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Application of Quantum GIS in the Development of 3D Maps in the Tourism Bakunjangan Application

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ABSTRACT

This research explores the use of Quantum GIS (QGIS) in developing 3D maps for the Bakunjangan tourism application in Banjarmasin City. The integration of spatial data, sensors, and open data sources such as OpenStreetMap (OSM) aims to improve accuracy, consistency, and visitor experience. The development of 3D maps follows the System Development Life Cycle (SDLC) method, which outlines strategies and processes for developing, designing, and maintaining software projects, ensuring that all goals, objectives, functionalities, and user needs are met. The urgency of this research lies in its ability to support the Banjarmasin City government in managing and developing local tourism, especially with the increase in tourist visits from 2,487 in 2022 to 3,895 in 2023. The 3D map feature in the Bakunjangan Application is expected to provide accurate information and a more satisfying experience for tourists, as well as enhance the competitiveness of tourism at the national level. The development of the 3D maps was conducted after a survey of 55 Ground Control Points (GCP) in various tourist areas. The QGIS application, with the help of the Qgis2threejs plugin, facilitates the creation of 3D map animations, although five tourist attractions could not be animated. To optimally display the 3D maps, an internet connection with a minimum speed of 10 Mbps is required. As a result, the Bakunjangan Application produced 65 interactive user interfaces and 50 3D animations of tourist attractions, with an application feasibility rating of 89%, placing it in the excellent category.

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1. INTRODUCTION

The use of technology in the development of the tourism industry is increasingly becoming a key focus in an effort to improve competitiveness and visitor experience. Banjarmasin City, as one of the main tourism destinations in Indonesia, has great potential to be developed further. In today's digital era, the utilization of geographic information systems (GIS) is crucial in mapping and developing base maps for tourism applications. this research is expected to increase the income of the surrounding community through the tourism sector [1]. GIS technology has become an invaluable tool in various aspects of modern life [2]. Quantum GIS (QGIS) has been recognized as one of the powerful and flexible GIS software in mapping and spatial analysis. In the context of developing 3D base maps for tourism applications, the application of QGIS is an attractive option due to its ability to integrate various types of spatial data and stunning visualizations. QGIS plays an important role in making a tedious process easy [3].

Although QGIS offers a significant range of features and capabilities, research into its application in developing 3D base maps for tourism applications, particularly in Banjarmasin City, is limited. This research aims to fill that gap by exploring how QGIS can be used to develop 3D maps. This research will evaluate how the advanced spatial analysis capabilities of QGIS can significantly improve the design [4] of urban planning and base maps relevant for tourism benefit applications in Banjarmasin. With a deeper understanding, it is hoped that this research can make an important contribution to the development of the local tourism industry and the improvement of the tourist experience. The Bakunjangan application is a data management technology for tourism potential in Banjarmasin City that can provide great benefits to the community and support tourism development in Banjarmasin City [5]. As the Bakunjangan Application runs for 1 year, to be precise in 2023, it provides convenience to tourists in exploring tourist attraction information that can help them plan tourist trips through the page https://bakunjangan.com.

Based on Banjarmasin Mayor Decree Number 610 of 2020 concerning the Determination of Community-Based Tourism Destinations in Banjarmasin City and added information from the Tourism Division of DISBUDPORAPAR Banjarmasin City until 2023 where the number of tourism can be seen in Table 1.

Table 1: Number of Tourism Objects by Subdistrict in Banjarmasin City

No	Subdistrict Name	Total Tourism
1	South Banjarmasin	9
2	East Banjarmasin	10
3	West Banjarmasin	5
4	North Banjarmasin	16
5	Banjarmasin Center	15
	Total	55

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QGIS is an open source Geographic Information System (GIS) program for displaying and analyzing GIS data. The program has evolved significantly in recent years and is now a valuable tool for the mineral exploration industry, and a viable alternative to commercially available GIS packages [6]. Mapping can be a very useful tool for exploring, understanding, and presenting information related to the geographical dimensions of a study [7]. Data collection, data processing, and data management are essential for creating 3D models of buildings [8]. Using coordinates, the resulting 3D model is geo-referenced to accurately locate the user's position on the tourism object. The first stage of the process involves collecting building information and sensor data, including geographic coordinates and relevant sensor measurements. The building then adopts a standardized coordinate system, such as WGS84, to match the coordinates of the given tourism object (-3.3169903°N, 114.5828238°E) with the established standard. The coordinates of the sensor data, obtained using the sensors on the smartphone, are transformed to align with the coordinate system of the selected building. With the proposed integrated solution, the user's real-time sensor-based position is connected to the 3D model of the building, ensuring accuracy and consistency in placement. The output from QGIS is mapping that contains information in the form of maps with indicators that are tailored to specific needs [9]. Maps, as visual products of geographic data, allow users to understand and analyze complex information in a spatial context. Therefore, map producers [10], both small and large scale, are the main users of GIS technology. They not only use GIS to collect and process data, but also develop it further to make the maps produced more informative, accurate, and in line with user needs

Efforts towards the realization of 3D GIS involve accurate and detailed 3D modeling of objects with semantic attributes and high-performance visualization [11]. Then the obtained data is integrated with geographic elements in the GIS system to build a spatial model of tourist attractions [12]. Quantum GIS is used for spatial analysis and more in-depth mapping of tourism sites, while Open Street Maps provides spatial data that can be integrated into the system to ensure the accuracy of tourism site information [13]. Unmanned Aerial Vehicle (UAV) is a type of aircraft that is controlled by a remote control system via radio waves [14]. UAV is an unmanned system, namely an electro-mechanical based system that can carry out programmed missions with the characteristics of a flying machine that functions by remote control by a pilot or is able to control itself [15] In other words, this UAV is better known as a drone device.

2. RESEARCH METHOD

Metode yang dipilih untuk penelitian ini adalah pendekatan deskriptif. Data yang diperoleh akan dianalisis secara holistik, baik secara kualitatif maupun kuantitatif. Pendekatan deskriptif bertujuan untuk menyajikan informasi secara terstruktur, objektif,

dan mendalam mengenai fakta-fakta serta karakteristik populasi di wilayah yang diteliti. The method chosen for this research is a descriptive approach. The data obtained will be analyzed holistically, both qualitatively and quantitatively. The descriptive approach aims to present information in a structured, objective and in-depth manner regarding the facts and characteristics of the population in the area under study. By using this approach, a comprehensive picture of the conditions and phenomena observed will be obtained. The qualitative data collected will provide deep insights to answer the research questions posed. In the 3D Maps development method, the author uses the System Developnment Life Cycle (SDLC) method. SDLC is a process that describes methods and strategies such as how to develop design and maintain software projects [16] and ensure that all goals, objectives, functional and meet user needs, SDLC consists of a number of stages that are carried out sequentially[17]. SDLC is the life cycle of a software/application growing according to the times. SDLC is a process that describes methods and strategies such as how to develop design and maintain software projects and ensure that all goals, objectives, functional, and user needs are met [18]. The SDLC process used in this research can be seen in Figure 1.

Figure 1. SDLC Stages

The Software Development Life Cycle (SDLC) starts from Planning & Analysis, where project needs are identified[19], followed by System design which details how the software will be built. Next, the Implementation phase includes writing code, followed by Testing & Integration to ensure quality. Afterward, the software is Deployed, and finally enters the Maintenance phase, where the system is updated and refined as needed. This is poured into the research stages of developing 3D Maps for the Banjarmasin City Tourism Benefits Application. The stages of this research method can be seen in Figure 2.

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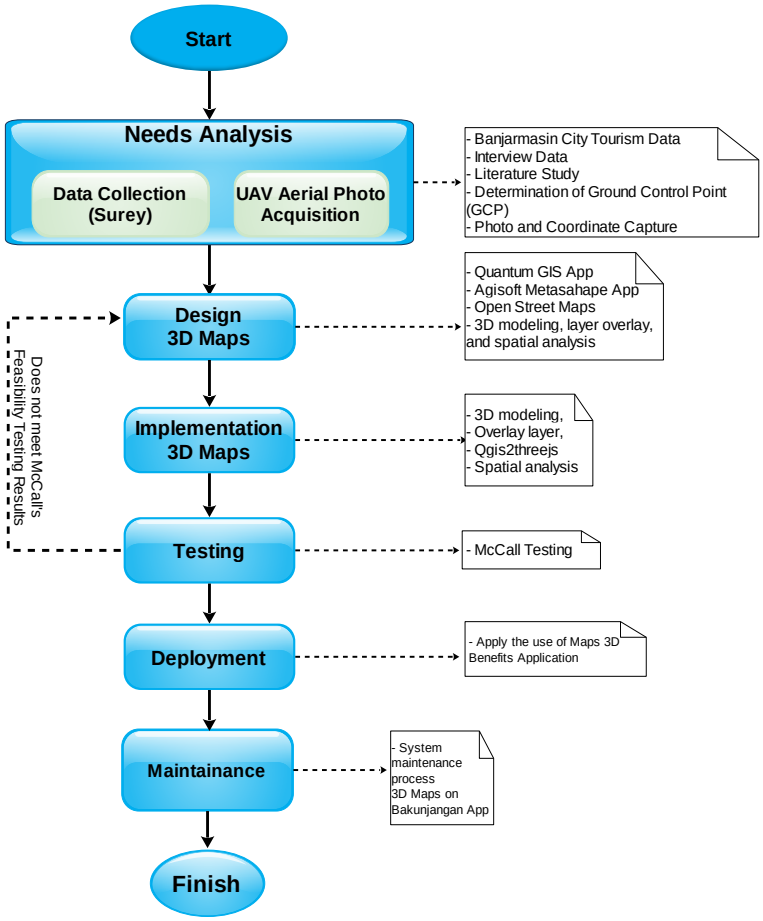

Figure 2. Research Stages

Stages of the 3D map development process for the Bakunjangan App:

a. Needs Analysis to identify data requirements, including tourism data, interviews, literature studies, and collection of UAV aerial photographs and GCPs.
b. 3D Maps Design is the stage of using applications such as QGIS, Pix4D, and OpenStreetMap to design 3D maps with layer overlay and spatial analysis.
c. Implementation of 3D Maps to model 3D maps and integrate various elements using QGIS2ThreeJS.
d. Testing is done using McCall criteria to ensure quality.
e. Deployment is done to implement 3D maps into the Bakunjangan Application.
f. Maintenance and Output Outcomes enter the final phase in system maintenance and publication of research results.

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3. RESULTS AND DISCUSSION

3.1. Needs Analysis.

In developing the Banjarmasin City Tourism Bakunjangan Application, needs analysis is carried out through two main approaches: functional needs analysis and hardware and software needs analysis. Functional Requirements Analysis focuses on identifying and determining the software and data requirements needed to build this application. This includes the main functions that the application must have to fulfill its purpose, such as the ability to display tourist maps, tourist attraction information, and user interaction. Hardware and Software Requirements Analysis which involves identifying the hardware and software needed during the development of the application. This includes the specifications of computers, servers, and programming software required to support the app's development and operational processes. Hardware such as drones for field data collection is also an important part of this analysis. to create a 3D map animation of potential tourist areas, some important data is required. The following are the data used.

3.1.1. Photos of Tourist Attractions.

These photos are secondary data obtained from direct surveys to the field, in locations that have tourism potential. The survey was conducted to visually document each tourist spot, which will later be used in making a more realistic and accurate 3D model. The process of analysis through direct visits by means of the photo process can be seen in Figure 3 (a), and Figure 3 (b) the process of setting up the Unmanned Aerial Vehicle (UAV) to take direct aerial photographs.

(a) (b)

Figure 3. Survey and Field Data Collection (a) Research team visiting one of the tourist sites, (b) UAV settings for taking aerial photos

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3.1.2. Ground Control Point (GCP).

Ground Control Point (GCP) installation was carried out by spreading 55 GCP points evenly in the Area of Interest (AOI). Each GCP point is installed with accurate coordinate measurements, which are then used to ensure the drone mapping matches the field conditions. This is important in data collection for the creation of accurate 3D maps in the Bakunjangan App, ensuring precise and detailed visualization at each tourist site. This process can be seen in Figure 4.

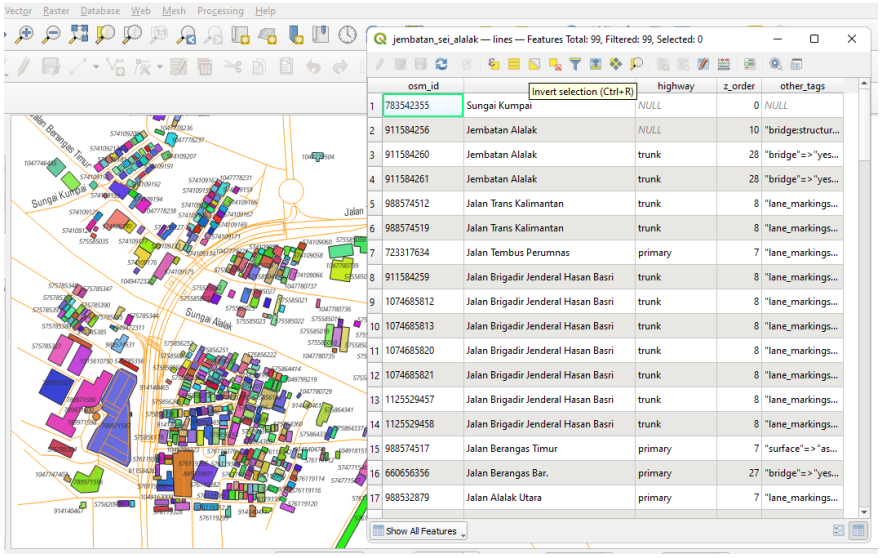
Figure 4. Coordinate adjustment process according to GCPs

3.2. Design 3D Maps.

Using Quantum GIS software to perform spatial data processing, base maps creation, and 3D visualization. Quantum GIS (QGIS) is a powerful open-source software for spatial data processing, base map creation, and 3D visualization. In the context of 3D map creation, QGIS allows users to process geographic and topographic data with high precision. With the ability to integrate various spatial data sources such as topographic maps, satellite images, and GPS data, QGIS enables the creation of detailed and realistic 3D models. The 3D visualization feature in QGIS allows us to view and analyze elevations, contours, and other geographic features more dynamically. There are several packages available from pyhton that are integrated with QGIS[20].

In addition to supporting various plugins that extend its functionality, QGIS also offers the ability to perform deep 3D data processing, such as the addition of visual effects, textures, and lighting settings. These are essential in creating a rich and realistic spatial representation on the 3D map created. The 3D map design process starts with managing the spatial data of each attraction. This spatial data selection allows us to properly organize the data attributes, which are later imported into QGIS. With this, we can manage supporting objects around each tourist site, such as roads, buildings, and other geographical features, thus providing a more comprehensive context and aiding in the visualization of the tourist area as a whole. This not only makes the 3D map more detailed and informative, but also

makes it easier for users to understand the spatial relationships between attractions and their surrounding features. This process can be seen in Figure 5, where the organization of spatial data and the management of supporting objects results in a 3D map that provides information and is ready to be used in the Bakunjangan App. After the field spatial data has been organized into one in the area of the tourist attraction map created, the next stage is just processed using the Qgis2threejs plungin to make each object into 3D which is shown in Figure 6.



	osm_id		highway	z_order	other_tags
1	783542355	Sungai Kumpai	NULL	0	NULL
2	911584256	Jembatan Alalak	NULL	10	"bridge:structur...
3	911584260	Jembatan Alalak	trunk	28	"bridge"=>"yes...
4	911584261	Jembatan Alalak	trunk	28	"bridge"=>"yes...
5	988574512	Jalan Trans Kalimantan	trunk	8	"lane_markings...
6	988574519	Jalan Trans Kalimantan	trunk	8	"lane_markings...
7	723317634	Jalan Tembus Perumnas	primary	7	"lane_markings...
8	911584259	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
9	1074685812	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
10	1074685813	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
11	1074685820	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
12	1074685821	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
13	1125529457	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
14	1125529458	Jalan Brigadir Jenderal Hasan Basri	trunk	8	"lane_markings...
15	988574517	Jalan Berangas Timur	primary	7	"surface"=>"as...
16	660656356	Jalan Berangas Bar.	primary	27	"bridge"=>"yes...
17	988532879	Jalan Alalak Utara	primary	7	"lane_markings...

Figure 5. Spatial Data Processing in Quantum GIS

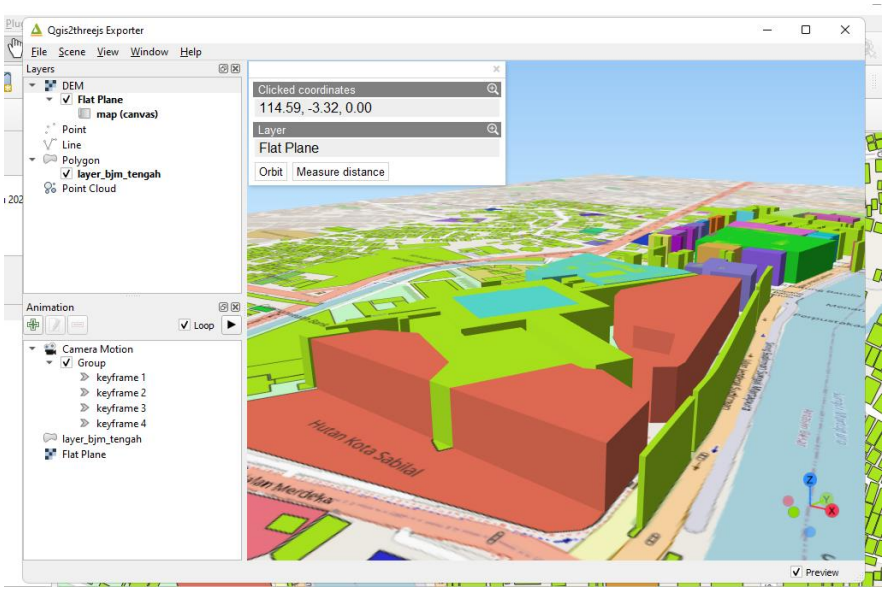


Figure 6. Qgis2threejs Plugin Process Spatial Data to 3D Maps

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In the development of the Bakunjangan App, the OSM base map is used as the main background to visualize the location and tourism potential in Banjarmasin City. This base map provides an accurate representation of the road network, buildings, and other geographic features, which are then supplemented with additional data such as photos and tourist information to support navigation and exploration in the Bakunjangan App. By utilizing the QuickMapServices plugin in QGIS, it is easier for us to get spatial data around the tourist attraction that we choose to locate. The process can be seen in Figure 7.

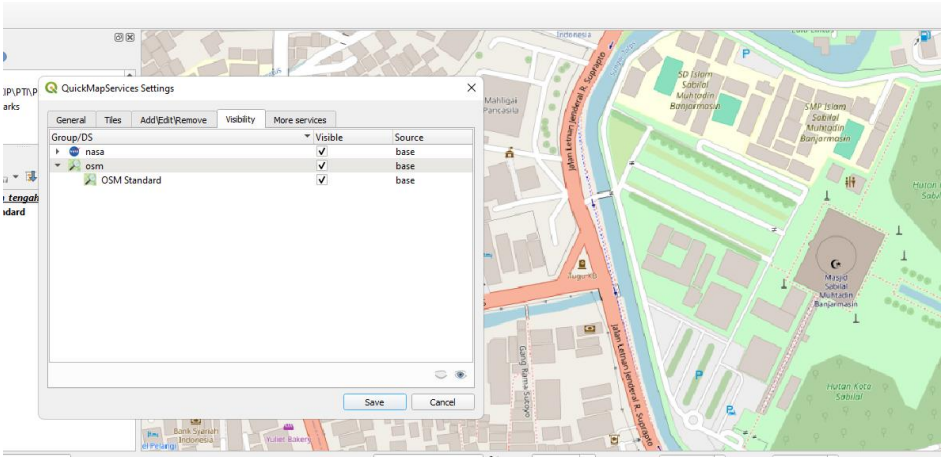

Figure 7. Determination of Base Maps in Quantum GIS

The process of forming 3D at tourist attractions researchers use 3D blender in combination with 3D maps that have been prepared in QGIS and generated using the Qgis2threejs plugin, the design can be seen in Figure 8.

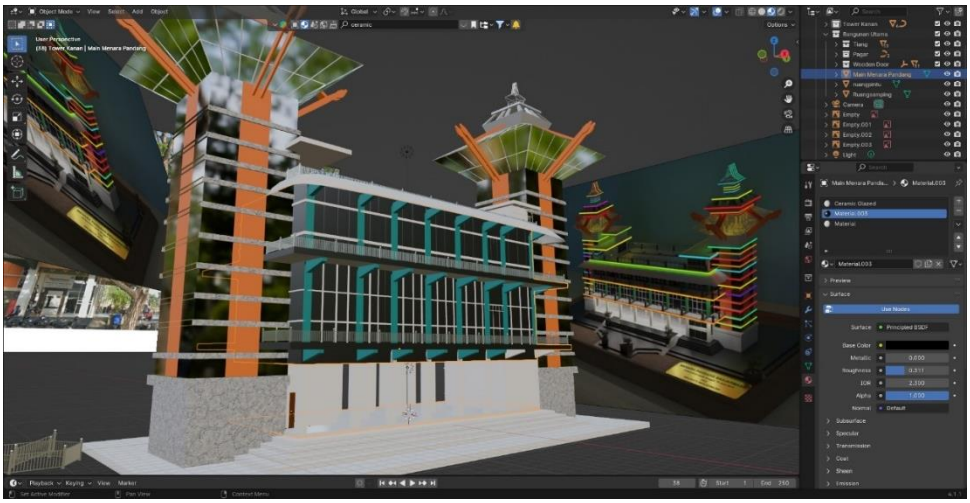

Figure 8. 3D Process of View Tower Tourist Attraction in Banjarmasin City

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3.2. Implementation of 3D Maps.

The initial stage in the implementation of 3D Maps for the Bakunjangan application begins with combining the results of UAV photos of each tourist attraction in the city in Banjarmasin. With the help of Agisoft Metasahape software, researchers get an important overview in seeing the 3D results of tourist objects that will be synchronized with Quantum GIS, this process is important in the implementation of the Bakunjagan Application later. The process of importing UAV photos can be seen in Figure 9. The next stage is testing the results of 3D maps from the Qgis2threejs Quantum GIS export plungin with the javascript settings shown in Figure 10.

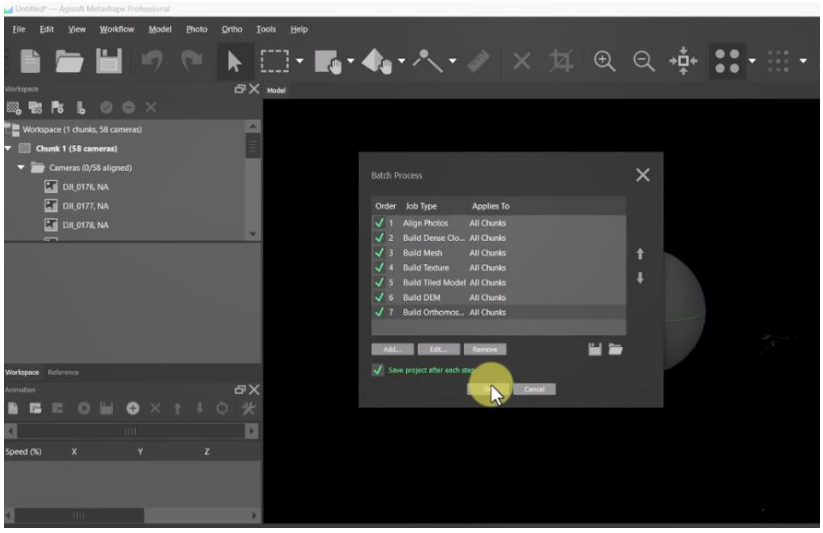

Figure 9. Import UAV Photos to Agisoft Metasahape

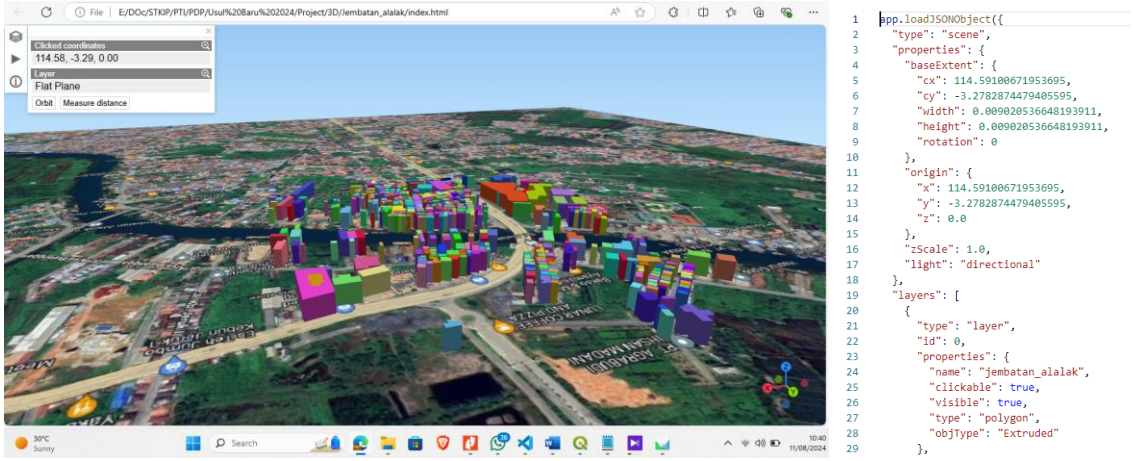

Figure 10. Testing 3D Maps on Microsoft EDGE browser with javascript code

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3.3. Testing.

This stage provides an important overview in the use of the Bakunjangan Application, where the process of assessing the feasibility of using the Bakunjangan Application uses McCall testing. Based on the evaluation results of the Bakunjangan Application taken from 25 tourists, 2 tourism managers and 1 employee of DISBUDPORAPAR Banjarmasin City with a frequency score of 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. From the results obtained from the calculation, the quality factor value is converted into a percentage using the equation:

$$\text{Functionality percentage} = \frac{Value\ obtained}{Maximum\ value} \text{ x } 100\%$$

So that the total quality ($\sum$) obtained are as follows :

$$\sum = \frac{(0{,}3\ x\ Fa1)+(0{,}2\ x\ Fa2)+(0{,}3\ x\ Fa3)+(0{,}2\ x\ Fa4)+(0{,}2\ x\ Fa5)}{Maximum\ value} \text{ x } 100\%$$

$$= \frac{(0{,}3\ x\ 3{,}58)+(0{,}2\ x\ 4{,}12)+(0{,}3\ x\ 2{,}98)+(0{,}2\ x\ 4{,}46)+(0{,}2\ x\ 3{,}90)}{5} \text{ x } 100\%$$

$$= \frac{4{,}45}{5} \text{ x } 100\% \quad = 89\ \%$$

With the following eligibility weight provisions:

Table 2: Feasibility Categories

Category	Percentage
Very Good	81% - 100%
Good	61% - 80%
Fairly Good	41% - 60%
Not Good	21% - 40%
Not Very Good	< 21%

Based on the provisions of the feasibility weight that have been explained with a score of 89%, the Bakunjangan Application is included in the very good category.

3.4. Research Novelty.

Developed a 3D interactive map feature that is directly integrated with the tourist details page of the Bakunjangan app. This map allows users to:

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View a simulated travel route from their location to the tourist destination. Explore tourist sites in 360-degree mode or 3D model-based street view mode. Benefits this feature provides a more realistic visual experience, making it easier for users to understand the layout of the destination before visiting. Adding a 3D view feature to tourist destinations. When users open the destination page they can access the 3D view of the tourist attraction directly in the app. Users can use the smartphone browser to view 3D objects from each destination, such as replicas of buildings, statues, or landmarks. This feature provides benefits to strengthen the attractiveness and provide a unique experience to tourists. This can be seen in figure 11.

Figure 11. 3D object of Sei Alalak Bridge Tourism

3.5. Deployment.

Interpreting the results of 3D maps previously processed in Quantum GIS by utilizing the plung in export Qgis2threejs to WEB component and other supporting software so that data migration is carried out to the Bakunjangan tourism application in Banjarmasin City by producing 65 interfaces and 50 3D Maps designs on each tourist attraction in Banjarmasin City which can be accessed easily via the website address www.bakunjangan.com. The following is one of the results of the interface of the Bakunjangan application can be seen in Figure 12.

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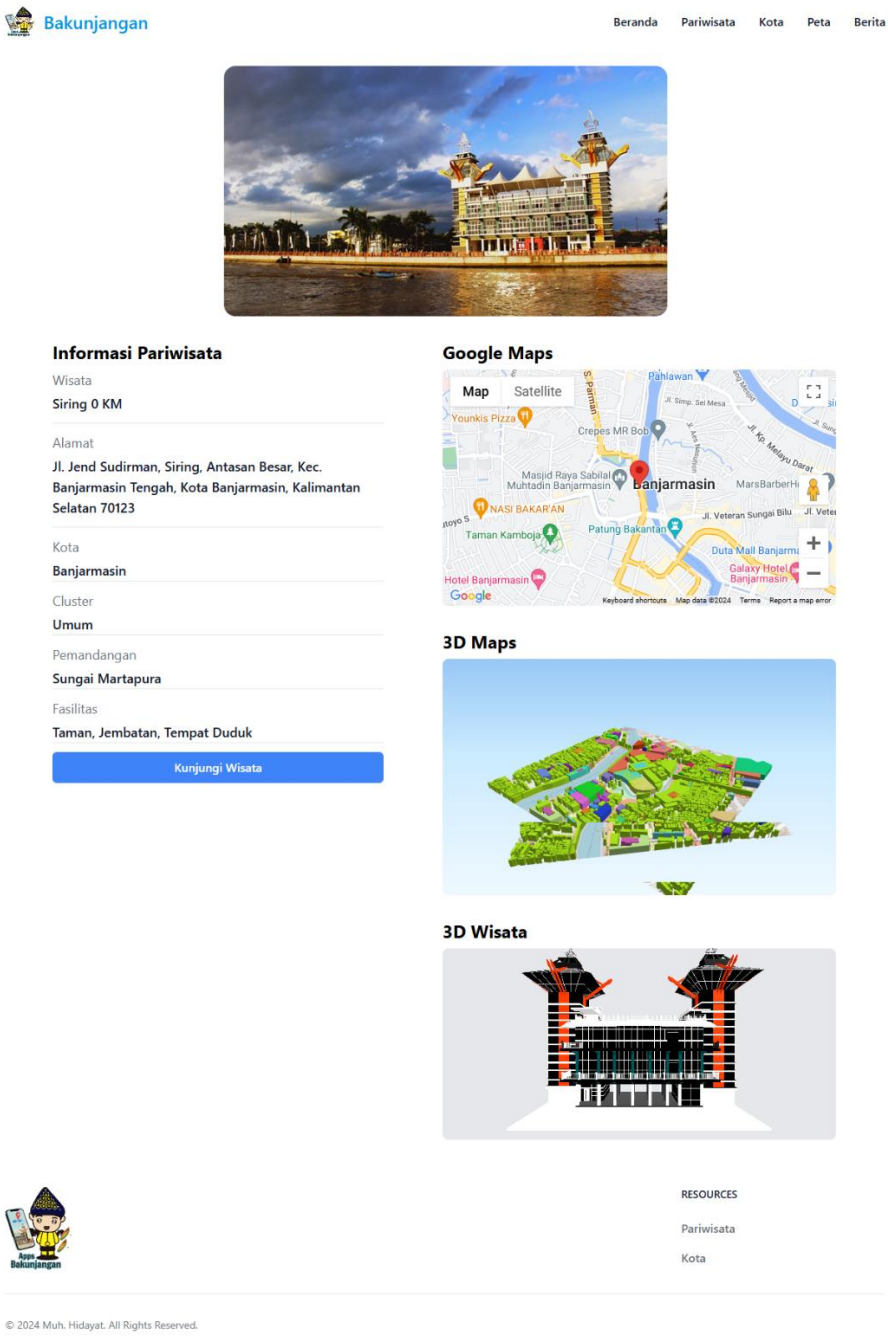

Figure 12. Banjarmasin City View Tower Tour Interface Page

3.6. Maintainance.

In the maintenance phase of the Bakunjangan Application, the main focus is to ensure that the application continues to function optimally and in accordance with user

needs. Activities carried out include regular updates to add new features or fix bugs found, monitoring the performance of the application to identify and resolve problems that may arise, and adjusting content or data in the application according to changes in the field. In addition, technical support is also provided to users to ensure a smooth experience in using the application. The Bakunjangan Application maintenance plan can be seen in Table 3.

Table 3: Application maintenance

No	Maintenance Activity	Description	Frequency
1	Regular Updates	Adding new features or fixing bugs found while the app is in use	Every 3 Months
2	Performance Monitoring	Identify and resolve application performance issues whether used on smartphone, Tablet, Computer and Laptop device browsers	Every other week
3	Content or Data Adjustments	Adjust content and data in the app according to changes in the field.	As needed
4	Technical Support	Provide technical assistance to users to ensure a smooth experience	As needed

4. CONCLUSION

The creation of 3D Map Animation in the Bakunjangan Application was carried out after a survey of 55 Ground Control Points (GCP) installation points in each tourist area in Banjarmasin City. The data visualization process using the aerial photo acquisition method proved to be more efficient and faster than terrestrial surveys. The Bakunjangan application can be accessed through www.bakunjangan.com

a. The Quantum GIS application, with the help of the Qgis2threejs plugin, provides significant benefits in creating 3D map animations. This plugin simplifies the process of visualizing and creating 3D models from the spatial data that has been collected.
b. Internet connection requirements To be able to display 3D maps optimally on all devices used, a fast internet connection with a minimum speed of 10 Mbps is required. This ensures that the 3D animation rendering runs smoothly without a hitch.
c. After adding 3D maps to the Bakunjangan application, we have created 65 interactive user interfaces and 50 3D animations of tourist attractions in Banjarmasin City. These animations provide a more interesting and informative visual experience for users.
d. There are five attractions that cannot be animated into 3D maps using the Qgis2threejs plugin in Quantum GIS. This indicates that this plugin has limitations in handling certain types of data or conditions.
e. Based on the analysis of the weight of the feasibility of using the application with a value of 89%, the Bakunjangan Application falls into the excellent category. This shows that

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this application is able to make a significant contribution in supporting tourism promotion and management in Banjarmasin City

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