

Leveraging Geospatial Technologies for Sustainable Tourism Development in Galle District, Sri Lanka.

J. Nayanajith¹, A.W.G.N.M. Abeyrathna² and P. Jayasinghe³

^{1,2,3} *Department of Geography, Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura*

Abstract

This study addresses a critical gap in sustainable tourism management in the Galle District, where the identification and promotion of new tourist attractions are essential to alleviate pressure on popular sites and support long-term tourism development. By integrating geospatial technologies (GST) with key data such as topography, accessibility, and infrastructure - the research identifies underutilized locations with the potential to become new tourist attractions. A mixed-methods approach was employed, combining field surveys, digital data acquisition, and spatial analysis through the Analytical Hierarchy Process (AHP) in QGIS. This integration provided a comprehensive evaluation of potential sites. The results include the development of a GIS-based web platform and a mobile application for real-time tourist data collection and management. These tools offer stakeholders an effective solution for managing tourism more sustainably by facilitating the discovery and promotion of lesser-known sites, which helps distribute visitor pressure more evenly across the region. By enhancing the identification process and promoting balanced visitor traffic, the study directly contributes to sustainable tourism management in the Galle District, offering insights that support both tourism growth and environmental sustainability.

Keywords: Geospatial Technologies, Sustainable Tourism Management, Galle District, Tourist Attractions, Analytical Hierarchy Process

1. Introduction

The connection between sustainable tourism and geospatial technology has garnered heightened interest in recent years, especially as the tourism sector confronts the problem of reconciling economic development with the preservation of cultural heritage and natural ecosystems. Sustainable tourism denotes development techniques that guarantee tourism benefits local economies while maintaining the natural and cultural integrity of tourist destinations (Tesema et al., 2020). The simultaneous emphasis on growth and conservation has emerged as a major aspect of tourist policy, particularly in areas endowed with significant historical and environmental

Corresponding author.

E-mail address: nayanajithku20@gmail.com (J. Nayanajith)

resources, such as the Galle District of Sri Lanka. Nevertheless, the contribution of geospatial technology to the promotion of sustainable tourism management is inadequately examined in empirical research, especially concerning Sri Lanka's developing tourism destinations. The Galle District, characterized by its many attractions and historical landmarks, exemplifies the potential of Geographic Information Systems (GIS) and other geospatial tools in facilitating sustainable tourist management practices.

Geospatial technology, including Geographic Information Systems (GIS), remote sensing, and location-based services, has become increasingly essential in the tourism industry. These technologies facilitate the analysis of tourism patterns, resource management, and informed decision-making about destination management and conservation (Voda, 2013). While extensive study has been undertaken on the applications of GIS in tourism management globally (Judijanto & Jayadi, 2024), the integration of these technologies specifically within the context of the Galle District is lacking in depth. Many studies concentrate on overarching conceptual frameworks or highlight geospatial technology alone, neglecting the specific socio-economic and environmental difficulties that Galle encounters as a tourism center. The Galle District, notable for its UNESCO World Heritage-listed Galle Fort, pristine beaches, and lush jungles, experiences tremendous strain from tourism, which risks damaging the integrity of its natural and cultural resources (Echtner, 2002). This underscores the need for research that explicitly tackles how geospatial technology might be employed to balance the dual objectives of economic expansion and resource conservation.

One of the significant gaps in the existing literature is the lack of practical studies evaluating how geospatial technology might be exploited to uncover new and underutilized tourism locations inside the Galle District. Current tourist trends in the region are disproportionately concentrated around a few established locations, resulting in over-tourism, environmental degradation, and uneven distribution of tourism benefits among local residents. The majority of visitor flows are diverted towards Galle Fort and its adjacent areas, leaving other potential attractions in the district underdeveloped or disregarded. The identification and promotion of new destinations through geospatial technologies could provide a solution to these difficulties, although research particularly addressing this possibility remain limited. This project tries to overcome this gap by applying spatial data analysis techniques such as weighted overlay, GIS mapping, and remote sensing to find areas of untapped tourism potential. By concentrating

on elements such as accessibility, topography, and local knowledge, this study attempts to offer actionable insights into the establishment of new, sustainable tourism destinations.

In addition to discovering new tourist sites, this study also addresses a fundamental requirement for real-time data collecting and analysis in tourism management. The development of a location-based smartphone application that collects and analyzes real-time data about tourist behaviors and preferences is one of the primary achievements of this research. This application responds to the increasing demand for reliable, up-to-date information, which is crucial for successful visitor management, resource allocation, and marketing initiatives. Current literature highlights the need for reliable tourist data for decision-making in destination management (Smith et al., 2020); however, there are few studies addressing the practical implications of mobile technology in providing this data in a region-specific setting such as Galle. The mobile application described in this study covers this gap by enabling destination managers to dynamically change their tactics based on changing visitor trends, thereby boosting both the tourist experience and the sustainable management of resources.

Furthermore, this project proposes the construction of an interactive GIS-based website meant to encourage sustainable tourist practices in the Galle District. This website would provide the guests with interactive maps, virtual tours, and curated content on local sites, enabling them to engage more fully with the district's cultural and environmental history. Such tools not only increase the visitor experience but also encourage responsible and sustainable travel behaviors. The potential for GIS technology to contribute to destination management has been well-documented (Nagendra et al., 2013), but its function in supporting sustainability by promoting less-visited, ecologically vulnerable places is a subject that merits additional research, especially in Sri Lanka.

Another notable gap in the literature addresses the role of local communities in sustainable tourism development. While most of the present conversation on geospatial technology in tourism management is oriented on technological capabilities, there is little focus on how these tools might be combined with local knowledge to support inclusive, community-based tourism development. Sustainable tourism cannot be realized without the active participation of local stakeholders, and this study stresses the need of incorporating local ideas into the selection and promotion of new tourist sites. By conducting field surveys and interviews with local people and tourism operators, this research aims to ensure that the advantages of

tourism are properly spread, contributing to both socio-economic growth and the preservation of the district's cultural legacy.

The Galle District presents a unique case study for the application of geospatial technology in sustainable tourist management due to its varied variety of attractions, from historical sites and cultural icons to nature reserves and biodiversity hotspots. However, the district also faces a variety of tourism-related difficulties, including environmental deterioration, over-tourism in particular places, and a lack of infrastructure in less-developed sections. This research intends to provide a detailed examination of these difficulties and offer practical answers through the application of GIS and other geospatial tools. By doing so, it contributes to the expanding body of research that studies the convergence of tourism management and geospatial technology, with a specific focus on sustainable tourism development in the Galle District.

This study intends to address several crucial gaps in the existing literature by giving empirical insights into the real-world applications of geospatial technology for sustainable tourist management in the Galle District. Through a mixed-method approach that integrates quantitative and qualitative data, including spatial analysis, interviews, and field surveys, this research strives to offer a comprehensive understanding of how geospatial technology might support sustainable tourist practices. The findings of this study will not only contribute to academic discourse but also provide practical recommendations for policymakers, destination managers, and local stakeholders, enabling them to make informed decisions that foster economic development while preserving the district's natural and cultural resources.

2. Materials and Methods

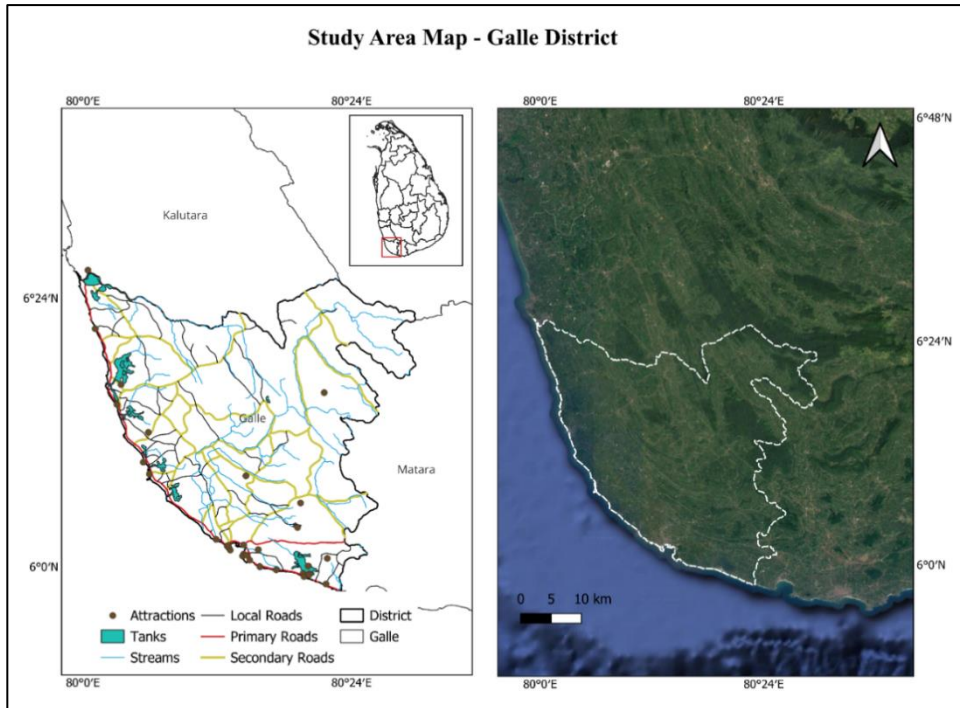


Figure 1: Study Area Map

2.1 Study Area

Nestled along Sri Lanka's southern coastline, the Galle District occupies an area of roughly 1,652 square kilometers and offers a compelling blend of natural beauty and historical charm. The famous Galle Fort, a UNESCO World Heritage Site that attests to the area's rich colonial past and architectural magnificence, is located at the center of it all. The fort's majestic ramparts, cobblestone streets, and houses from the colonial era evoke awe and nostalgia while taking tourists back in time.

The area is home to numerous sights that pique the interest of the senses and capture the imagination beyond Galle Fort. Along the shoreline are immaculate beaches that are perfect for leisurely strolls and peaceful sunsets. Unspoiled natural settings, such as verdant tea plantations and beautiful jungles, entice travelers to discover their hidden treasures. Wildlife sanctuaries are rich in biodiversity and provide rare opportunities to see animals like elephants, leopards, and unusual birds.

The cultural landscape of the Galle District is equally vibrant, dotted with historic temples, traditional towns, and lively markets. Visitors can

purchase unique gifts and get cultural insights from the elaborate woodcarvings, colorful textiles, and intricate lacework displayed by the local artists. Throughout the year, the neighborhood is alive with festivals and cultural activities that celebrate its unique traditions and promote community togetherness.

The Galle District, a well-known tourist attraction in Sri Lanka, draws a wide range of visitors, from nature lovers and history buffs to beachgoers and adventure seekers. It is the perfect starting point for discovering the treasures of the Southern coast.

2.2 Methodological Flow Diagram

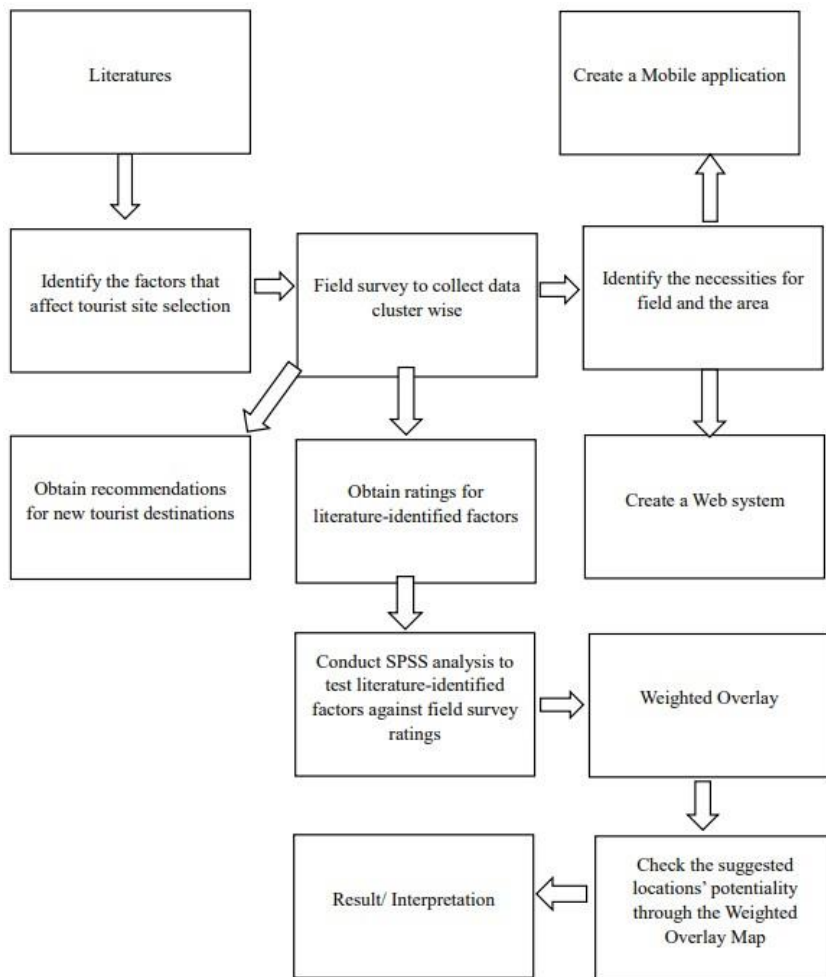


Figure 2: Methodological Flow

The research methodology was meant to systematically assess and promote new tourism destinations by employing geospatial technology, merging field survey data with literature-identified characteristics that influence site selection. The procedure began with a field survey conducted cluster-wise, which allowed for a collection of data suitable to distinct geographic clusters, offering a localized insight of possible tourism locations. This geospatial method allows the discovery of significant clusters and patterns relevant to tourism development.

Following the survey, characteristics affecting tourist site selection were identified through a comprehensive examination of the literature, giving a theoretical foundation for evaluating and comparing diverse locations. Next, the necessities for the field and the location were defined, refining the focus of the survey and assuring alignment with the main criteria necessary for effective tourism promotion. After data collection, ratings for the literature-identified factors were gathered, representing respondents' perceptions on the relevance of each item. This enabled the discovery of proposals for new tourist sites, where locations with great potential for tourism were selected.

To validate the significance of the literature-derived components, SPSS analysis was undertaken, assessing the link between these factors and the field survey ratings. This statistical method confirmed the importance of the factors in the local environment. A weighted overlay analysis, employing geospatial technology, was then utilized to analyze the potential of each recommended location, combining the field survey scores with geospatial data to determine the viability of each site for tourism development. As a major outcome of this research, a mobile application was built to provide a solution to the existing difficulty of gathering tourist arrival data from multiple sites. This program, powered by geospatial technology, provides real-time data collecting from tourists at each site, delivering critical insights for future tourism management and regional growth. Alongside the app, a web system was established to give tourists with thorough information about selected places, boosting eco-tourism and supporting sustainable growth.

The final results and interpretations were led by the weighted overlay analysis, allowing for the selection of the most promising tourism destination. This methodology leverages geospatial technology not just for tourism promotion but also for the sustainable development of the selected places, assuring a data-driven and technologically advanced approach to tourism in the area.

2.3 Population, Sample, and Sampling

The demographically this research is studying includes the many types of tourism, tourist places, foreign tourists, and local residents in Sri Lanka's Galle District. The district offers a diversified terrain for exploration given its wealth of tourism products, which include agritourism destinations, natural reserves, scenic beaches, religious icons, and cultural heritage sites.

To gather a diverse and representative sample for the questionnaire survey, this study will employ cluster sampling. Tourist attractions will be grouped based on geographical proximity and thematic similarities. Within each cluster, a representative sample of attractions will be chosen. Additionally, the sample will cover local communities existing near the sampled attractions and international tourists visiting them. This approach ensures data collection from various stakeholders, including residents, business owners, cultural practitioners, and foreign visitors from diverse backgrounds and interests.

2.3.1 Cluster for Cultural Heritage

Many cultural heritage sites are found in the Galle District, including as the well-known Galle Fort, the Martin Wickremasinghe Folk Museum, and Ambalangoda Mask Museum. In order to ensure equitable representation across attractions, a sample will be chosen using a systematic random sampling process to represent this cluster.

2.3.2 Coastal Cluster and Beaches

Due to its well-known beaches which include Thalpe, Mirissa, and Unawatuna, the district draws tourists from all over the world. Using a systematic random sampling approach, a sample will be selected from these beaches taking into consideration the variety and appeal of coastal attractions.

2.3.3 Cluster of Nature and Wildlife

The Madu River Estuary, the Sinharaja Forest Reserve, and turtle hatcheries are just a few of the district's many ecosystems. In order to fully capture the distinctive characteristics and biodiversity of each site, systematic random sampling will be used to get a sample from this cluster.

2.3.4 Spiritual & Religious Cluster

The area's spiritual tourism experience is enhanced by places of worship including St. Mary's Cathedral and the Japanese Peace Pagoda.

Systematic random sampling will be used to choose a sample from these locations, guaranteeing representation from a variety of religious backgrounds.

2.3.5 Cluster of Rural and Agritourism

Agritourism destinations like Koggala Lake and Handunugoda Tea Estate give tourists a glimpse into rural life and farming methods. To capture the diversity of agritourism experiences, systematic random sampling will be used to select a sample from this cluster.

2.4 Sampling Methodology

The sample approach for this study includes systematic random sampling and convenience sampling to ensure full representation of the tourism dynamics in the Galle District. This strategy is aimed at capturing a wide assortment of opinions from both local inhabitants and foreign visitors across different sorts of tourism destinations.

To structure the sample, tourist attractions are first divided into clusters based on two key criteria: geographical distribution and thematic similarity. Geographical distribution refers to dividing attractions based on their location within the district. For example, coastal regions like Hikkaduwa or Unawatuna, famed for their beach tourism, form one cluster, while inland areas rich in cultural and historical value, such as the Galle Fort or old temples, create another. This provides an equitable spatial representation of attractions across the Galle District. Thematic similarities focus on classifying attractions by their distinct tourism focus. For instance, cultural heritage sites like temples are located separately from natural attractions like animal sanctuaries and beaches. This thematic category helps capture the diversity of tourism experiences within the region.

Once the clusters are identified, systematic random sampling is applied to identify specific attractions within each cluster. Attractions are listed in a methodical manner, and every attraction is chosen for data collection. This ensures that a variety of attractions from each geographical and thematic cluster are included while keeping unpredictability in the selection process.

For participant selection, the study combines a combination of systematic random sampling and convenience sampling. At each selected attraction, participants including both visitors and local inhabitants are approached via convenience sampling, focusing on those who are readily accessible throughout the survey period. This strategy helps gather multiple

opinions from many stakeholders such as foreign tourists, local business owners, cultural practitioners, and locals around tourist areas.

This comprehensive sampling technique guarantees that the study collects a broad range of opinions from diverse types of tourists and stakeholders in the Galle District. By presenting insights from both locals and visitors, the technique helps informed decision-making for fostering the sustainable expansion of the tourism business in the region.

2.5 Data Collection

In order to obtain thorough insights into the dynamics of tourism and sustainable practices within the Galle District, the data collection process of this study used a combination of primary and secondary sources.

2.5.1 Primary Data Collection

Questionnaires given to the people who visit numerous places of attraction in Galle District were used to collect primary data. A variety of data was intended to be collected by the survey instrument such as satisfaction levels, travel preferences, demographic profiles, and opinions about sustainable tourism practices. On-site surveys were carried out at popular tourist destinations, enabling direct communication with guests and on-the-spot data gathering. Furthermore, online surveys were disseminated via email lists and social media platforms in order to reach a larger audience and collect opinions from those who were unable to visit the district in person. A variety of visitor viewpoints and experiences were guaranteed by the employment of both in-person and online survey techniques.

Table 1: Demographic Data

Number of Respondents for each cluster										
Demographic Characteristic	Religious & Spiritual (Foreign Tourists)	Religious & Spiritual (Local Community)	Rural & Agriculture (Foreign Tourists)	Rural & Agriculture (Local Community)	Beach & Coastal (Foreign Tourists)	Beach & Coastal (Local Community)	Cultural Heritage (Foreign Tourists)	Cultural Heritage (Local Community)	Nature & Wildlife (Foreign Tourists)	Nature & Wildlife (Local Community)
Age Group										
18-25	-	1	-	-	2	4	7	6	5	6
26-35	2	-	1	1	7	5	4	4	6	4
36-45	-	-	-	-	3	3	1	1	1	-
46 +	3	4	4	4	3	3	3	4	3	5
Gender										
Male	4	2	3	4	5	11	8	9	12	6
Female	1	3	2	1	10	4	7	6	3	9
Nationality										
European	4	-	2	-	3	-	5	-	8	-
Asian	-	-	3	-	3	-	4	-	2	-
North American	1	-	-	-	2	-	2	-	3	-
Russian	-	-	-	-	6	-	3	-	2	-
Australian	-	-	-	-	1	-	-	-	-	-
Others	-	-	-	-	-	-	1	-	-	-
Sri Lanka	-	5	-	5	15	15	-	15	-	15

According to the Sri Lanka Tourism Development Authority statistical report (2020) the data for each tourist attractions in Galle District are as follows,

(a) Evaluating the Necessities for the Area

Several significant tourist attractions in the Galle District were evaluated for their visitor demographics, underlining the need for gathering tourist

arrival data. The Kanneliya Conservation Forest attracted 868 foreign visitors and 18,959 domestic visitors, making it an important destination for both international and local tourism. The Galle National Museum attracted 1,301 foreign visitors and 6,315 domestic visitors, confirming its appeal, particularly among locals. Similarly, the Galle Maritime Museum had 1,092 foreign visitors and 9,160 domestic visitors, demonstrating a balance between international and local interest. The Hikkaduwa Turtle Hatchery was notably popular, with 2,474 overseas visitors and 9,284 domestic visitors. In comparison, the Kottawa Conservation Forest got only 66 foreign visitors and 899 domestic visitors, presumably due to its unique appeal. Despite these figures, the lack of consistent data collecting on tourist arrivals, particularly year-wise or on a monthly basis, creates substantial gaps in comprehending visitor trends. This limitation limits effective planning and the development of tourism initiatives customized to fulfill the demands of both tourists and local businesses. Moreover, the respondents stressed that importance of comprehensive data gathering system for visitor arrivals is crucial to enhance decision-making and encourage sustainable tourism growth in the region.

Furthermore, the demand for a web system in the region is clear when considering the demographic data and preferences of tourists and the local community. A considerable majority of responses falls under younger, digitally-inclined age groups, with 25% of foreign tourists and 20% of the local community aged between 18 and 25, showing a strong reliance on digital platforms for trip planning, recommendations, and reviews. Additionally, a balanced gender distribution, with 60% of local respondents and 45% of foreign respondents being male, shows that a web system needs to cater to a broad audience. The range in nationalities, with 40% of international responders being European, 20% Asian, and 10% Russian, further highlights the necessity for a multi-lingual, user-friendly web system that can handle various preferences and deliver customized information. Moreover, interests in specific clusters, such as environment and wildlife (30% of foreign tourists) and cultural heritage (25% of foreign tourists), underscore the need of promoting specific attractions that fit with visitor preferences. Respondents stressed that they need digital platform that allow small enterprises to offer their products and services.

(b) Local Community Perspective

The opinions of the locals shed light on what they think about the new attractions in the Galle District. 20% of the participants voiced misgivings about new attractions, noting issues with community-based tourism programs like those at the Kottawa Conservation Forest. On the other hand, the same percentage of participants, that is, 20% of them, thought favorably of new

attractions, emphasizing the value of animal sanctuaries such as the Hikkaduwa Turtle Hatchery. Furthermore, 24% of the total emphasized the historical relevance of locations like the Galle Maritime Museum and endorsed them as distinctive aspects of the district's attractions. Comparably, 16% of the total highlighted the value of historical sites such as the Galle National Museum, in enhancing the region's cultural landscape. Lastly, 20% of the total had no opinion about new attractions. They were particularly against those connected to community-based tourism projects like those going on at the Kanneliya Conservation Forest.

2.5.2 Secondary Data Collection

To supplement the original data obtained, secondary data was gathered from academic institutions, non-profit organizations, online resources (USGS Earth Explorer), and government bodies such as the Sri Lanka Tourism Development Authority (SLTDA) and UNESCO World Heritage Centre. These sources gave useful insights into environmental indicators (SLTDA report, 2020), cultural heritage sites (UNESCO, 2021), tourism infrastructure, and other pertinent issues effecting the sustainability of tourism in the Galle District. The material from these secondary sources was evaluated to supplement and contextualize the findings from the original data collection.

Collected Secondary Data:

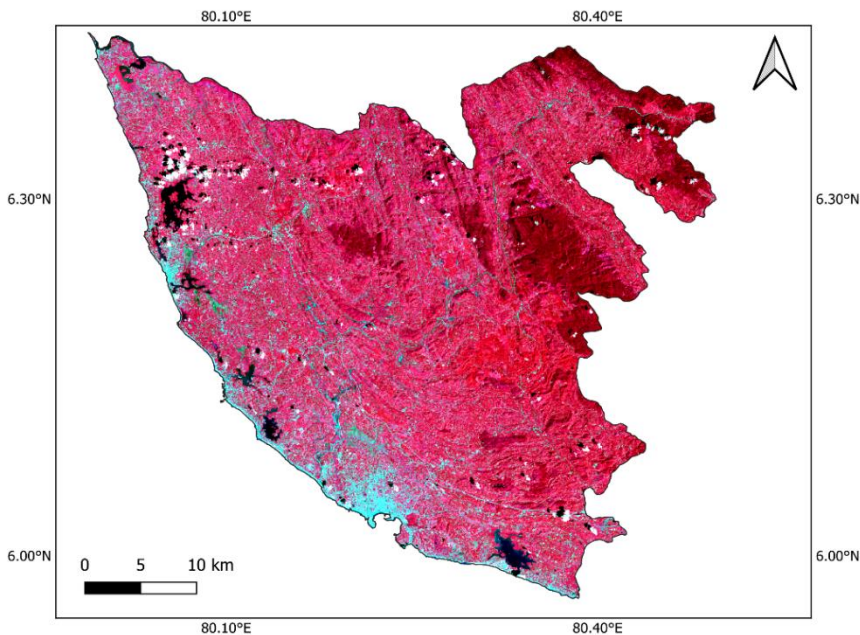


Figure 3: True Color Composite of Landsat 8 Satellite

Source: USGS Earth Explorer, 2023

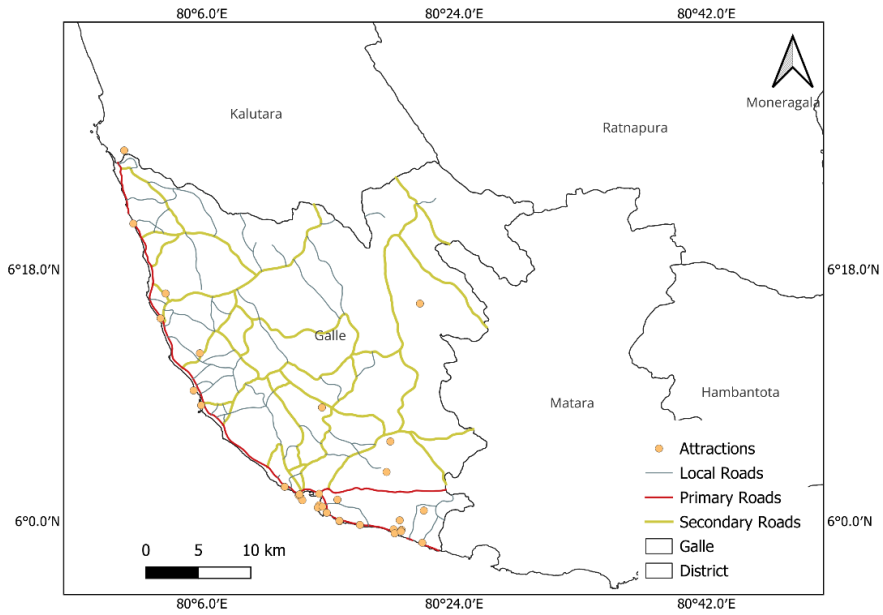


Figure 4: Road Layer
Source: Department of Survey, 2023

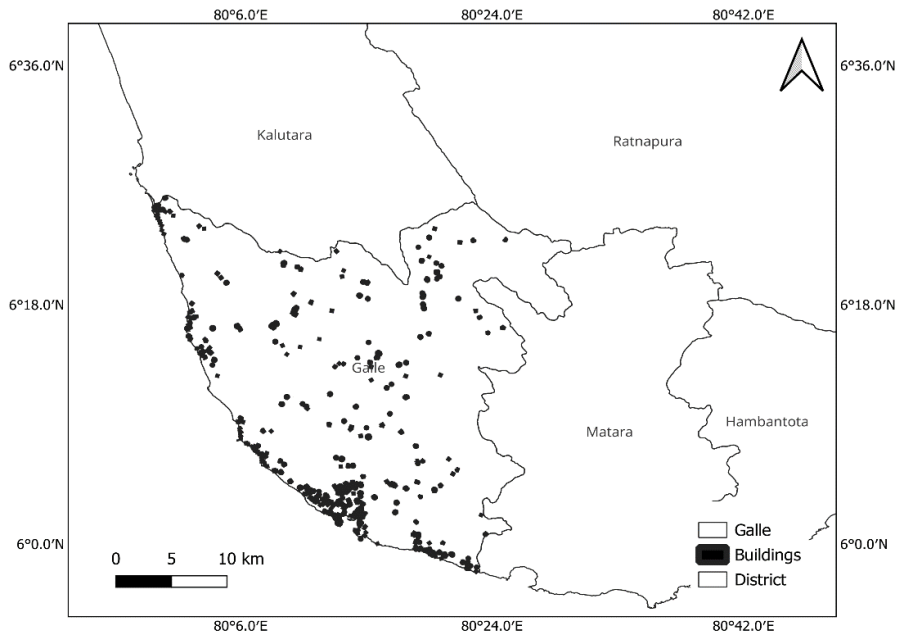


Figure 5: Buildings Data
Source: Survey Department, 2023

Table 1: Secondary Data

Data and description	Updated year	Data source
Landsat 8 OLI	2023	Earth explorer (USGS)
Population	2019	Department of Census and Statistics
District GND and DSD	2023	Department of Survey
Road	2023	Open Street Map (OSM)
Buildings	2023	Open Street Map (OSM)
Elevation		Department of Survey

2.6 Data Collection Methods:

This study used online surveys, in-person interviews, and observational approaches to obtain data. Trained researchers performed in-person interviews with tourists at popular tourist destinations in the Galle District, enabling direct communication with guests and the gathering of comprehensive data. In order to reach a larger audience and gather opinions from those who might not have been physically present in the area, online questionnaires were sent electronically. In order to augment survey data and give further context to the results, observation techniques involved systematic monitoring of tourist behavior, environmental conditions, and infrastructure amenities.

A thorough analysis of sustainable tourism practices and visitor perceptions in the Galle District was made possible by the combination of primary and secondary data collection methods. This analysis helped to clarify the opportunities and problems related to the development of sustainable tourism in the area.

2.7 Data Analytical Methods:

In this research, a combination of quantitative and qualitative methodologies was applied to examine the need for a web system and mobile application to promote tourism in the Galle District. Data gathering comprised both in-person and online surveys. In-person polls were done using convenience sampling at key tourist locations, while online surveys targeted recent visitors via social media and tourism organizations. To ensure the credibility of online responses, verification procedures such as IP monitoring and follow-up questions were employed to check authenticity.

Tourists were picked through a mix of random and convenience sampling methods within clusters based on geographical location and thematic similarity of sites, guaranteeing broad representation from foreign and local

tourists. The demographic data collected were evaluated using descriptive statistics to find trends in visitor behavior. SPSS analysis was done to assess the association between literature-identified factors impacting site selection and tourist preferences, validating the importance of these factors.

A weighted overlay study in QGIS 3.38.2 analyzed the potential of tourist locations by merging survey findings with factors collected from literature. Finally, the web system and mobile application were designed to address data shortages and provide real-time insights to stakeholders, facilitating sustainable tourist development in the Galle District. This technique ensures a representative sample and trustworthy data gathering, addressing shortcomings in existing methods for promoting tourism in the region.

2.7.1 Ratings for Tourist Destinations

The ratings table was generated by combining ratings from respondents based on their evaluations of each destination. The ratings for Topography, Accessibility, Infrastructure, and Local Awareness were determined by averaging the scores reported by the respondents. This strategy ensures that the final scores reflect the overall visitor experience and site features, based on demographic data.

Table 2: Ratings from respondents for each attraction

Destination	Topography (1-5)	Accessibility (1-5)	Infrastructure (1-5)	Local Awareness (1-5)
Galle Fort	5.0	4.8	4.5	4.8
Martin Wickremasinghe Folk Museum	4.2	4.3	3.8	4.1
Ambalangoda Mask Museum	3.5	4.2	3.7	4.0
Old Dutch Market	4.0	4.6	4.3	4.3
All Saints Church	3.8	4.1	3.5	3.7
National Maritime Museum	4.3	4.2	4.0	4.2
Dutch Hospital Shopping Precinct	3.7	4.5	4.2	3.9
Thalpe Beach	5.0	4.9	3.8	4.3
Mirissa Beach	4.8	4.5	4.0	4.6
Unawatuna Beach	4.7	4.8	4.3	4.5
Weligama Beach	4.9	4.7	4.0	4.4

Hikkaduwa Beach	4.5	4.9	4.2	4.6
Koggala Beach	4.0	4.3	3.8	4.0
Dalawella Beach	4.1	4.7	3.5	3.9
Madu River Estuary	4.9	4.2	3.7	4.2
Sinharaja Forest Reserve	5.0	3.5	2.8	4.0
Hikkaduwa Turtle Hatchery	4.6	4.8	3.6	4.3
Kottawa Conservation Forest	3.5	3.2	2.5	3.5
St. Mary's Cathedral, Galle	4.3	4.1	4.0	4.2
Japanese Peace Pagoda	4.2	4.3	3.7	4.1
Galle Lighthouse	3.7	4.1	3.4	3.7
Sri Sudharmalaya Temple	3.5	3.6	2.7	3.5
Church of St. Augustine	4.0	4.2	3.6	4.0
Koggala Lake	5.0	4.2	3.5	4.2
Handunugoda Tea Estate	4.0	3.5	4.2	3.8
Piyangala Tea Plantation	4.0	3.6	3.5	3.6
Galle Rice and Spice Farms	3.5	4.1	3.5	3.7
Diyakotha Farm	3.3	3.2	2.8	3.5
Bentota Beach	5.0	4.9	4.4	4.8
Sri Lanka Arts and Crafts Centre	3.8	4.1	4.0	3.9
Moragalla Beach	4.5	4.8	3.7	4.2
Balapitiya Beach	4.4	4.7	3.5	3.9
Beruwala Lighthouse	3.8	4.1	4.1	3.8
Yatagala Viharaya Rajamaha	4.3	4.2	3.6	4.1

2.7.2 Weighted Overlay

i. Criteria Identification

In this study, we attempted to evaluate the attractiveness of several tourist locations in the Galle District based on four major criteria: Topography, Accessibility, Infrastructure, and Local Awareness. These criteria were

identified through literature research and stakeholder interviews, assuring their relevance to the study's aims.

ii. Pairwise Comparison

We applied the Analytic Hierarchy Process (AHP) as described by Saaty (1980) to establish the relative relevance of each criterion. A pairwise comparison matrix was built to ease this evaluation:

$$a_{ii} = 1 \text{ for all } i$$

Table 3: Pairwise Comparison according to the AHP Method

Criteria	Topography	Accessibility	Infrastructure
Topography	1	1.15	1.10
Accessibility	0.87	1	0.80
Infrastructure	0.91	1.25	1

iii. Normalization and Weight Calculation

$$\begin{bmatrix} 1 & 1.15 & 1.10 \\ 2.79 & 3.40 & 2.90 \\ 0.87 & 1 & 0.80 \\ 2.79 & 3.40 & 2.90 \\ 0.91 & 1.25 & 1 \\ 2.79 & 3.40 & 2.90 \end{bmatrix}$$

The pairwise comparison matrix was normalized by dividing each element by the sum of its respective column. The resulting normalized matrix was:

$$\begin{bmatrix} 0.358 & 0.338 & 0.379 \\ 0.312 & 0.294 & 0.276 \\ 0.326 & 0.368 & 0.345 \end{bmatrix}$$

Weights for each criterion were calculated by averaging the normalized values:

$$\text{Weight} = \frac{1}{n} \sum_{i=1}^n \text{normalized value}$$

Topography: 0.332

Accessibility: 0.333

Infrastructure: 0.335

iv. Weighted Scores

Total Weighted Score Hotels and Restaurants = (Topography) + (Accessibility) + (Infrastructure)

Table 4: Total Weight Score for Hotels and Restaurants in Galle District

Hotel/ Restaurant Number	Location (1-5)	Accessibility (1-5)	Facilities (1-5)	Total Weighted Score
Hotel 1	5.0	4.8	4.5	4.76
Hotel 2	4.2	4.3	3.8	4.11
Hotel 3	3.5	4.2	3.7	3.80
Hotel 4	4.0	4.6	4.3	4.30
Hotel 5	3.8	4.1	3.5	3.80
Hotel 6	4.3	4.2	4.0	4.17
Hotel 7	3.7	4.5	4.2	4.14
Hotel 8	5.0	4.9	3.8	4.55
Hotel 9	4.8	4.5	4.0	4.43
Hotel 10	4.7	4.8	4.3	4.60
Hotel 11	4.9	4.7	4.0	4.53
Hotel 12	4.5	4.9	4.2	4.53
Hotel 13	4.0	4.3	3.8	4.03
Hotel 14	4.1	4.7	3.5	4.10
Hotel 15	4.9	4.2	3.7	4.27
Hotel 16	5.0	3.5	2.8	3.77
Hotel 17	4.6	4.8	3.6	4.34
Hotel 18	3.5	3.2	2.5	2.07
Hotel 19	4.3	4.1	4.0	4.14
Hotel 20	4.2	4.3	3.7	4.08
Hotel 21	3.7	4.1	3.4	3.74
Hotel 22	3.5	3.6	2.7	3.26
Hotel 23	4.0	4.2	3.6	4.07
Hotel 24	5.0	4.2	3.5	4.23
Hotel 25	4.0	3.5	4.2	4.90

Hotel 26	4.0	3.6	3.5	4.70
Hotel 27	3.5	4.1	3.5	3.70
Hotel 28	3.3	3.2	2.8	3.11
Hotel 29	5.0	4.9	4.4	4.77
Hotel 30	3.8	4.1	4.0	3.96
Hotel 31	4.5	4.8	3.7	4.33
Hotel 32	4.4	4.7	3.5	4.20
Hotel 33	3.8	4.1	4.1	3.99
Hotel 34	4.3	4.2	3.6	4.03

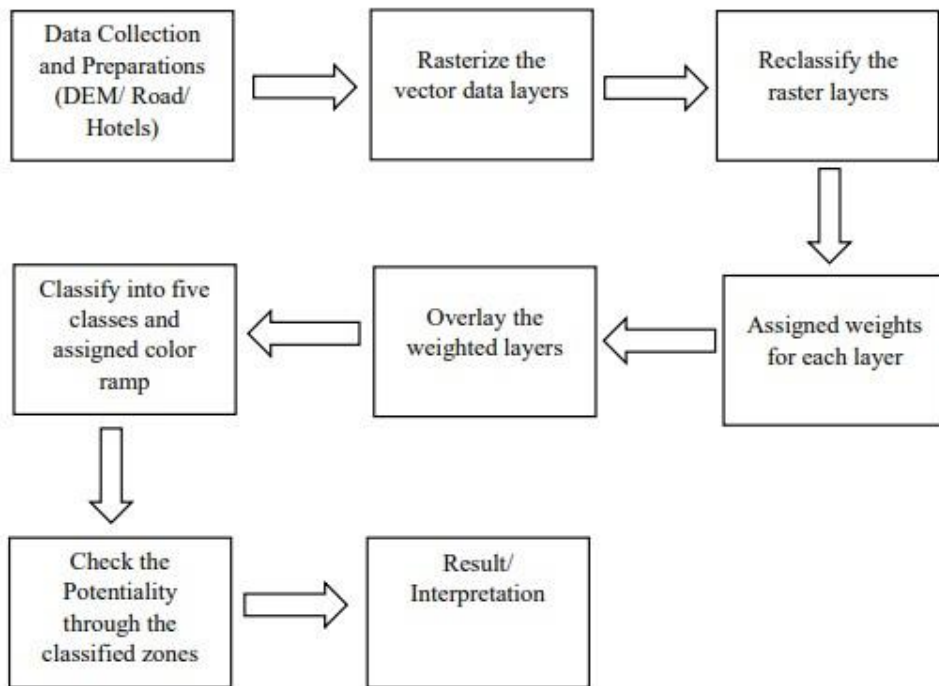


Figure 6: Weighted Overlay Flow

2.7.3 Mobile Application and Web System Development

The creation of the GIS web-based platform and mobile application incorporated a range of current technologies and frameworks. For the web platform, Visual Studio Code was utilized as the integrated development environment (IDE), with Node.js, JavaScript, and CSS for front-end and back-

end development, supported by MongoDB as the database. This approach allowed for fast handling of geospatial data and real-time interaction.

For the mobile application, Android Studio and the Flutter framework were chosen to provide cross-platform functioning. The program incorporated Firebase for the database and leveraged an open-source QR code generator for easy data input. Some of the primary problems faced included refining the web system's speed for real-time geographic data display and ensuring smooth synchronization between the mobile app and Firebase. These were solved by fine-tuning the data handling processes and doing rigorous testing for both systems.

3. Results

The study's findings reveal that great progress has been made in employing geospatial technologies to help tourism management and uncover new attractions in the Galle District. After rigorous data collecting and strong analysis, three remarkable outcomes have been identified:

3.1 Development of a GIS Web-Based Website

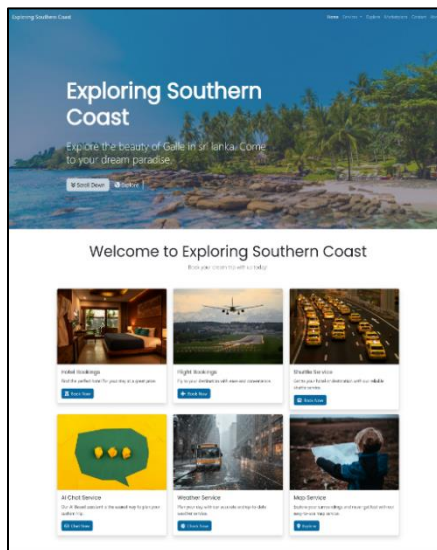


Figure 7: Web System Interface

A GIS web-based platform has been painstakingly constructed using HTML, CSS, and JavaScript together with GIS technologies like Google Maps and OpenLayers. This platform meets the requirement for updated and conveniently accessible tourism information. It acts as a complete resource, providing up-to-date information on local events, lodging, transportation, and attractions across the Galle District.

With its interactive maps and user-friendly interfaces, the website allows users to access vital information, helping them to make well-informed decisions and navigate with ease when traveling.

The backend is provided by Node.js, which facilitate data management and integration with geospatial databases. The effectiveness and user-friendliness of the GIS web-based platform have been proven through rigorous usability testing and iterative user feedback loops, highlighting its essential role in increasing interaction with the region's offers and improving tourist experiences. Additionally, the usage of a database management system such

as MongoDB enables efficient storage and querying of geospatial data, boosting the overall usefulness of the platform.

3.1.1 Structure and Attachments

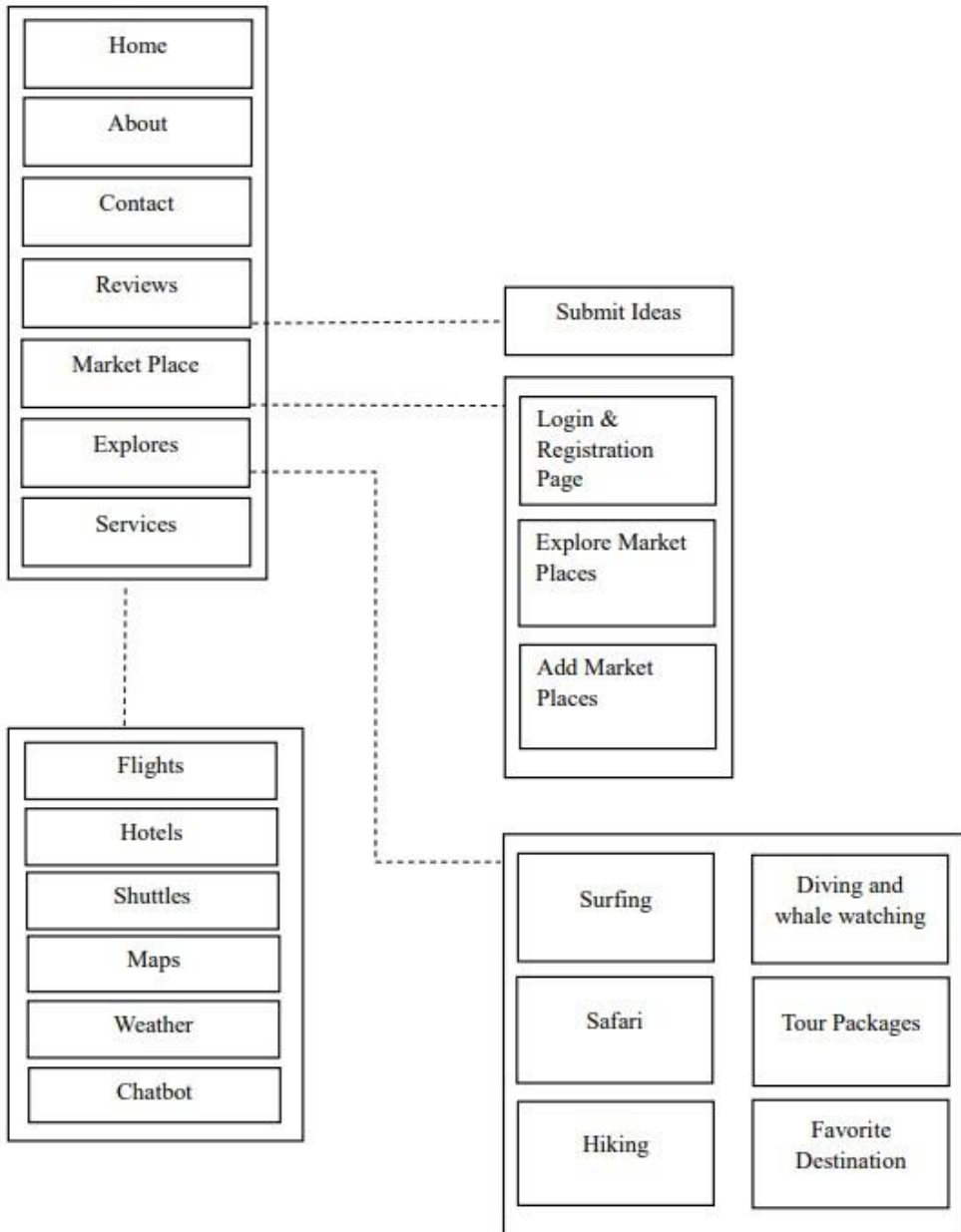


Figure 8: Web System Architecture

Link: <https://nayana.onrender.com/>

GitHub Code: <https://github.com/Jagodage/Nayanajith.git>

3.2 Development of a Mobile Application for Tourist Data Collection

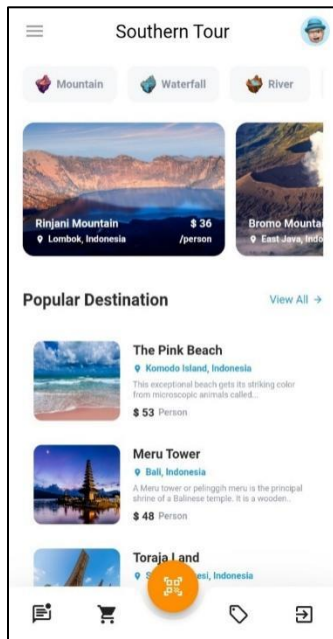


Figure 9: Mobile Application Interface

In response to the demand for more effective and organized tourist data collecting, a carefully designed mobile application has been developed utilizing Flutter for cross-platform compatibility on both iOS and Android smartphones. This program employs geolocation technologies to precisely track demographic information at numerous tourist destinations in the Galle District. Through the integration of Firebase for real-time data storage and Google Maps API for location tracking, the application provides good user experiences while collecting useful data. The mobile application has proved great utility in speeding up data collection processes and delivering essential insights into visitor behaviors and preferences. This has been done through field testing and iterative refinements directed by user input, enabling for continual improvement. The analytics produced from this data can be important in defining tourism strategy and boosting visitor interaction in the Galle District.

3.2.1 Structure of the Mobile App

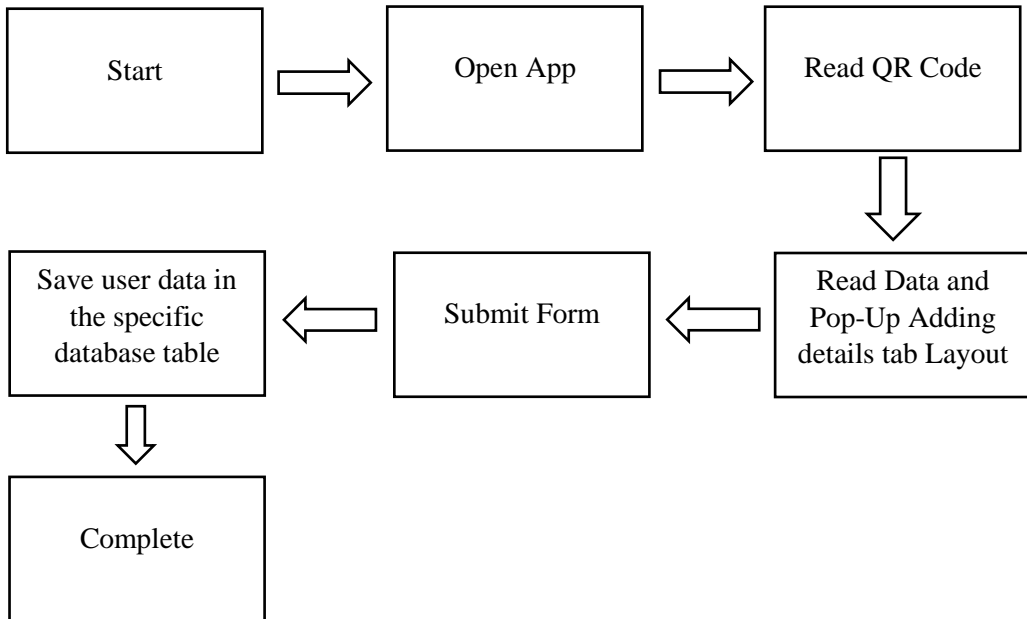


Figure 10: Mobile App Structure Flow Diagram

Source Code: <https://github.com/Jagodage/Nayanajith.git>

QR Codes: <https://drive.google.com/drive/folders/1xseYa2jjZ9PEGg-os-9V2IEzvK7Ov3NI?usp=sharing>

3.3 Discovery Potentiality of New Tourist Attraction

In discovering potentiality of new tourist attraction, we utilized various geospatial technologies, focusing on key correlation findings in our weighted overlay analysis. While local awareness (correlation = -0.436, $p = 0.029$) was rejected as a significant factor, we considered topography (correlation = 0.430, $p = 0.032$) and infrastructure (correlation = 0.533, $p = 0.006$). These two factors played a crucial role in identifying optimal routes and high-potential areas, confirming that accessible infrastructure and favorable topography are essential to identify new tourist destinations. Based on the factors identified through SPSS analysis, a weighted overlay analysis was performed to evaluate the suitability of the attractions suggested by respondents. The weighted overlay technique allowed for the integration of multiple criteria, ensuring a comprehensive assessment of the potential for tourism development in the suggested locations. This approach helped to identify areas that align with the preferences and insights provided by the respondents, thereby offering a more targeted strategy for tourism development in the Galle District.

3.3.1 Weighted Overlay Analysis: Distribution of Suggested Tourist Attractions

A weighted overlay analysis was conducted to assess the suitability of potential tourist attractions in the Galle District. This analysis integrated multiple layers, including road networks (Figure 11) (representing accessibility), slope (Figure 12) (reflecting topography), and hotel locations (Figure 13) (indicating infrastructure). Each factor was weighted according to its importance in determining tourist site potentiality, and the combined layers were overlaid to produce a final suitability map.

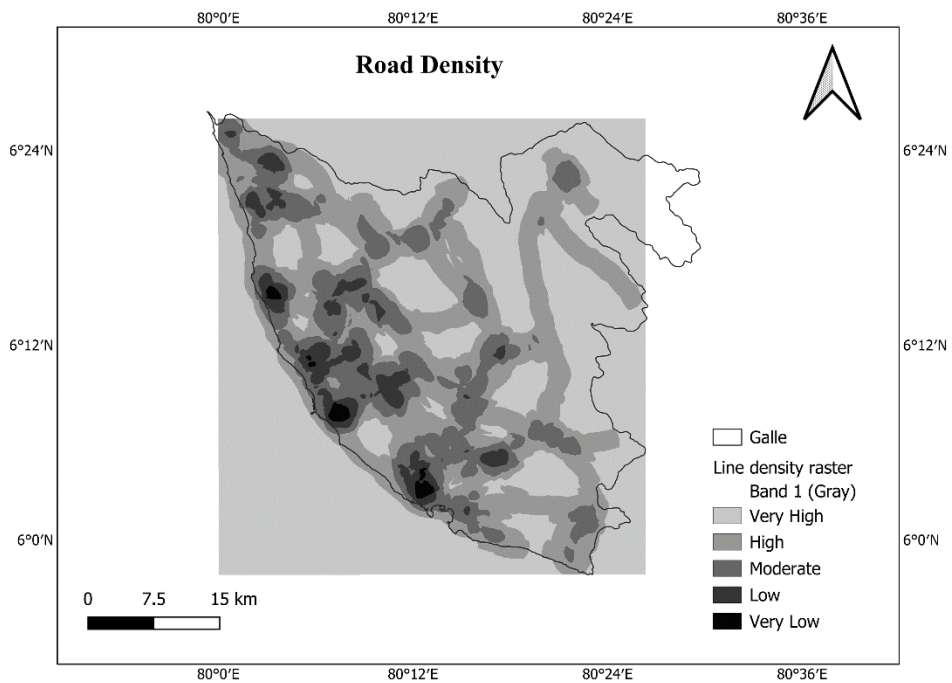


Figure 11: Reclassified Road Layer

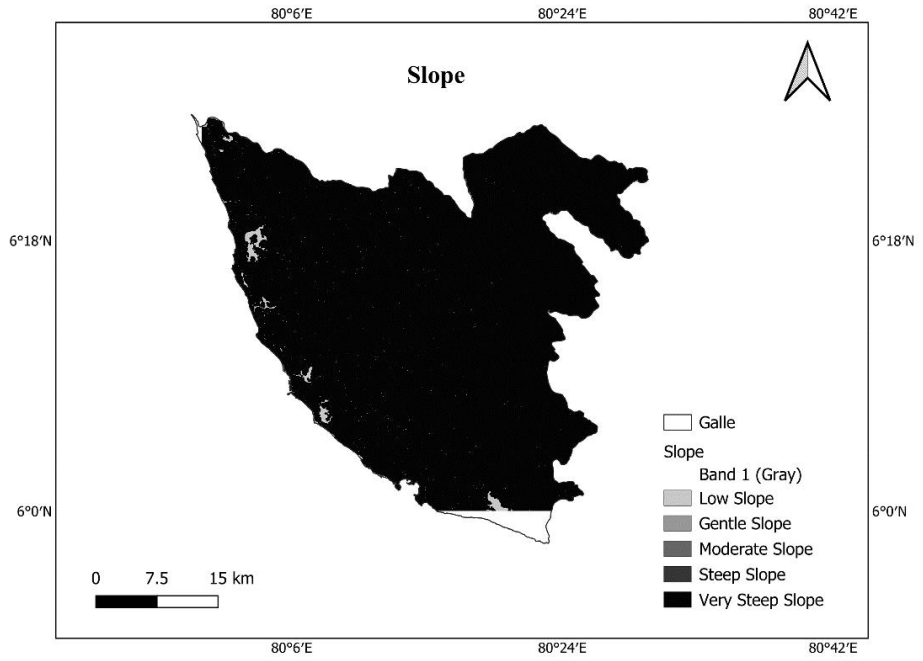


Figure 12: Reclassified Slope Layer

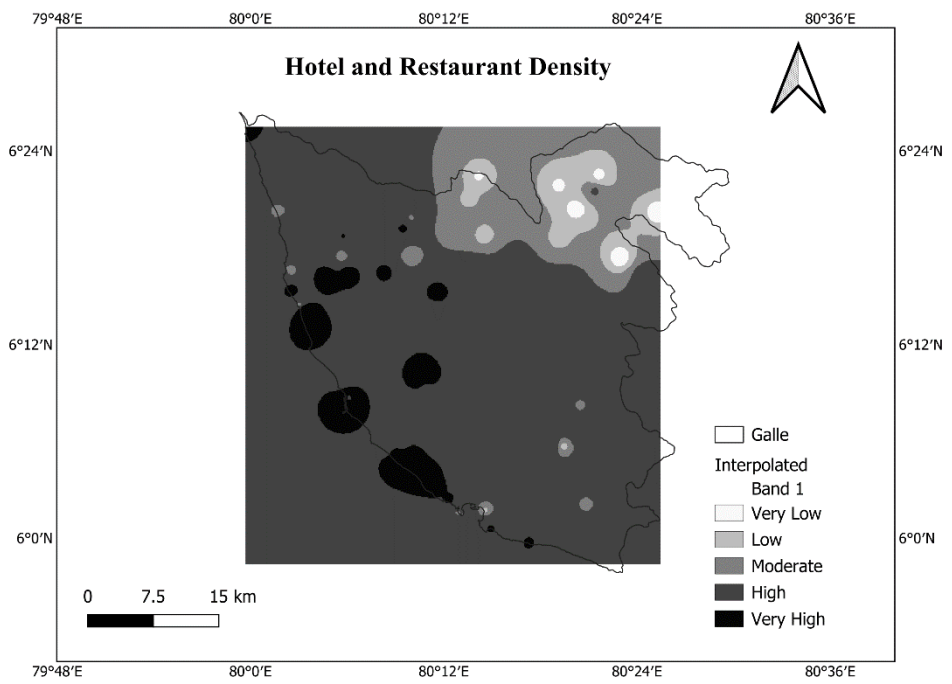


Figure 13: Reclassified Hotel and Restaurant Layer

The resulting map highlights areas with varying levels of tourism potential, categorized into five classes: very low potential, low potential, moderate potential, high potential, and very high potential. The final output, as seen in the map (Figure 14), identifies the areas with the highest potentiality, concentrating mainly in the Southern region of the district, where the convergence of favorable topographic, infrastructural, and accessibility factors is most prominent.

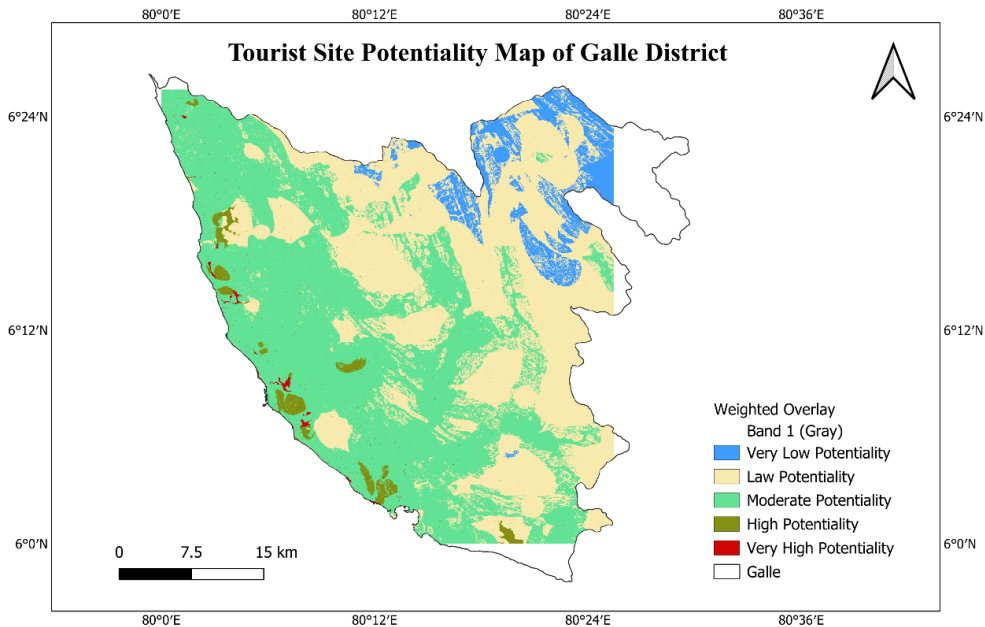


Figure 14: Weighted Overlay Map for Tourist Site Potentiality in Galle District

The analysis of tourism potential in the Galle District has identified three primary zones: high potential, moderate potential, and low potential (Figure 15). These classifications are based on a weighted overlay analysis that evaluates environmental conditions, accessibility, and infrastructure to determine their suitability for sustainable tourism development.

The high-potential areas, including Telwatta Bird Sanctuary, Madampa Village, and Balapitiya Cinnamon Garden, show strong prospects for tourism growth due to their natural beauty, good accessibility, and existing infrastructure. Madampa Village and Balapitiya Cinnamon Garden, with their concentration on agritourism, offer immersive experiences in cinnamon growing, while Telwatta Bird Sanctuary is perfect for eco-tourism and animal observation. However, despite the opportunities, possible problems like environmental repercussions and the need for community support must be addressed. For instance, ensuring that tourism does not disrupt local wildlife

habitats or negatively effect farming methods is vital. Engaging local communities in planning and decision-making will be important for minimizing resistance and supporting sustainable development.

Moderate-potential locations, including Ahungalla Beach, the Tsunami Memorial, Seenigama Muhudu Viharaya, and Handunugoda Tea Estate confront certain infrastructural and accessibility issues but retain significant value for niche tourism markets. Ahungalla Beach might benefit from expanded tourist facilities, while cultural attractions like the Tsunami Memorial and Seenigama Muhudu Viharaya could be renovated to lure historical and religious tourists. At Handunugoda Tea Estate, agritourism could prosper with greater infrastructure, yet the development must combine modernization with conserving traditional customs. Addressing these physical deficiencies, while also addressing any environmental issues or community opposition, is vital for sustainable tourism expansion.

Low-potential regions, such as Piyangala Tea Plantation and Kottawa Conservation Forest, give distinct but more niche prospects. These areas struggle with remoteness and insufficient infrastructure, but they could nevertheless attract travelers interested in authentic agritourism or eco-tourism experiences. However, development here must respect the ecological sensitivity of the forest and probable logistical issues. Enhancing transportation and visitor amenities could improve access, but care must be taken to prevent environmental degradation and to secure the support of local populations.

While the Galle District provides different tourism development potential, tackling issues such as environmental protection, community involvement, and infrastructural upgrades will be crucial for sustained success.

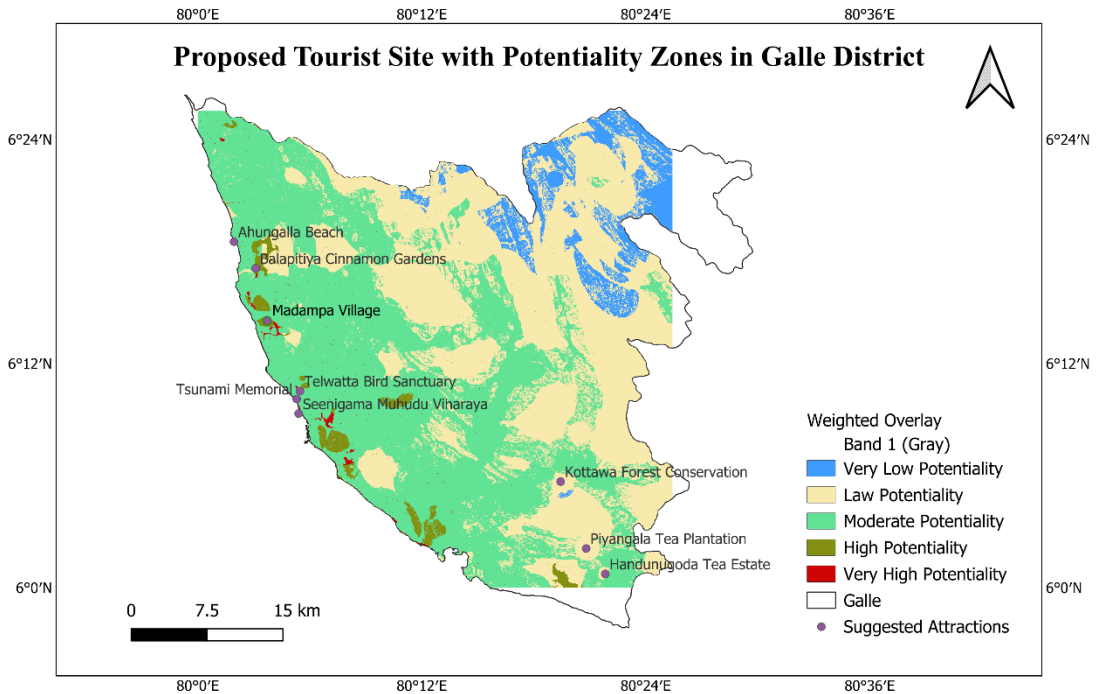


Figure 15: Suggested Locations with the potentiality Map

4. Discussion

The study's findings have major significance for fostering environment friendly tourism in the Galle District. By examining the effects of geospatial technology, exploring sustainable tourism practices, and measuring both economic and environmental implications, we get a deeper understanding of how to foster a vibrant tourism business while protecting the region's natural and cultural heritage.

4.1 Impact of Geospatial Technologies

Geospatial technologies, including mobile applications and Geographic Information Services (GIS)-based web services, have transformed how tourists engage with the Galle District. These technologies allow travelers to explore places more responsibly and effectively, boosting the whole experience (García et al., 2019). Interactive maps, personalized recommendations, and real-time updates have simplified travel and enabled visitors to discover lesser-known locations (Shoval & Ahas, 2016). Additionally, Destination Management Organizations (DMOs) have benefited from these technologies by being able to improve resource allocation

and make data-driven decisions, resulting in more successful tourism management (Zhang et al., 2021).

4.2 Sustainable Tourism Practices

Incorporating eco-friendly tourism strategies into the Galle District's destination management strategy is vital for long-term survival. Environmental conservation, community engagement, and cultural preservation guarantees that tourism may prosper without harming the area's heritage (Butler, 2020). Initiatives like eco-lodging, ethical tour operators, and community-based tourism not only reduce environmental impacts but also help to the socio-economic development of local communities (López-Guzmán et al., 2021). By promoting awareness about sustainable tourism practices, travelers can be encouraged to limit their ecological imprint and assist local livelihoods, fostering a culture of responsible travel (Becken, 2017).

4.3 Economic and Environmental Implications

Sustainable tourism has both economic and environmental ramifications for the Galle District. Economically, sustainable tourism practices can create jobs, diversify local income streams, and stimulate economic growth (Cabrera-Cánovas et al., 2020). Eco-friendly infrastructure, support for local craftspeople, and the promotion of unique cultural experiences help preserve the destination's character while giving financial benefits to tourist stakeholders (Gössling, 2021). From an environmental standpoint, sustainable tourism practices help preserve biodiversity, protect natural resources, and lessen the consequences of climate change (Hall et al., 2016). Measures like trash management, renewable energy consumption, and habitat restoration lessen tourism's ecological footprint and maintain the long-term health of local ecosystems (Sharpley, 2020).

The report underlines the necessity for the Galle District to implement sustainable tourist practices. By harnessing geospatial technologies, supporting responsible tourism behaviors, and emphasizing environmental protection, tourism stakeholders can establish a destination that balances economic development, environmental integrity, and cultural authenticity. A holistic approach to sustainable tourism is vital to safeguard the natural and cultural heritage of the Galle District for future generations.

4.4 Balancing Benefits and Limitations of Geospatial Technology in Tourism

To present a fair view on geospatial technology in tourism management, it is vital to examine both its benefits and limits. One big worry is data privacy

in mobile applications, as these apps routinely capture sensitive user information. Compliance with legislation like the General Data Protection Regulation (GDPR) is vital to preserve user data and maintain confidence (Voigt & Von dem Bussche, 2017). Additionally, traditional GIS technology may struggle with real-time data processing, making it difficult to react to rapidly changing tourism conditions (Miller & Goodchild, 2015).

Specific examples of how geospatial technology might help sustainable tourism include regulating tourist flows to avoid congestion in sensitive environments. For instance, GIS has been used in the Galapagos Islands to track visiting patterns and guide visitors away from overexploited regions, thus safeguarding indigenous wildlife (Duncan et al., 2015). Furthermore, GIS can help discover sustainable transportation routes, so lowering carbon footprints and supporting eco-friendly practices (Cohen et al., 2018). Addressing these limits while stressing the benefits of geospatial technology provides a more comprehensive understanding of its role in sustainable tourism.

5. Conclusion

The main conclusions, ramifications, and potential avenues for further research that were discovered during the investigation are summarized in the research conclusion. It summarizes the findings of the study and sheds light on the role that geospatial technologies play in promoting environmentally friendly tourism in the Galle District.

5.1 Summary of Findings

In conclusion, this study has provided important new information about how to promote sustainable tourism in the Galle District, highlighting the critical role that geospatial technologies play in improving visitor experiences, encouraging eco-friendly tourism, and advancing sustainability on all sectors, economic, environmental, and social. This study has shown how technology-driven approaches can effectively promote sustainable tourism objectives by identifying new tourist attractions, and analyzing the data from mobile applications.

5.2 Implications for Sustainable Tourism

The conclusions of the study have significant ramifications for the growth of sustainable tourism in the Galle District and elsewhere. Tourism stakeholders can enhance tourist pleasure, reduce adverse environmental effects, and optimize destination management strategies by utilizing geospatial technologies. Personalized experiences, real-time monitoring, and data-driven decision-making are made possible by the integration of mobile

applications and GIS-based technologies, which promotes a more resilient and sustainable tourist sector.

In addition, the focus on sustainable tourism practices helps to promote responsible tourism practices, empower local people, and preserve natural and cultural resources. Through the implementation of conservation, community participation, and fair economic development as top priorities, the Galle District may bolster its appeal as a sustainable tourism destination, drawing in discriminating visitors and cultivating enduring socio-economic advantages.

5.3 Future Research

Future research in the Galle District should explore the long-term effects of sustainable tourism on ecosystems, local livelihoods, and cultural preservation. Studies on how scalable and adaptable successful models are to other regions would provide valuable insights. Additionally, emerging technologies like blockchain, AI, and virtual reality present opportunities for enhancing tourism experiences while minimizing environmental impact.

Longitudinal studies tracking tourist behavior and market trends can help stakeholders adjust strategies and improve sustainable practices over time. Engaging local communities in tourism planning and adopting advanced technologies will ensure that tourism development in the Galle District remains both sustainable and beneficial to all.

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