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Combating Overtourism: The Use of Web-GIS in Visualizing Tourist Distribution and Travel Patterns

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Abstract

Web-GIS in the tourism sector can be done using website technology, namely by visualization based on tourism spatial attributes that display polygon-based patterns and points of tourist attraction locations to combat overtourism in tourist attractions. With the development of geospatial technology, tourists' distribution and travel patterns can be visualized by collecting data on tourist visits to tourist attractions and their routes. With the YWDM method, this web-gis was developed using the YWDM methodology with several phases according to the methods used. This application uses an open-source programming language, namely Javascript, and uses JSON as an upstream geodatabase. The results show that Web-GIS visualization of the distribution and travel patterns can make monitoring the density of a tourist attraction easier. It is well developed in providing more accurate information on the distribution and density of tourist attractions. With the YWDM methodology, visualization can be done like the software development stage and equipped with steps in need for spatial data management.

Keywords: Web-GIS, YWDM, Overtourism, Tourist Distribution, Travel Pattern.

INTRODUCTION

The development of information technology is developing rapidly, so it is necessary to adjust information technology on an ongoing basis. In this study, the data used is the Greater Bandung area as sample data. By using technology to support the institution's performance, it is necessary to adjust its information technology according to technological developments. One of the uses of information technology is web GIS-based applications in the tourism sector which can find out the location and information related to tourist attractions and the distribution of tourists through web GIS.

Visualization of the distribution of tourists based on GIS is a means of information used by stakeholders to make it easier to track the distribution of visitors to tourist destinations, the tourism office, service users (tours and agents), and the community (Abdullah et al., 2019). The pattern of tourist travel in an area is one of the essential aspects that tourism stakeholders need to know. The tourist travel pattern is a link in the travel chain from where tourists stay in the area (hub), through an entrance/exit to a destination (entry point), in which tourists use facilities to support tourism activities to attractions. Tourism is related to what tourists will do, see, and buy around the attraction. Therefore, the movement of tourists needs to be described through a clear visualization of travel patterns to assist policymakers in formulating tourist deployment strategies to overcome the accumulation of excess tourists in a place (overtourism).

In contrast to spatial studies or other fields, the tourism sector is usually visualized in the form of polygon-based spatial patterns(Novianti et al., 2020). With the development of technology in geospatial, the visualization can be done

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well with the existence of Web-GIS technology or web-based mapping involving the participation of stakeholders and the public(Boers & Cottrell, 2007). Maps from third parties can be taken according to the conditions in which the satellite takes data, so this application needs to process the data and then visualize it with the actual conditions. The development of geographic information systems is a combination of the development of the Web and GIS applications, both of which are complex (Maocan et al., 2017). Therefore, when developing a geographic information system, it may be necessary to use a different methodology that is completed at each stage rather than using a general software development methodology.

One of the proposed WebGIS development methods is YWDM (Y WebGIS Development Methodology). This is a theoretical methodology proposed by Ananda, Curia, and Ngigi that applies joint software development approaches, web development approaches, and applications. This methodology is called Y and derives from the representation of the methodology diagram in the form of the letter Y. At YWDM, the development of this system is done in two ways. That is, creating applications and web applications related to data and GIS technologies. Universal. The development phase is divided into four phases, followed by the implementation phase (Ananda et al., 2016). The implementation phase is further divided into several phases. Integration, optimization, testing, deployment, configuration, training testing, system maintenance, and GIS data and web applications upgrades. Some studies were conducted only up to Phase 3, but Phase 4 was used for web services in this study (Rowland et al., 2020). The development of this application is expected to use the YWDM technique. WebGIS development is more accessible to build than using the usual SDLC methodologies, especially the requirements to meet the visualization of spatial data. This methodology addresses the context of software development and spatial specifications. The implementation of this methodology reveals that from the perspective of tourist attraction users, or road users, for example, the development of geographic information system applications can be made more accessible to the users' needs (Fauzi, 2020).

LITERATURE REVIEW

2.1. Overtourism

UNWTO (UNWTO, 2018) defines overtourism as the impact of tourism on tourist destinations or parts thereof, affecting the quality of life of citizens and the quality of experience of visitors. The UNWTO report further reports on economic development, lower transportation costs, ease of travel, and rapid urbanization caused by an increase in the middle class between developed and developing countries, which make cities more popular as businesses, or the tourism sector; described as the growth of tourist destinations. In summary, lack of proper management and chaotic development are the main reasons for excessive tourism. The UNWTO report clearly states that tourism must be developed and managed sustainably for visitors and communities. Tourism is an opportunity for people and their communities to share their interests, which is why the relationship between the sector and the community must be strengthened.

According to Dodds (Dodds & Butler, 2019), overtourism occurs when too many visitors and tourists simultaneously arrive at a particular location. Therefore, tourism pollution is closely related to the problem of mass tourism saturation in many tourist destinations around the world, which affects the inhabitants' quality of life and brings negative experiences to tourists. There is a possibility. Therefore, tourism pollution has become a major media issue in the last decade due to criticisms and demonstrations in various tourist cities/destinations led by social movements. Previous studies have described how the phenomenon of "anti-tourism" or "tourism phobia" occurs in some cases, such as in Barcelona and Venice (Martins, 2018). The rise of tourism movements has become a well-known problem due to the surge in visitor numbers.

In the case of Bandung, this is not a stranger. According to (Triani, 2019), traffic congestion caused by tourism activities in the Lembang region, especially during the extended holiday season, can lead to tourist dissatisfaction. Traffic jams from tourists outside the city force Bandung residents to get in the way when they want to travel on weekends and holidays. Uncontrolled tourism flows can lead to tensions between residents and tourists and economic and environmental imbalances.

2.2. Tourist Distribution and Travel Patterns

Within the scope of tourism travel, it is known that there are three elements, namely:

a) The element of attraction grouping, namely the aspect of concentration of tourist attractions.
b) The element of grouping service centres, namely the centralization of services.
c) The element of communication, namely the existence of a road network and communication lines that connect each centralized object and service facility with a series of gates.

With the premise that tourism potential can be a suitable object if the thing is easy to achieve, and can be offered for use, then this object depends on the determinants of the location of the gate, transportation routes/means, completeness of tourism supporting facilities, all of which are reflected by tourists' ability to stay.

There are two approaches to this: 1) The approach in terms of achievement describes the pattern of tourist reach to the object. This approach relies on a particular area as the origin of tourists and the use of transportation means and networks. Therefore, the description of this approach reflects the ability the reach of tourists and the length of visit/duration of tourists; 2) The process in terms of utilizing the potential of the object starts from the utilization of the possibility of the existing thing, namely analyzing the potential that exists in the object. Then the utilization of this potential is adjusted to the type of tourist demand. From this approach, it can be seen that there are variations in the attractiveness of tourist destinations.

By combining these two approaches, an alternative pattern of selected tourism travel is obtained by taking into account the following factors:

a) Gateway: Utilization of a tourist attraction requires the support of facilities for ease of achievement and comfort during travel and while staying in the tourist attraction area. The gate is the entrance to a tourist area. The existence of a good gate is a gate through which regional transportation routes and the destination object are not far from the gate.
b) Length of Stay: Observation of the length of stay of tourists in a tourist destination is carried out by looking at the tourist's ability.
c) Priority Order of Tourist Destinations: The order of priority of tourist destinations is used to determine alternative routes according to the limited time of tourists per available funds, then the selection of which attractions need to be visited.

2.3. Y-WDM Methodology

The Y Model Web GIS Development Methodology (Y-WDM) is the name of this methodology (Ananda et al., 2016). The main stages of the process are shown in Figure 1. Three distinct aspects make up the development process. Development of online applications, integration, and management of GIS. The proposed method considers that Web-based GIS development leveraging Y-WDM results in hybrid solutions with the quality of both traditional GIS and web apps. To create a solid product, it is crucial to mix the best practices of each method. The phase that contains the deliverable after each phase is expressly identified by this methodology. This provides a feedback loop to the earlier stage to add flexibility and allow for adaptation to shifting user requirements. The next part describes the approach phase's details.

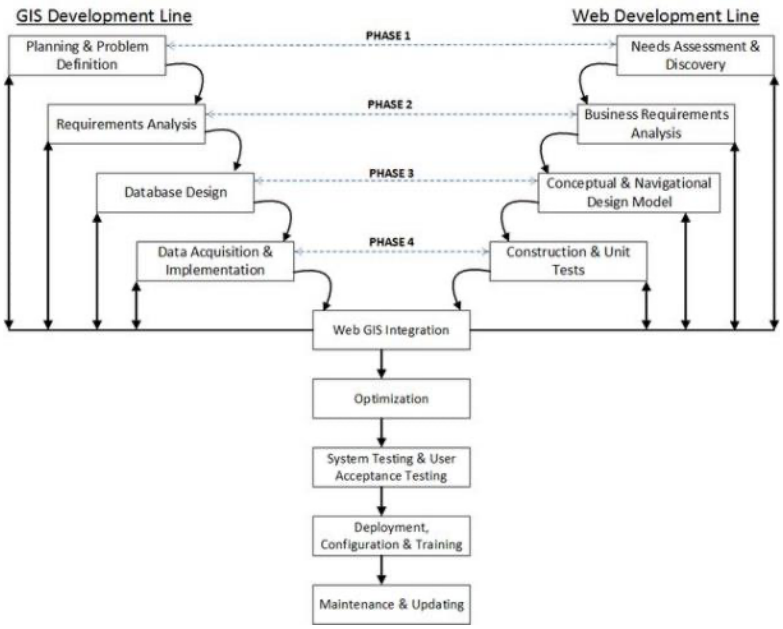


Figure 1. Y-WDM Methodology

Phase 1 The problem's scope is determined at the problem definition step of the software development process. During this stage, there are two simultaneous actions. i.) Planning and problem description – It is essential to determine the problem in terms of its geographic relevance since the system that is being designed must take into account certain spatial elements. In addition, a comprehensive plan for the growth of GIS is also essential. Plans can be visualized using comprehensive workflow diagrams and feasibility studies. ii) Demands Analysis and Discovery – Web applications are interactive; thus, it is critical to consider end-user needs from the beginning. For example, what objectives do users have for the system? This can be determined by performing a quick user survey and focus group discussions with the system's designated end users.

Phase 2 The project's analytical phase is now conducted. The functional and non-functional requirements for GIS and web components must be determined together. Depending on the section addressed, different tools are employed in this step. Discussions and interviews can be used to identify the GIS requirements. Structured interviews and surveys can also be used to determine web requirements. It is crucial to investigate the business processes that your system supports so that you may modify them to satisfy those demands. This stage develops a requirements specification incorporating the system's user and geographic requirements.

Phase 3, Interactive applications comprise phase 3 web applications. For such a system, it is crucial to build a conceptual and navigational model. The conceptual model provides a concise overview of the entire system. Thanks to this, you can now see the most crucial features of your system. A diagram model can be used to illustrate this. The web navigation model illustrates how various online pages are connected. Web engineering based on UML provides the proper syntax for this paradigm. Geodatabase database design is also a part of this step. Entities in the system can still be defined using the relational model.

Phase 4 This stage of the GIS development process is crucial. There are now many methods being used for data collection. That includes various techniques, such as field studies, satellite measurements, survey maps, census, and aerial photos. The database schema that was developed previously shows the collected data. Scripting languages can be used to code web pages. There are numerous open-source tools available. However, you can only develop an online page prototype because the final implementation depends on geodatabase information. Rendering and interpreting geographic data in geodatabases takes up most web page work. On the website, unit tests are run to look for problems at specific function locations.

Phase 5 (Integration and Management Phase), The last and longest phase is this one. For different system components to function together, integration involves integrating them. During this stage, integration testing is carried out to look for compatibility problems and general performance. Optimizing the system will be necessary, primarily while supplying the map layers. Here, several optimization methods, such as optimizing the tile cache, are used to quicken performance. System testing is crucial because it puts the system in its actual operating environment, which the developer might use in real life or a simulated one. During deployment and configuration, the system may be exposed to several incompatibilities due to the transition from the development to the operational environment. Users of the system are allowed to evaluate the system's usability characteristics. Alpha and beta testing can be used to accomplish this. In order to minimize any potential system resistance, it is essential to involve as many users as possible in the process. The continued maintenance will make an effort to meet any new requirements.

METHODS

A sophisticated combination of web and GIS application development creates a web-based geographic information system. Therefore, it seems necessary to use a method entirely different from the standard software development method for creating this system. YWDM is one of the methods proposed for creating geographic information systems (Y-Web GIS development methodology). This is a theoretical technique by Ananda, Curia, and Ngigi that uses standard methods for software development, web development, and GIS software. This method's name, Y, was derived from the method diagram's representation of the letter Y. At YWDM, the production of web applications and data and GIS technology are the first two steps in developing geographic information systems. There are typically four steps in the development phase, followed by the implementation phase. Finally, there are various phases in the project execution. GIS data in web applications: integration, optimization, testing, deployment, configuration, training testing, system maintenance, and upgrades (Han et al., 2010). Because applications that share data might be developed in distinct Javascript programming languages or run on different platforms, web services are the industry standard for doing so. REST web services are thus built using the REST API architecture (Grecea et al., 2016). A server used for implementation that can store geographic data is used. This study uses the Web Map Service (WMS) service to offer location data and a REST API to visualize maps using geospatial data converted from tourist attractions.

RESULT AND DISCUSSION

This chapter will describe the research results in webGIS development using the YWDM methodology, which began in phase 1.

3.1. Phase 1

a) Web GIS Development Line Planning and Problem Definition: How to prepare spatial data containing the parameters of the research area, which in this study are regional boundaries, the locations of tourist destinations based on coordinates, and the number of visitors.
b) Web Development Line Need Assessment and Discovery: This study is needed to manage the distribution of visitors and tourist attraction data, which is represented in a map to assess information and identify the dispersion needs of each tour and travel agent. Maps are also required to forecast the amount of a tourist attraction's area concerning the anticipated amount of tourists

Table 1. Tourist Travel Route

Tourist Attraction	Latitude	Longitude	1st	2nd	3rd	4th	5th	6th	7th
Lembang	-6.81400	107.62250	558	108	153	27	27	0	9
Dago Utara	-6.85930	107.62916	171	234	288	162	27	0	0
Wisata Belanja Dago	-6.87615	107.61774	108	234	225	162	18	90	45
Kebun Binatang	-6.89136	107.60709	126	252	180	162	81	45	36
Gedung Sate	-6.90194	107.61877	126	324	126	144	36	81	45
Wisata Belanja Riau	-6.90635	107.61519	108	108	378	135	9	72	72
Cihampelas	-6.89007	107.60420	108	252	216	180	63	27	36
Alun-Alun Braga	-6.91895	107.60975	180	135	216	216	27	54	54
Pasar Baru	-6.91754	107.60443	63	117	234	198	99	81	90
Trans Studio Bandung	-6.92786	107.63591	162	207	216	108	45	18	126
Saung Angklung Udjo	-6.89827	107.65530	99	198	207	180	108	45	45
Ciwidey	-7.11794	107.43485	171	396	153	63	9	63	27

3.2. Phase 2

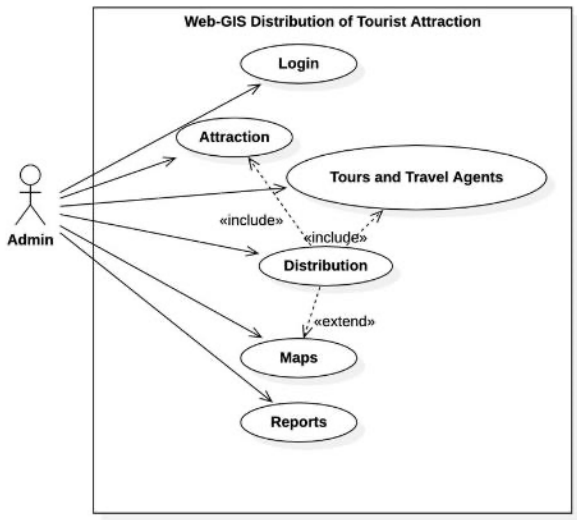
a) Web GIS Development Line Requirement Analysis :
1) The system can process digital map file format input (GeoJSON). It is additionally stored in the geodatabase.
2) The technology may create user-controlled, interactive web maps of the area of research.

b) Web Development Line Analysis Business Process:
By examining the user interface, functional requirements may well be determined when conducting business process analysis. This requirement may be illustrated using a use case diagram. As presented in Figure 2, leverage case diagrams to define the system's behaviour in response to the interaction between actors and the strategy for achieving the user's requirements. The essential actor may be a person or a system. Table 2 illustrates and summarizes the use cases obtained from the functionality requirements of the users. This use case diagram illustrates the functional requirements of the Web GIS related to planning the visualization of the distribution of tourist attractions and the distribution of tourists. Where in the picture, there are the main features of web GIS, namely:
    a) Manage User: features to manage users and access rights to access this application.
    b) Base Map: a characteristic to manage base map data which will be visualized in the boundary layer, road network, contour, and toponomyBase Layer: a feature to manage base and

subbase data which will be visualized in the boundary layer, road network, contour, and toponomy

c) Distribution Pattern: a feature for organizing base map data to be displayed in spatial pattern layers, overlays on existing spatial structure, forest areas, and other layers containing spatial patterns.
d) Itinerary Data from Travel Agencies (TA): Space: features to manage primary map data, which will be presented in the distribution layer, tourist attraction information.
e) Report: a function for generating a printed report containing a visualization map, attribute data per layer, scale, and legend.

This function searches data from characteristics per layer and combines the base map, spatial pattern, and spatial structure.



F**igure 2.** Use Case Diagram

Table 1. Functional Requirement of the Web-GIS

No	Code	Functions
1	FR01. *User Manage*	Manage user access rights in the application
2	FR02. Itineraries from Travel Agencies Data and Number of Tourist Visits	CRUD Travel Agencies Data
3	FR02. Tourist Attraction Management	CRUD Tourist Attraction
4	FR03. Location Point Distribution Management	CRUD Layer Location of Tourist Attraction
5	FR04. Tourist Distribution Management	CRUD Layer Itineraries from Travel Agencies
6	FR05. Report	Reporting
7	FR06. Maps Visualization	*View Maps with layering*

The results of phase 1 are recorded from the user for the required spatial needs, then the next stage is to make a list of any requirements in the system, and the results are in the functional requirements table above.

3.3. Phase 3

a) Web GIS Development Line Database Design: In the design of this application, data modelling utilizes a class diagram that specifies a tourist attraction and the required spatial data mapping.

b) Online Development Line Conceptual and Navigation Design Mode: This web GIS design incorporates YWDM with Uml Diagrams and software development leveraging the Javascript programming and geojson as the geodata format. The designed architecture ensures business requirements and practices follow business processes.

3.4. Phase 4

a) Data Acquisition and Implementation: Throughout this phase, the tourist object data, the itineraries of travel agencies, as well as the number of tourists, along with the order of trips by travel companies are accumulated using a raster format; this format is an image file format that can represent coordinates and styles in the shape of a map. Nevertheless, this data cannot be processed and implemented directly in a web form; hence this step converts raster data to vector data and back to JSON data. The information of base maps is derived from satellite data that has been modified into Open Street Map coordinates (OSM) shown in figure 3.

b) Construction Units and Tests: At this stage, programming begins in conformity with the appropriate established for phase 3, leveraging javascript programming. The testing phase with a black box technique is performed at this step.

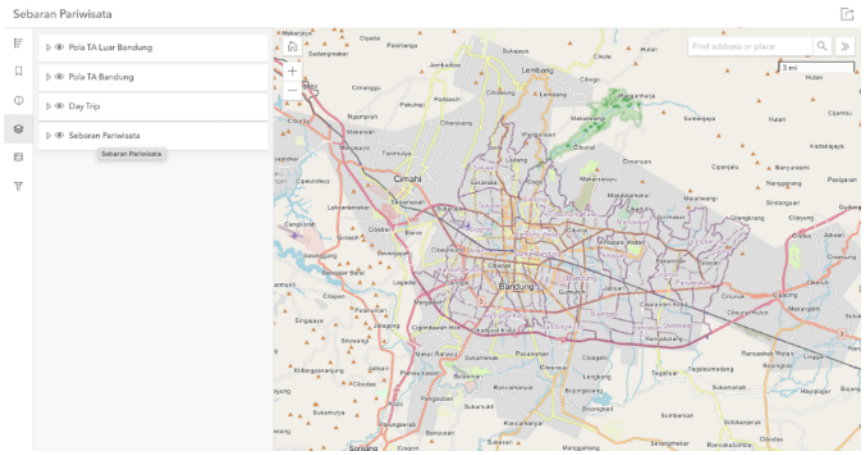


Figure 3. Base Map

The base map application page results from integrating spatial data and web construction for the basic map feature application needs. This page provides map visualization and base map layers, namely administrative and administrative boundaries.

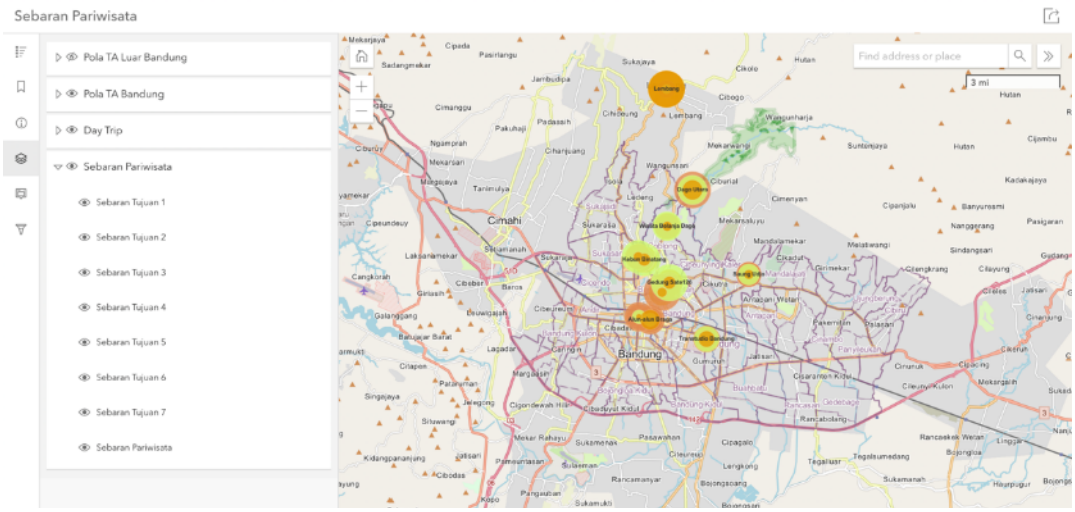


Figure 4. Visualization of Tourist Distribution based on Location

The base map application page results from integrating spatial data and the construction of tourist attraction visualization. This page visualizes tourist attraction locations and distribution information based on tourist attraction attributes. The bigger and more colourful each circle produced, the higher the tourist visits and the distribution of tourist attractions. This data is obtained from Table 1, according to the visit column.

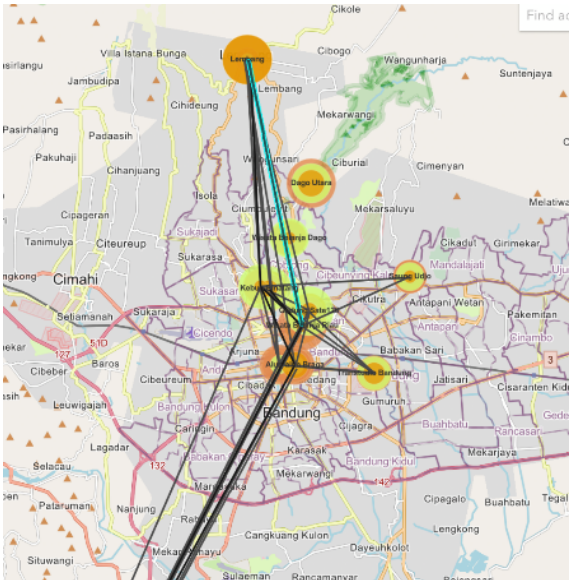


Figure 4. Visualization of Tourist Distribution and Travel Pattern

The visualization page of the distribution of tourists from tourist attractions results from integrating spatial data and web construction to display information on the distribution of tourists and the travel routes taken. This page provides map visualization and distribution layers. The results of the visualization above show the distribution path of tourists to tourist attractions, and the larger the circle visualization means, the higher the tourist visits. The visualization results are from data in Table 2, with an overlay of the distribution layer and tourist attraction.

CONCLUSIONS

Thus, the research on the topic of visualization of the distribution of tourism destinations objects and travel routes is an example of research on spatial and web-based information systems that could be used for monitoring the spread of tourist attractions and visitors, especially in the utilization of information technology to deter an excessive number of tourists from visiting tourist attractions. It may well be accomplished by applying the following strategy:

a) The outcomes of the analysis, design and implementation of visualizations can be applied with a methodology user's needs for monitoring visitor distribution and travel routes.
b) Design and develop a web-based visualization of spatial data requirements specification and phase-adjusted according to YWDM.
c) The findings of this study related to monitoring improvements in the community's tourism industry, notably in preventing overtourism.

The primary objective of this research is to solve the issues posed by the advance in technology in the creation of webGIS, as well as improve effectiveness in managing the object under investigation.

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