipal administrations as a result of the integration of tree supplies and historical garden evaluation with all organizational and decision-making procedures, as well as the provision of a guaranteed comprehensive and current database containing all components of greenery [43].

Building Information Modelling, GIS, and PSS now allow all that to an unparalleled level, from the bigger to the smaller architectural scale [44]. As such, the goal of the Unnat Bharat Abhiyan is to empower individuals from higher education establishments to collaborate with rural residents by recognizing their advancement concerns and creating remedies to quicken sustainable progress. For efficient execution of decisions and planning, strategists and lawmakers must rely on geographical infrastructure as well as data that are not spatial [45].

Regarding highway infrastructure development, BIM and WebGIS are powerful tools that let users fully comprehend the unique status of a building, support three-dimensional models of that structure, and address spatial issues to the fullest extent possible. This paper initially covers the current state of highway maintenance before proposing the use of BIM+WebGIS integrated technologies in the creation of a platform for managing highway maintenance. The digital shift in the field of the maintenance of highways is achieved through the investigation of this technology framework, and the advancement of highway administration in the area of science, technology, and cognitive ability is encouraged. It also offers reference knowledge to improve highway fine governance through technological approaches [46].

Meanwhile, the Strait of Mytilene in Greece was utilized as a case study, and a user-friendly webGIS app was created [30]. The process starts by examining the precision of spatial interpolators, which are frequently used in oceanographic investigations to determine the geographical distribution of pertinent variables. The construction of the representative theme layer then uses the best interpolator that was disclosed for each variable. The data gathered from the best thematic layers that depict the geographical patterns of the elements under investigation is combined in the second stage to create a new thematic component that shows the environmental state of the research region [47], [48].

These studies prove that webGIS been successfully implemented for infrastructure planning throughout the world.

## D. Conclusion

Smart city adoption with intelligent citizens and intelligent management will no more be an idealistic goal because of great collaboration and backing for open data across the society, administrations, and Web GIS systems. One of the studies examines how metropolitan populations of various sizes respond to online GIS technologies. This is significant since the usage of Web Geographic Information Systems in land use tracking mechanisms pertains to and is focused on urban populations. This will make the technology useful and affordable for application in all emerging nations. The tailored GIS solutions dramatically enhanced data management, visualization, and decision-making processes.

This paper's SLR considered 50 papers on the topic of WebGIS and infrastructure planning. The papers were derived from some digital libraries. After processing 50 research papers from the web of science database, we cannot avoid the evidence and the majority of articles are dominant in WebGIS being the best option for infrastructure management.

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