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Original Research Paper

WebGIS-Based Birdwatching Ecotourism Planning in Kwau Village

Dian Reski Amelia[1*], Andreas Leonardo Sumendap[1], Petrus Abraham Dimara[2]

[1] *Department of Informatics, Faculty of Engineering, University of Papua. Manokwari, Indonesia.*
[2] *Department of Forestry, Faculty of Forestry, University of Papua. Manokwari, Indonesia.*

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***Corresponding Author:**
Dian Reski Amelia
Email:
reskidian73@gmail.com

Abstract: Ecotourism development in Kwau Tourism Village remains limited due to the absence of systematic spatial mapping and insufficient accessible information on bird distribution, despite the area's high endemic bird diversity and strong potential for birdwatching. This study addresses the lack of integrated ecological information by combining spatial and non-spatial datasets to support informed planning and sustainable destination management. Field-based GPS mapping of bird observation points was conducted, followed by hotspot analysis and documentation of temporal behavioral patterns (feeding and lekking). All datasets were processed in ArcGIS and integrated into an interactive WebGIS platform to assist tourism managers, local communities, and visitors in interpreting spatial patterns and planning visits more effectively. The results show that bird observations are concentrated in forest zones with relatively dense canopy structure and low anthropogenic disturbance, with peak activity occurring in the morning and late afternoon. Accessibility analysis further indicates that trekking routes vary from very easy to high difficulty depending on distance, slope, and terrain conditions. Overall, the study provides a replicable village-scale GIS model that strengthens decision-making for bird-based ecotourism through integrated mapping, route information, and behavioral timing. Future research is recommended to extend multi-season monitoring and evaluate long-term visitor impacts and WebGIS updates to support adaptive management and carrying-capacity-based regulation.

Keywords: Accessibility, Bird Activity, Decision Support System, Ecotourism Management, WebGIS.

1. Introduction

Ecotourism offers a sustainable approach to tourism management by prioritizing environmental conservation and the preservation of local culture while simultaneously generating economic benefits for surrounding communities. Indonesia's exceptional biodiversity, particularly in West Papua, provides strong potential for the development of bird-watching tourism as a key component of nature-based ecotourism strategies [1]. Kwau Tourism Village, located in Mokwam District, Manokwari Regency, is widely recognized for its rich diversity of endemic bird species, which represents a valuable attraction for ecotourism development. However, despite this ecological potential, bird-based ecotourism in Kwau Village remains underdeveloped, mainly due to the absence of systematic spatial mapping and the lack of integrated, accessible information for both local communities and visitors [2].

Geographic Information Systems (GIS) have increasingly been applied as effective tools for spatial planning, environmental management, and decision support in ecotourism development [3]. GIS-based mapping enables the visualization and integration of ecological resources, tourism infrastructure, and accessibility, thereby supporting informed planning and sustainable tourism management [4]. Previous studies have demonstrated the usefulness of GIS in ecotourism suitability analysis and destination planning. Nevertheless, existing research generally focuses on regional-scale assessments or single thematic layers, and rarely integrates bird observation data with iconic local tourist destinations in a village-level ecotourism context. To date, no comprehensive and integrated GIS-based map has been developed that combines bird-watching data with key tourism attractions in Kwau Tourism Village, Manokwari Regency, Mokwam District.

Addressing this research gap, the present study applies GIS to develop an integrated ecotourism map that combines bird observation data with prominent tourism destinations in Kampung Kwau, following approaches used in GIS-based ecotourism planning and suitability mapping studies [5]. Spatial data are utilized to map bird observation points and trekking routes, while hotspot analysis techniques are employed to identify key bird-watching zones, as previously applied in ecotourism resource assessments [6]. In addition to spatial analysis, this study incorporates non-spatial temporal analysis to examine bird activity patterns, such as periods of heightened activity or display behavior, which are important for optimizing visitor experience and visit planning [7] [8].

Accordingly, this research aims to identify the spatial distribution of birds, analyze bird hotspots as primary bird-watching zones, and integrate these findings with iconic tourist destinations in Kwau Tourism Village. Furthermore, the study seeks to develop an interactive Web-GIS platform that can function as a spatial decision-support tool for village tourism managers, tourists, and other stakeholders in planning visits and managing ecotourism areas sustainably [9]. By explicitly integrating ecological, temporal, and tourism destination data at the village scale, this research contributes a practical and replicable GIS-based model for sustainable bird-based ecotourism management that can be adapted to similar ecotourism destinations in other regions.

2. Literature Review

2.1. Ecotourism as a Framework for Sustainable Nature-Based Tourism

Ecotourism is widely conceptualized as a form of tourism that integrates environmental conservation, cultural preservation, and local economic development. Rather than merely offering recreational experiences, ecotourism functions as a management framework that balances ecological integrity with visitor use and community benefits [10]. Within this framework, wildlife-based tourism, particularly bird-watching; has gained increasing attention due to its relatively low environmental impact and its capacity to support biodiversity conservation when properly managed. However, the sustainability of bird-based ecotourism depends on spatial planning, visitor control, and informed decision-making to prevent habitat disturbance and resource degradation.

2.2. Bird-Based Ecotourism and Community-Based Management Contexts

Bird-based ecotourism has been recognized as an effective strategy for promoting conservation awareness while generating alternative livelihoods for local communities, especially in rural and biodiversity-rich regions. Studies on community-based ecotourism emphasize that areas with high ecological value often face challenges related to limited infrastructure, insufficient data integration, and weak management systems [11]. These limitations can reduce the effectiveness of ecotourism initiatives and restrict local participation in tourism planning. Consequently, the success of bird-based ecotourism increasingly depends on tools that enable communities and managers to access spatial information, understand resource distribution, and support informed planning decisions at the local scale.

2.3. The Role of Geographic Information Systems (GIS) in Ecotourism

Geographic Information Systems (GIS) have been extensively applied as decision-support tools in ecotourism planning and natural resource management [12]. Unlike conventional mapping approaches, GIS allows for the integration of multiple spatial and non-spatial datasets, facilitating comprehensive analyses of environmental suitability, accessibility, and tourism infrastructure. Previous studies demonstrate that GIS-based approaches enhance the ability of planners to visualize ecological resources, evaluate tourism potential, and identify spatial conflicts between conservation and tourism activities [13]. The integration of wildlife distribution data, accessibility networks, and supporting facilities within a GIS framework enables more informed decision-making, particularly in sensitive ecosystems where uncontrolled tourism may pose ecological risks.

2.4. Spatial Data and Hotspot Analysis in Ecotourism Planning

Spatial analysis techniques, including hotspot and suitability analysis, are commonly used in ecotourism planning to identify areas with high potential for wildlife observation and visitor activities. In the context of bird-based ecotourism, hotspot analysis supports the identification of key observation zones based on species presence, accessibility, and environmental conditions. However, spatial suitability alone is insufficient to ensure sustainable tourism outcomes. Recent studies highlight the importance of incorporating temporal factors, such as daily and seasonal variations in wildlife activity, as well as anthropogenic disturbances linked to visitor presence [14]. These findings suggest that integrating temporal patterns into spatial planning can improve visitor experience while minimizing ecological disturbance, thereby strengthening sustainable ecotourism management strategies.

2.5. Conceptual Basis for Web-GIS–Integrated Ecotourism Management

Recent advances in Web-GIS technologies have expanded the role of GIS from analytical tools into interactive platforms for participatory planning and tourism management. Web-based GIS systems enable real-time access to spatial information, facilitate stakeholder engagement, and support adaptive management through interactive visualization[15]. In the context of ecotourism, Web-GIS platforms provide a conceptual foundation for integrating wildlife hotspots, tourism destinations, and accessibility information into a single spatial decision-support environment. Such systems enhance transparency, improve coordination among stakeholders, and support sustainable management by enabling evidence-based planning and monitoring at the local level. This conceptual approach underpins the development of GIS-integrated ecotourism mapping initiatives in biodiversity-rich rural destinations.

3. Methodology

Data collection for this research was conducted through direct field surveys in Kwau Village over a two-day period. On the first day, observations were carried out from 13.00 to 16.30 WIT in forest areas located farther from settlement zones. On the second day, field observations were conducted from 05.30 to 09.00 WIT in forest areas closer to the village, specifically selected to capture bird activity during peak morning feeding and display periods [16]. Although the duration of field observation was limited, the selected time windows were deliberately aligned with periods of highest bird activity, thereby maximizing the effectiveness of data collection within the available timeframe.

To mitigate the limitation of the short observation period, the primary field data were complemented with multiple supporting data sources. First, spatial and ecological information was strengthened through local ecological knowledge obtained from experienced bird guides and local residents who possess long-term familiarity with bird habitats, seasonal movement patterns, and species behavior in Kwau Village. The integration of local ecological knowledge has been widely recognized as an effective approach to enhance biodiversity monitoring and conservation planning, particularly in data-limited field studies [17]. These insights were used to validate observation locations and ensure that recorded bird observation points represent commonly used bird-watching sites. Second, secondary data from previous studies, local tourism records, and available biodiversity documentation were consulted to contextualize field observations and support spatial interpretation.

Spatial data collection involved mapping bird observation locations through direct field observations using Avenza Maps to record GPS coordinates for each observation point. These data were analyzed to identify spatial distribution patterns of birds and to delineate areas with high observation intensity. Bird habitats were further identified based on environmental characteristics observed in the field, such as vegetation type, topographic conditions, and surrounding land cover. In addition, trekking routes, accessibility networks, and key tourism destinations in Kwau Village were mapped and integrated with

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bird observation data to support ecotourism planning and route optimization.

Non-spatial data focused on temporal aspects of bird activity, including feeding and display behavior. These data were obtained not only through direct field observations during the survey period but also through post-observation confirmation with experienced local bird guides. Additional information regarding typical feeding times, display periods, and seasonal activity patterns was collected through follow-up interviews and remote communication methods, such as phone calls and messaging applications, with tour guides who have long-term, direct experience in guiding bird-watching activities in Kwau Village [17]. This triangulation approach was applied to strengthen the reliability of temporal data and to compensate for the limited duration of direct field observations [18], [19].

Furthermore, socio-economic data were collected through semi-structured interviews with local residents and village tourism managers to capture community perspectives, management practices, and expectations related to bird-based ecotourism development in Kwau Village [20]. These data provide contextual insight into local readiness, stakeholder roles, and management challenges relevant to sustainable ecotourism planning.

Overall, this study is positioned as a baseline and exploratory investigation that integrates spatial, temporal, and socio-economic information to support the development of a GIS-based ecotourism planning framework. While longer-term and multi-seasonal data collection would provide deeper temporal insights, the combined use of targeted field observations, local ecological knowledge, post-observation expert confirmation, and secondary data allows the methodology to adequately address the research objectives and provides a robust foundation for future ecological monitoring and Web-GIS system refinement.

4. Finding and Discussion

4.1. Finding

This study generated two integrated categories of findings, namely spatial and non-spatial data, which were subsequently consolidated into a WebGIS platform to support bird-based ecotourism planning in Kwau Tourism Village. Spatial data were obtained from georeferenced bird observation points collected using Avenza Maps and processed in ArcGIS, while non-spatial data were derived from direct observations and structured interviews with experienced local bird guides.

Table 1. Bird observation points and tourism destinations in Kwau Tourism Village

No	Location Name	Latitude	Longitude
1	Small Waterfall	-1.088575	133.927814
2	Kwau Waterfall	-1.091129	133.922847
3	*Pandanus conoides*	-1.090699	133.923245
4	*Parotia sefilata* 1	-1.100698	133.902557
5	*Parotia sefilata* 2	-1.100759	133.905315
6	*Parotia sefilata* 3	-1.100752	133.905664
7	*Amblyornis inornata* 1	-1.100184	133.905995
8	*Amblyornis inornata* 2	-1.100187	133.906974
9	*Amblyornis inornata* 3	-1.098496	133.908255
10	Papuan Lorikeet Homestay	-1.100613	133.909091
11	Coffee Garden	-1.091929	133.929914
12	Giant Banana Tree	-1.101680	133.909349
13	Rumah Kaki Seribu	-10940054	133.924990
14	Bird Feeder 1 (*Epimachus fastosus*)	-1.103685	133.901323
15	Bird Feeder 2 (*Drepanornis albertisi, Parotia sefilata, Paradigalla carunculata, Amblyornis inornata*)	-1.100587	133.901739
16	Bird Feeder 3 (*Amblyornis inornata*, *Parotia sefilata*, *Ailuroedus arfakianus*)	-1.100658	133.907284
17	Bird Feeder 4 (*Diphyllodes magnificus*, *Ptiloris magnificus*, *Manucodia ater*)	-1.081664	133.924072
18	Bird Feeder 5 (*Paradisaea apoda*, *Diphyllodes magnificus*, *Ptiloris magnificus*, *Manucodia ater*)	-1.079484	133.922666

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1) Spatial Findings: Bird Observation Points and Tourism Destinations

A total of 18 georeferenced points were documented, comprising activity sites of Parotia sefilata, display and nesting areas of Amblyornis inornata, and several feeding locations with high species diversity. These observation points were spatially integrated with mapped ecotourism destinations, including the homestay area, Rumah Kaki Seribu, waterfalls, coffee gardens, banana landmarks, and red fruit (*Pandanus conoideus*) sites. All spatial data were exported in CSV format from Avenza Maps and processed in ArcGIS to generate a comprehensive spatial distribution map (Table 1, and Figure 1).

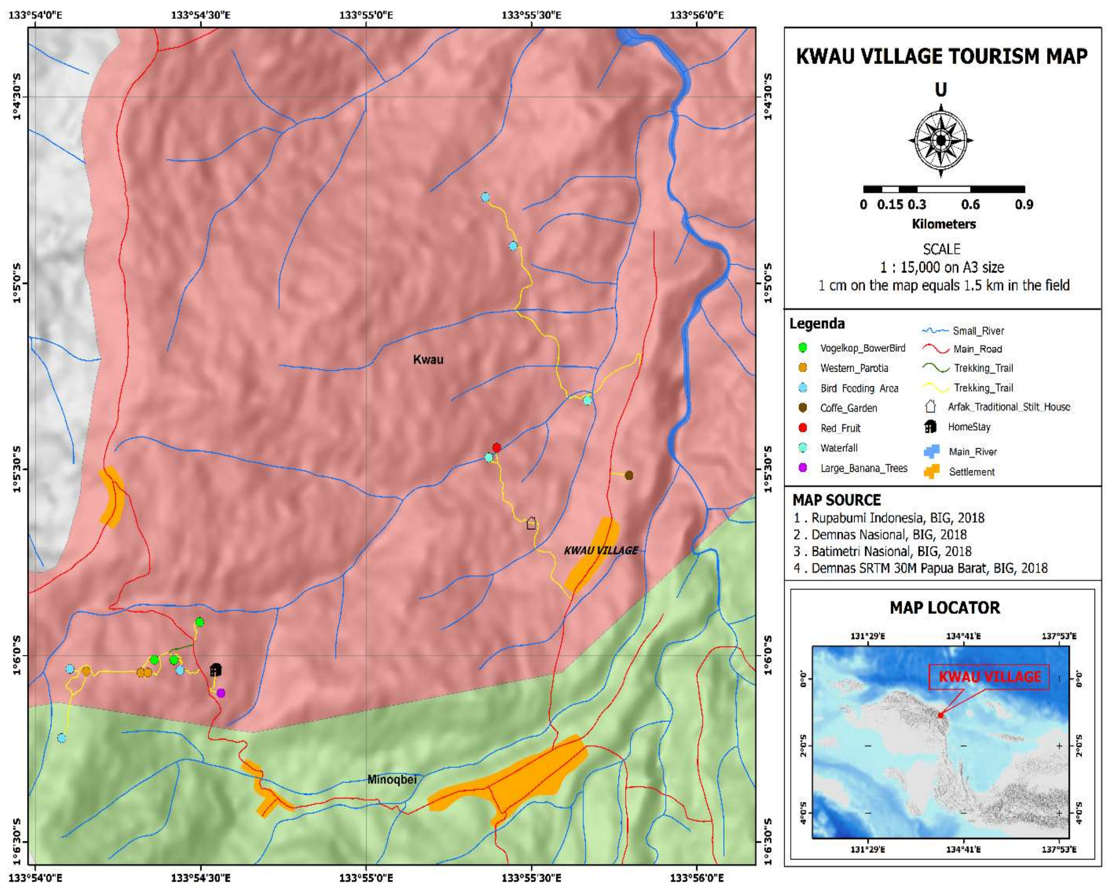

Figure 1. Spatial Distribution of Bird Observation Points and Tourism Destinations in Kwau Tourism Village

The resulting spatial pattern indicates that bird observation points are predominantly located within forest zones characterized by medium to dense canopy cover and relatively low levels of anthropogenic disturbance. This pattern is consistent with ecological evidence showing that tropical forest bird species tend to occupy habitats with high structural complexity that provide suitable conditions for feeding, mating, and display behaviors [21]. The mapped distribution also confirms that ecotourism attractions in Kwau Village are spatially interconnected with biologically significant habitats, reinforcing the potential for integrated nature-based tourism development [22].

Spatial clustering analysis reveals three dominant groups:

(1) lek and display sites of *Parotia sefilata*,
(2) activity zones of *Amblyornis inornata*, and
(3) multi-species feeding sites.

These clusters are located in forest landscapes that align with habitat preferences identified in previous studies on bird distribution and ecological suitability [23]. The recommended trekking route (yellow) connects the most accessible observation points near the homestay and offers gentler terrain compared to alternative routes with steeper slopes. Although the shorter route presents a more direct path, the recommended route balances accessibility and biodiversity exposure, thereby enhancing visitor safety and experience [24]. Overall, the map delivers a clear visualization of the available trekking route options based on terrain characteristics and accessibility to bird observation sites, thereby demonstrating how route selection can enhance efficiency in ecotourism management within Kampung Kwau [25].

This section presents some of the bird species identified in Kwau Tourism Village. This representation only covers a small portion of the overall bird diversity found at the study site, as shown in Figure 2.

Source: Kwau Tourism Village tour guide, Mr. Hans Mandacan & Mr. Obaja Mandacan

Figure 2. Several bird species are found in Kwau Tourism Village:
(A) Western Parotia (*Parotia sefilata*)
(B) Vogelkop Bowerbird (*Amblyornis inornatus*)
(C) Magnificent Bird-of-Paradise (*Diphyllodes magnificus*)

Figure 2 illustrates selected bird species recorded during the study, representing only a fraction of the overall avifaunal diversity in Kwau Village. This finding aligns with broader regional studies indicating that Papua and the surrounding areas support exceptionally high bird species richness across diverse forest habitats [26].

2) Non-Spatial Findings: Bird Activity Patterns

Interviews with local guides provided detailed insights into bird activity patterns in Kwau Village. *Parotia sefilata* (dancing birds) exhibited consistent lek activity during 6:00–9:00 AM and 3:00–4:00 PM, a pattern consistent with research showing that tropical forest lekking species exhibit peak mating activity during the morning and evening light cycles [27]. Seasonal observations further supported this behavior, as guides explained that males were most active from June to September, which aligns with broader activity rhythms documented in tropical forest birds across a range of environmental conditions [28]. From October to November, females begin their egg-laying period, resulting in a natural decline in male activity.

Another group of species, known locally as *Amblyornis inornata* (clever birds), exhibited males actively grooming their display structures and collecting 10–15 decorative objects daily. This pattern is consistent with international literature showing that display-building species regulate their spatial use and activity timing based on light and temperature, particularly the setup and maintenance of their display structures. This pattern is consistent with research showing that ground-dwelling display-building species often partition their habitat use and activity schedules based on environmental factors such as light, temperature, and resource availability [29]. Foraging locations also show consistent temporal patterns, with most birds primarily migrating during the morning and evening periods,

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characterized by cooler temperatures and light conditions that favor energy-efficient foraging.

These daily and seasonal activity patterns align with global ecological findings, which suggest that tropical forest birds typically maximize feeding, vocalization, and social behavior during the morning and evening periods when heat stress is lower, and opportunities for interaction are higher [30].

3) Trekking Accessibility: Distances, Time, and Terrain

Accessibility analysis indicates that trekking routes from the homestay to bird observation sites range from very easy to high difficulty, depending on distance, slope, and terrain conditions (Table 2). Short-distance routes to feeding sites and banana landmarks are classified as easy to medium, while routes to distant lek sites involve steeper terrain and higher difficulty levels. This classification follows internationally recognized trail assessment criteria that emphasize distance, slope, and surface conditions to ensure visitor safety and experience quality in nature-based tourism.

Table 2. Trekking Distances, Time Estimation, and Terrain Characteristics

No	Starting Point – Destination	Distance (km)	Time	Terrain	Difficulty
1	Homestay – Nearest feeding site	0.37 km	15 min	Moderately steep	Medium
2	Homestay – Farthest bird site	1.40 km	1 hr	Moderately steep	High
3	Homestay – Nearest smart bird observation	0.46 km	15 min	Moderately steep	Medium
4	Homestay – Smart bird (near)	0.60 km	20 min	Moderately steep	Medium
5	Homestay – Dancing bird (near)	0.66 km	30 min	Moderately steep	Medium
6	Homestay – Dancing bird (far)	1.13 km	1 hr	Steep	High
7	Homestay – Giant banana tree	0.14 km	2 min	Flat	Easy
8	Settlement – Rumah Kaki Seribu	1 km	15 min walk / 5 menit kendaraan	Mixed	Easy
9	Rumah Kaki Seribu – Waterfall	0.50 km	20 min	Steep	Medium
10	Rumah Kaki Seribu – Farthest Buah Merah site (near waterfall)	0.50 km	20 min	Moderately steep	Medium
11	Settlement – Bird observation point (downhill, near settlement)	2.30 km	30 min walk / 10 min vehicle	Mixed	High
12	Settlement – Bird observation point near homestay	3 km	30 min walk / 10 min vehicle	Mixed	Medium

4) WebGIS Integration

All spatial and non-spatial data collected in this study were subsequently integrated into an interactive WebGIS platform embedded in the official website of Kwau Tourism Village. This integration includes bird observation points, trekking routes, tourist destinations, elevation data, and behavioral information, combined into a cohesive web-based visual environment. The map was created using ArcGIS, and the spatial data was exported in GeoJSON format for easy integration into the WebGIS platform. For map visualization and data interaction, Leaflet.js was used, an open-source JavaScript library that enables the creation of interactive maps. This approach follows recent international studies demonstrating that WebGIS significantly enhances data accessibility, spatial understanding, and information delivery in nature-based tourism destinations [31].

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On the main WebGIS interface, users can view an interactive map displaying bird locations, trekking paths, and surrounding environmental features. This spatial visualization serves as a digital interpretation tool, allowing visitors to explore distribution patterns, habitat preferences, and access routes before heading into the field. Global research indicates that integrating geospatial datasets into WebGIS platforms greatly supports tourist decision-making and improves ecotourism planning efficiency [3].

Each mapped point on the platform contains a pop-up window revealing detailed attribute information, including local, Indonesian, and Latin bird names; physical descriptions; unique behaviors such as lek dancing or bower construction; conservation status; recommended viewing times; coordinates; and photographic documentation. The use of Leaflet.js enables the creation of interactive pop-up features, enhancing user engagement and deepening visitors' understanding of biodiversity values in protected or semi-protected landscapes [15].

This WebGIS integration offers significant benefits for digital tourism promotion. Visitors can evaluate distances, estimated walking times, terrain difficulty, and the spatial layout of endemic species even before arriving on-site. Contemporary ecotourism research demonstrates that WebGIS supports sustainable visitation by offering efficient navigation, reducing environmental disturbance, and strengthening environmental education for tourists [32].

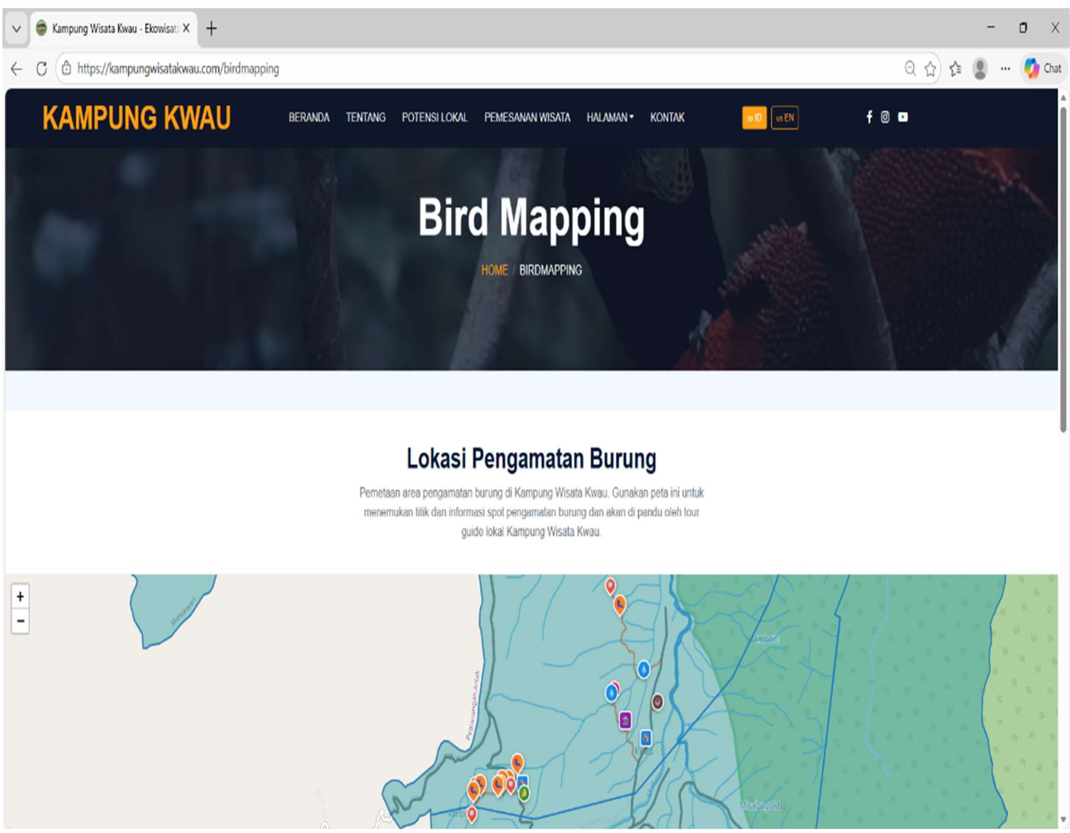

Figure 3. Main WebGIS Interface Showing Bird Distribution in Kwau Tourism Village

The spatial distribution of bird species and the detailed attribute data for each observation site are displayed through the system's visual components, where Figure 3 illustrates the main WebGIS interface for Kwau Tourism Village and Figure 4 presents the pop-up information window for specific observation points.

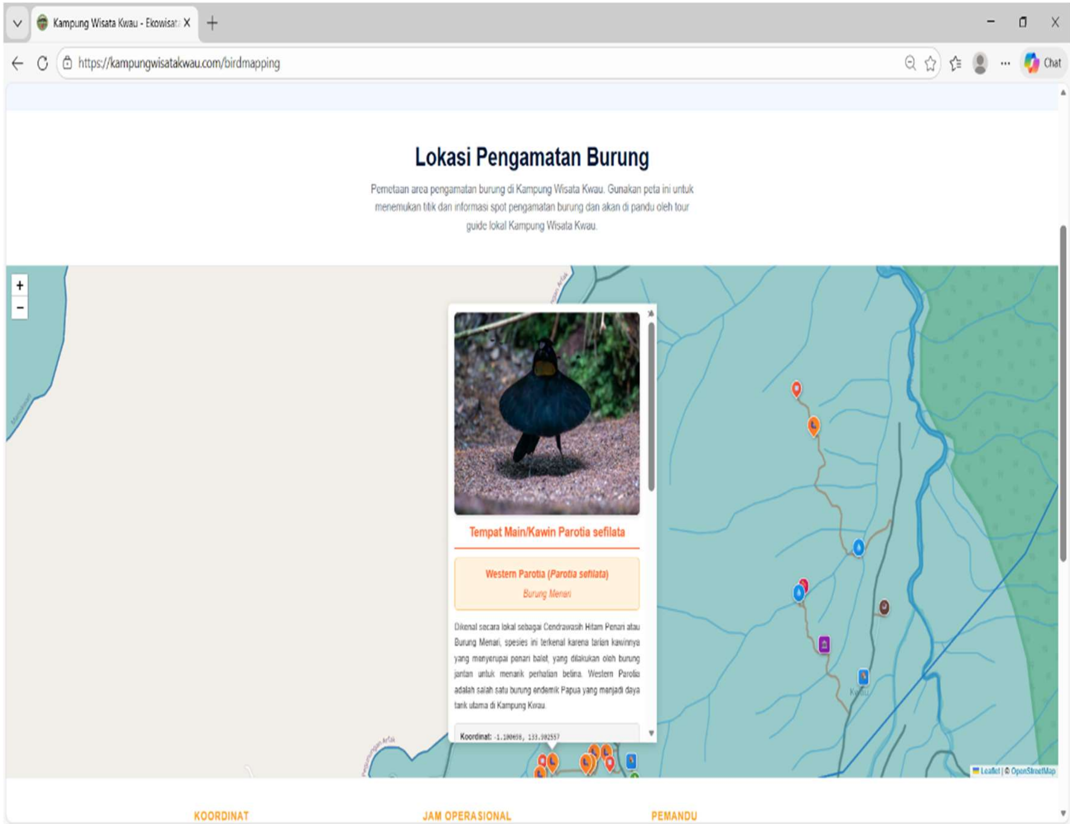

Figure 4. Pop-up Information Window for Bird Observation Points within the WebGIS Platform

4.2. Discussion

The findings provide a practical basis for sustainable bird-based ecotourism management in Kwau Tourism Village by linking ecological resources, visitor accessibility, and digital information delivery within a single spatial framework. The spatial clustering of 18 observation points into three main groups (dancing bird sites, smart bird activity sites, and multi-species feeding sites) indicates that birdwatching resources are not evenly distributed, but concentrated in specific forest zones. This pattern reinforces the management implication that visitor movement should be guided toward designated observation corridors to minimize disturbance in sensitive habitats, consistent with evidence that forest birds are highly responsive to habitat disturbance and structural change [29].

From a tourism-planning perspective, the trekking accessibility results provide measurable guidance for route management. Distances from the Homestay to observation sites range from short walks (e.g., 0.37–0.66 km) to longer and more physically demanding routes (up to 1.40 km), with terrain shifting from flat/easy to steep/high difficulty. This variation supports the practical need for differentiated route recommendations (beginner vs. experienced visitors) and the inclusion of safety-oriented trail classification as part of nature-based tourism planning [33]. Compared with many ecotourism mapping studies that remain at regional suitability scales, the village-scale outputs here translate directly into operational decisions, such as which sites can be promoted for general tourists and which should be limited to guided visits only [22].

Temporal patterns further strengthen decision-making because they define when visitation pressure should be concentrated or avoided. The peak activity windows reported for lekking and display behaviors (06:00–09:00 and 15:00–16:00) provide a concrete scheduling basis for tourism operations, such as setting recommended departure times from the Homestay and structuring guided tour packages around biologically optimal observation periods. This aligns with ecological evidence that diurnal birds exhibit higher activity during cooler and lower-stress periods of the day, improving observation success while reducing prolonged disturbance caused by repeated site visits [30]. Practically, this supports a management approach that prioritizes time-based visitor regulation rather than relying only on spatial zoning.

The WebGIS integration represents the main applied contribution of this study because it converts static field observations into an interactive decision-support environment. By providing map layers, routes, and point-based attribute information (species identity, behavior, recommended viewing time, and accessibility), the WebGIS platform improves pre-visit planning and can reduce unnecessary off-trail movement, which is a common source of disturbance in wildlife tourism settings. This supports the role of WebGIS as a destination-management instrument that enhances navigation, transparency of spatial information, and visitor education [34].

Nevertheless, several limitations should be acknowledged. Field observations were conducted over a two-day period, which may not fully represent seasonal variation, rare species occurrence, or weather-driven behavioral changes. In addition, observation points are influenced by detectability and accessibility bias, meaning that areas closer to routes may be better sampled than more remote habitats. These limitations suggest that the spatial pattern reported here should be interpreted as a baseline distribution of commonly used birdwatching sites rather than a complete inventory of avifaunal diversity. Future work would benefit from multi-season monitoring and repeated surveys to strengthen temporal representativeness and support adaptive updates to the WebGIS database.

Overall, the study contributes an operational village-scale model that integrates habitat-linked bird observation clusters, time-based behavioral information, trekking accessibility metrics, and WebGIS delivery into a unified planning tool. This combination offers directly actionable outputs for route recommendation, visit scheduling, and sustainable destination management in Kwau Tourism Village, while providing a replicable approach for other biodiversity-rich rural ecotourism destinations.

5. Conclusion

This study demonstrates that bird-based ecotourism development in Kwau Tourism Village is strongly shaped by the spatial concentration of biologically significant habitats, species-specific activity patterns, and the effective use of geospatial technologies at the village scale. Spatial analysis shows that key observation sites for endemic species such as *Parotia sefilata* and *Amblyornis inornata* are concentrated in forest zones with relatively dense canopy cover and low levels of anthropogenic disturbance, highlighting the importance of habitat quality in guiding ecotourism planning. Temporal findings further indicate that bird activity peaks during early morning and late afternoon periods, providing practical guidance for scheduling birdwatching activities to maximize observation success while minimizing disturbance.

Beyond ecological insights, the integration of bird observation data, trekking accessibility, and tourism destinations into an interactive WebGIS platform represents the main applied contribution of this study. By transforming static field observations into an accessible decision-support environment, the WebGIS enables route differentiation, site prioritization, and pre-visit planning based on distance, terrain difficulty, and behavioral timing. These village-scale outputs translate directly into operational management decisions, such as distinguishing sites suitable for general visitors from those requiring guided access, thereby supporting visitor safety and sustainable destination management.

Overall, this research contributes a practical and replicable GIS-based framework that links spatial ecology, visitor accessibility, and digital information delivery to support community-based ecotourism development. While the findings are based on short-term field observations, they provide a robust baseline for adaptive management and future system enhancement. Continued ecological monitoring, expansion of WebGIS functionalities, and integration of visitor-flow and carrying-capacity indicators are recommended to further strengthen sustainable bird-based ecotourism in Kwau Tourism Village and similar biodiversity-rich rural destinations in West Papua.

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