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Research Paper

Zone-Based Tourism Planning Using Satellite Imagery

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Abstract

Tourism planning serves as a strategic approach to mitigate and address the damage incurred by tourist attractions, such as the Tangkolak Bahari Center (TMC) mangrove ecosystem, which has experienced a loss of 2 hectares. The primary objective of this research is to formulate a zone-based tourism plan utilizing PlanetScope Dove-R sensor satellite imagery to provide spatial information specific to its application in December 2022. The methodology encompasses various techniques, including observation, structured interviews with tourists, focus group discussions involving tourism managers and local government representatives, digitization, and delineation. The result of research is Zones within the TMC tourist attractions, comprising Main and Supporting Space Plans, Primary and Secondary Circulation Plans, Avicennia, Rhizopora stylosa, and Sonneratia Conservation Vegetation Plans, as well as Plans for Nature, Conservation, Culinary Activities and Facilities, and Green Planning. Notably, the TMC tourist attraction remains viable, covering an area of 2.73 hectares in the West TMC and 1.79 hectares in the East TMC. It is imperative to underscore the importance of considering the sustainability of the mangrove ecosystem in utilizing these areas.

Keywords: Planning; Tourism; Zone; Mangrove Ecosystem; Satellite Imagery.

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1. Introduction

Coastal ecosystem resources, as recognized, encompass mangrove ecosystems, coral reefs, seagrass, and small islands (Asyiawati & Akliyah, 2017). In Indonesia, the mangrove ecosystem spans approximately 3.36 million hectares (Ministry of Environment and Forestry, 2022), equivalent to around 20% of the world's total area (Harini et al., 2019; World Bank, 2023). Mangroves are a variety of tropical coastal communities dominated by several species of typical trees or bushes that can grow in salty waters (Martuti et al., 2019). These ecosystems can endure high salinity (Rahman et al., 2020) and harsh conditions such as frequent high tides and storms (Mafi-Gholami et al., 2019). Additionally, they contribute to carbon absorption (Zhu & Yan, 2022), play a role in element cycles, and address climate change challenges (Liu et al., 2020; Yu et al., 2020). Their significance extends to mitigating the impact of natural disasters like tsunamis and typhoons (Nurdin et al., 2015), preventing erosion and abrasion, serving as a nutritional source for biota, and supplying resources for both human and marine tourism (Prihadi et al., 2018; Tufliha et al., 2019). According to Martuti et al. (2019), Harini et al. (2019), Marlianingrum et al. (2019), Hajializadeh et al. (2020), and Jariego et al. (2023), mangroves function as habitats, shelters for various marine biota, feeding grounds, nursery grounds, and spawning grounds. Consequently, mangroves foster thriving communities of diverse species (Etemadi et al., 2019). Various types of mangrove wood products, such as paper, building materials, charcoal, and construction materials, are essential (Soedarmo, 2018; Jariego et al., 2023). Furthermore, non-wood products, including honey, medicines, tannin, drinks, fish, shrimp, and crabs, are obtained, contributing to valuable packaged products for communities. In summary, the mangrove ecosystem emerges as a potent resource due to its rich processes and multifaceted utility.

Ecologically, coastal ecosystems are intricately linked to human behavior and activities (Utina et al., 2017). Within the realm of human activities, certain practices can exert a negative or detrimental influence, causing harm to mangrove ecosystems, which evident at the Tangkolak Maritime Center (TMC) tourist attraction in Cilamaya Wetan District, Karawang Regency, where a significant portion (2 hectares) of the ecosystem area was lost in 2019. The reduction in mangrove ecosystem area poses severe repercussions for the affected location, including the loss of plant and animal species (Rajan et al., 2013), as well as adverse economic and ecological conditions (Rahmayanti, 2014). This decline has been observed in recent years (Canty et al., 2018; Soanes et al., 2021). Following its inauguration at the end of 2018, the tourist attraction experienced a substantial surge in visits, which directly contributed to the ensuing damage. The considerable influx of tourists, characteristic of tourist attraction development (Poedjiastoeti et al., 2022), can influence the stability of the mangrove ecosystem, with potential harm caused by tourist activities. While an increase in visitor numbers can positively impact the local economy, it may also jeopardize the sustainability of existing resources (Rajan et al., 2013); Ely et al., 2021). Tourist visits, a significant aspect of tourism activities, have the potential to generate plastic waste, particularly microplastics. These particles can accumulate in sediment, disrupting the ecosystem's balance and adversely affecting the biota and food chain associated with it (Anggraini et al., 2020). Continuous natural and social disturbances (Sarastika, 2021) can gradually diminish or even eliminate this restorative capacity (Hanggara et al., 2021). Human utilization of mangrove ecosystems for tourism activities poses a potential threat to the ecosystem. Consequently, there is a need to plan tourism activities based on zones, providing information on existing spaces according to their designated use, which is the aim of this research. The objective is to contribute valuable insights to the local government as a regulatory body, facilitating the realization of sustainability and balance in the utilization of the mangrove ecosystem. This, in turn, will continue to offer economic and environmental benefits to the community surrounding the TMC tourist attraction location.

To safeguard the mangrove ecosystem from potential harm, regional mapping plays a crucial role in equipping local governments with essential knowledge for formulating effective policies within the tourism sector. Broadly defined, planning is an intricate process that involves considering various approaches and aspects to achieve specific goals and address existing challenges (Kasim, 2021). It is characterized as an activity undertaken with foresight, where the outcome is contemplated before choosing among available alternatives (Persada, 2018). Specifically, tourism planning is geared towards ensuring tourist satisfaction, promoting community welfare, and preserving ecological integrity (Hermantoro, 2018). The conceptual framework for tourism planning, as articulated by Zain (2011) regarding the mangrove ecotourism site plan includes inventory, analysis, synthesis and planning.

The remote sensing approach is a valuable method for regional mapping in coastal areas due to its efficiency and speed, especially for large, inaccessible, and costly objects such as mangrove ecosystems (Fawzi, 2016; Fatmawati et al., 2017). The *PlanetScope Dove-R* sensor, part of the *PlanetScope* system, offers a spatial resolution of 3x3 meters, enabling the recording of a total area ±575 km^2. Oktaviani & Johan (2016) classify this spatial resolution as high, and high spatial resolution satellite imagery is known to provide more detailed mapping of mangroves (Samanta et al., 2021). This approach aligns with the perspective of Zain (2011), who asserts that spatial presentation of zoning during the final planning step can be more efficient and accurate through remote sensing data analysis. Consequently, this research will utilize *PlanetScope* satellite imagery with *Dove-R* sensors to plan tourism activities based on zones, aligning with the previously mentioned research aim.

2. Methods

2.1 Study Area

The research is centered on TMC, situated in Sukakerta Village, with coordinates at 107°562'334" East Longitude and -6,182,019 South Latitude. TMC shares its borders with the Java Sea to the north, Blanakan District in Subang Regency to the east, Ciasem District in Subang Regency to the southeast, and Cilamaya Kulon and Banyusari Districts to the west and south (refer to Figure 1). Notably, the Cilamaya Wetan District encompasses an area of 69.66 km^2, constituting 3.97% of Karawang Regency's total area. Muara Village holds the largest area at 14.11 km^2 (20.26% of Cilamaya Wetan District), while Tegalsari Village has the smallest area at 1.98 km^2 (2.84% of Cilamaya Wetan District's total area). Further details about the area of each village can be found in **Table 1** below.

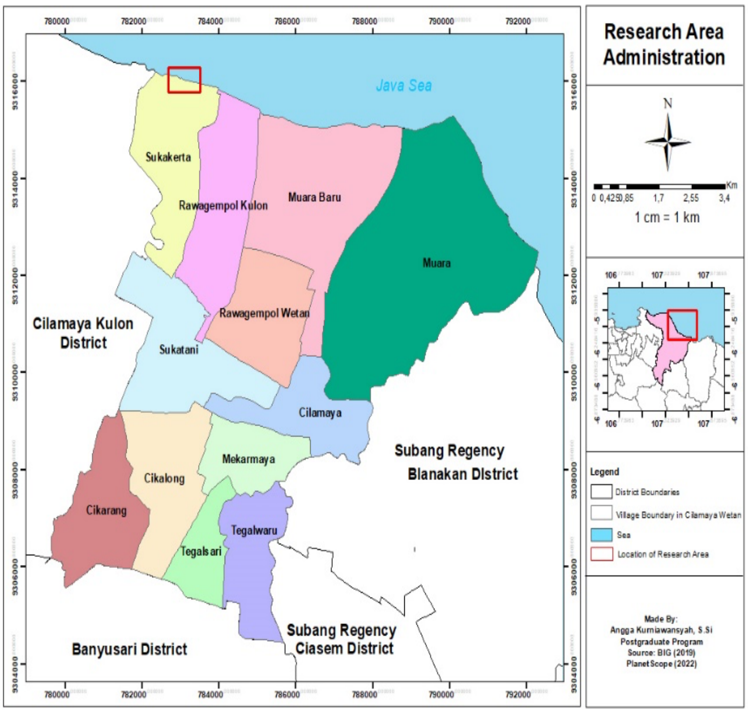

Figure 1. Administration of Cilamaya Wetan District, Karawang Regency
Source: Badan Informasi Geospasial (2019) and Data Processing (2022)

Table 1. Village Area in Cilamaya Wetan District, Karawang Regency

No	Village	Total Area	
		Km²	%
1	Cikarang	3,50	5,02
2	Cikalong	4,11	5,90
3	Cilamaya	3,79	5,44
4	Mekarmaya	3,97	5,70
5	Muara	14,11	20,26
6	Muara Baru	9,43	13,54
7	Rawagempol Kulon	5,64	8,10
8	Rawagempol Wetan	4,82	6,92
9	Sukakerta	6,36	9,13
10	Sukatani	7,91	11,36
11	Tegalsari	1,98	2,84
12	Tegalwaru	4,04	5,80
Total		**69,66**	**100,00**

Based on data from the Karawang Regency Regional Government Work Plan Book (Rencana Kerja Pemerintah Daerah/RKPD, 2016), the coastal area of Cilamaya Wetan District is characterized by a slope of 0-2%. This slope range is considered relatively flat and sloping, encompassing both coastal and water-bordering areas. In accordance with its lowland morphology, Cilamaya Wetan District experiences an air temperature ranging from 26°C to 32°C, with an average of 27°C. Additionally, the district witnesses a yearly rainfall intensity of 1,056 mm, humidity levels of up to 80%, an average air pressure of 0.01 millibars, and a solar radiation time of 66% (Regional Government of Karawang Regency, 2009; Abadi, 2016; Central Statistics Agency, 2021). Furthermore, the wind speed in the Cilamaya Wetan District ranges from 30 to 35 km/hour (Abadi, 2016). These climatic aspects play a crucial role in ensuring the comfort of tourists during their visits (Kurnia, 2016; Wijanarko, 2016; Tuahena et al. 2019; Rukayah, 2020; Lampar, 2021) as in the *Holiday Climate Index* (HCI) (Scott et al., 2016).

2.2 Collection and Processing Data

Tourism planning involves several key steps, as outlined by Zain (2011) in the context of site landscape planning and design. These steps include data inventory, data analysis, data synthesis, and planning (refer to **Figure 2**). The data for tourism planning were gathered through Focus Group Discussions (FGD) with tourism managers and local government, as well as structured interviews conducted with tourists during field surveys. The inventory data comprises both physical and non-physical information related to TMC tourist attractions. Physical data encompasses administrative boundaries, site area, temperature, wind patterns, facilities, scenic views, accessibility, vegetation, and wildlife. Non-physical data, detailed in **Table 2**, includes visitor activities. This physical data takes into account various factors influencing a person's comfort during their activities. These factors, based on the studies by Hakim (2014), Scott et al. (2016), and Tuahena et al. (2019), encompass circulation (movement of vehicles/people between spaces), climate and natural conditions (temperature, wind, and rainfall), noise (distance from the city center/office), cleanliness (availability of garbage facilities), and aesthetics (beauty of the view).

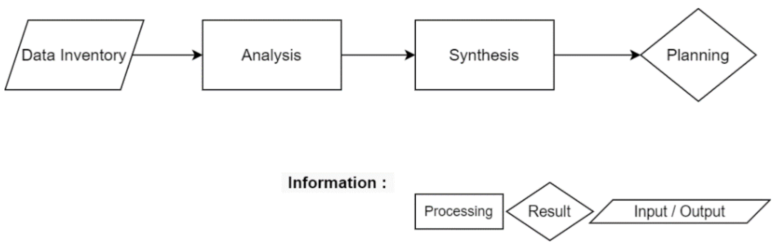

Figure 2. Step of Tourism Planning
Source: Data Summary (2022)

Table 2. Tourism Planning Tabulation

No	Data	Analysis	Synthesis
		Physical	
1	Administration		
2	Site Area		
3	Temperature		
4	Wind		
5	Facility	Potential and Constraints	Options for exploiting potential and controlling constraints
6	*View*		
7	Accessibility		
8	Vegetation		
9	Animals		
		Non-Physical	
1	Visitor Activity	Potential and Constraints	Options for exploiting potential and controlling constraints

Source: Central Statistics Agency (2021)

Afterwards, the data will undergo analysis to assess the potential and identify obstacles at the TMC tourist attraction. Following this, a data synthesis process will be executed, aiming to understand the utilization of potential, address existing obstacles or issues, and formulate zoning strategies. This involves identifying areas that require maintenance and those that need to be replanned within the TMC tourist attraction. The conclusive step involves planning, wherein detailed plans are crafted, utilizing *PlanetScope Dove-R* sensor satellite image data recordings to delineate specific zones.

During the planning phase, digitization was implemented on-site at the TMC tourist attraction, guided by FGD sessions with tourism managers and local government representatives to discuss existing tourist boundaries. The comprehensive plans formulated encompass Space Plans, Circulation Plans, Conservation Vegetation Plans, Activities and Facilities, and Green Planning Plans. The FGD served as a platform for the exchange of thoughts, opinions, and experiences, aiming to establish a shared understanding, consensus, and decision-making (Oktapia, 2019). Following the FGD, a delineation was executed on the previously digitized map based on the outcomes of the discussions. Upon acquiring the designated zones, structured interviews were conducted with tourists to gather data for the Activity and Facility Plan. The final phase in tourism planning involves the symbology process, conducted to enhance the accessibility of information or knowledge by visually representing data intended for display on the map. Subsequently, the tourism planning data undergoes processing in ArcGIS 10.4 software, utilizing insights from the FGD, structured interviews, and synthesis incorporating data from *PlanetScope* sensor *Dove-R* satellite imagery.

3. Results and Discussion

3.1 Social and Physical Condition

According to data from the Central Statistics Agency (2021) Cilamaya Wetan District has a population of approximately 85,426 people, distributed among 28,569 families. Sukakerta Village constitutes about 7.66% of the total district population, with approximately 6,544 people, comprised of 3,325 men (7.88% of the village population) and 3,219 women (7.17% of the village population). The mangrove ecosystem at the TMC tourism site covers an area of 6.5 hectares, as determined through the interpretation of *PlanetScope* sensor Dove-R satellite imagery (refer to **Table 3** and **Figure 3**). According to the research conducted by Kurniawansyah et al. (2023), the mangrove ecosystem's area in Sukakerta Village for TMC tourism in 2019 was 6.0 hectares. Consequently, there has been an increase of 0.4 hectares in the total mangrove area over the last three years. It is noteworthy that TMC West has only one designated area for tourism activities, measuring 0.27 hectares. In contrast, TMC East has two areas allocated for tourism activities, consisting of a main area spanning 0.86 hectares and a supporting area covering 0.02 hectares.

Table 3. The Area of The Sukakerta Village Mangrove Ecosystem

Village	Information		Total Area (Ha)
Sukakerta	Tourism Location	West	3,2
		East	3,3
	Non-Tourism Location		5,6

Source: Dove-R PlanetScope Sensors and Data Processing (2022)

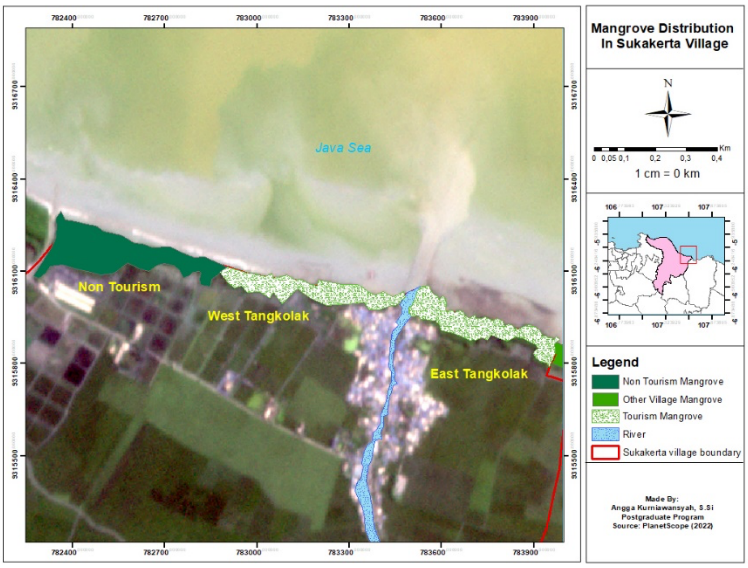

Figure 3. Mangrove Distribution of Sukakerta Village, Cilamaya Wetan District
Source: Dove-R PlanetScope sensor and Data Processing (2022)

For easy access to the primary circulation areas of TMC attractions, whether traversed on two or four wheels, the asphalt roads are quite sufficient. In the western part of TMC, visitors need to pass through local settlements to reach the tourist attractions, while in the eastern part, direct connection to the local road eliminates the need to traverse through surrounding communities. Notably, accessibility to the secondary circulation areas of TMC tourism objects differs between the west and east. In the west, footpaths are the primary means of access, complemented by roads with a casted surface. On the other hand, in the east, footpaths are the main mode of accessibility. Existing facilities at the TMC tourist attraction include food and drink stalls, souvenir shops, gazebos, bridges, wooden shipbuilding, swings, bathrooms, and a maritime gallery. The vegetation across the TMC tourist attraction is categorized into three types: *Avicennia, Rhizopora stylosa*, and *Sonneratia*. In the east, all three types of mangrove vegetation are present, while in the west, only the *Avicennia* species is found. The diversity of biota at TMC tourism sites is extensive, encompassing gobid fish, shrimp, crabs, and cranes. These animals are evenly distributed in both the western and eastern parts, with the exception of cranes, which are exclusively found in East TMC.

In TMC tourism destinations, the western and eastern areas offer distinct perspectives. The Western TMC features captivating offshore views from shipbuilding locations, towering mangrove clusters near bridges, and shipbuilding sites. Additionally, it serves as a gathering spot for cranes in the afternoon. On the other hand, the Eastern TMC presents picturesque offshore scenery and sunsets viewed from bridge structures and gazebo buildings, designed to enhance tourist experiences. It also includes areas for planting diverse types of mangroves and serves as another gathering point for cranes in the afternoon. Tourist activities at TMC tourism destinations are categorized into three aspects: nature, culinary, and conservation. The natural aspect encompasses appreciating the scenery, strolling along roads or tracks, engaging in photography/selfies, and observing wildlife. Culinary activities involve eating and drinking, while the conservation aspect focuses on planting mangrove seedlings. Community activities at TMC tourism destinations involve utilizing mangrove tree trunks for firewood and construction materials, maintaining food and beverage stalls and souvenir shops, planting mangrove seedlings, and providing tour guide services. These community activities are guided by the local perception of the mangrove ecosystem, viewed as a protective barrier against waves, a hub for tourism, and a source of wood and non-timber products for household fuel and various processed foods and beverages.

3.2 Tourism Planning

The data analysis step involves understanding the potential and constraints of TMC tourist attractions. The objective is to enhance ecological functions by maximizing the utilization and development of existing potential while addressing and overcoming disruptive or obstructive constraints. The synthesis step is crucial for effectively harnessing the identified potential within the object and managing any obstacles or issues identified through data inventory (Zain, 2011). The result of this synthesis step is object zoning, which is defined as a form of space utilization by determining boundaries following resource potential in coastal ecosystems, as stated by (Priyanto et al., 2016) regarding Technical Guidelines for Mapping Zoning Plans for Coastal Areas and Small Islands.

The planning step constitutes a multifaceted phase, evolving through various plans derived from the sequential execution of inventory, analysis, and data synthesis activities. These encompass Space Plans, Circulation, Vegetation, Activities and Facilities, and Green Planning. These plans can be effectively presented spatially using computerized techniques, such as drawing with AutoCAD or utilizing remote sensing technologies, where data analysis is conducted with heightened efficiency and accuracy (Zain, 2011). This research leverages presentations based on *PlanetScope Dove-R* sensor satellite image recordings. These plans are denoted as zones, representing areas with natural attractions like plants, animals, or specific ecosystem formations. These areas possess ample space, ensuring the preservation of potential and energy, making them enticing for tourism and natural recreation. Additionally, the surrounding environmental conditions play a crucial role in supporting efforts towards tourism development. During this step, tracking (digitization and delineation) is executed using Avenza Maps software. Subsequently, conversion to ArcGIS software is undertaken to integrate information pertaining to Space Plans, Circulation, Vegetation, Activities and Facilities, and Green Planning. The planning outcomes gradually materialize and are distinctly presented in **Table 6**, **Figure 4**, **Figure 5**, and **Figure 6** below.

Figure 4. FGD with Tourism Managers and Local Government (left) and Interviews with Tourist (right)
Source: Documentation (2022)

Table 6. Tourism Planning

No	Planning	Space	Specification	Symbology
1	Space Plans	Zone	Main	SPm
			Support	SPs
2	Circulation Plans		Primary	CPp
			Secondary	CPs
3	Conservation Vegetation Plans		*Avicennia* Conservation	VPac
			Rhizopora stylosa Conservation	VPsc
			Sonneratia Conservation	VPss
4	Activity and Facility Plans		Nature	AFpn
			Conservation	AFpc
			culinary	AFpu
5	Green Planning Plans		Planting mangrove seedlings	GPP

Source: Processing Data (2022)

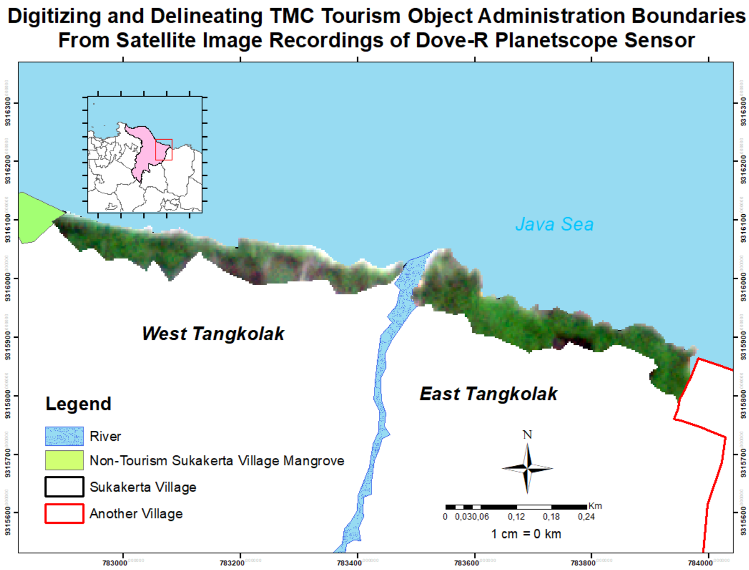

Figure 5. Results of Digitizing and Delineating TMC Tourism Object Boundaries From Satellite Image Recordings of *Dove-R PlanetScope* Sensors
Source: Processing Data (2022)

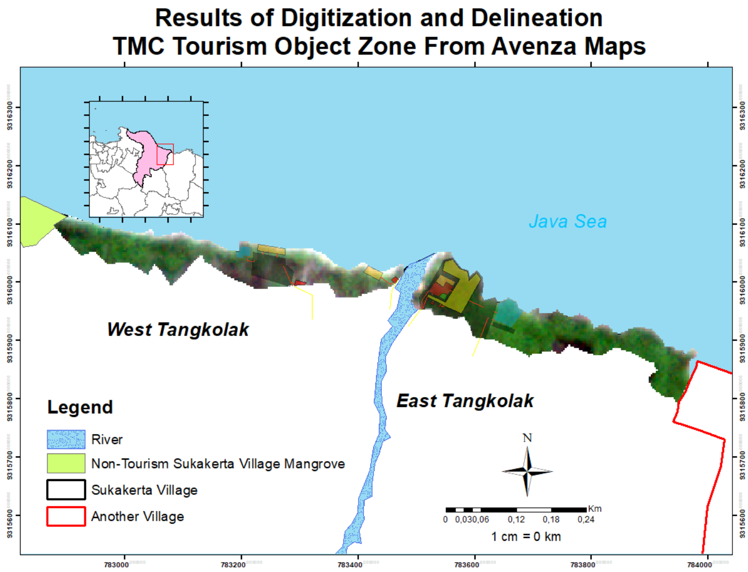

Figure 6. TMC Zone Digitization and Delineation Results From Avenza Maps
Source: Processing Data (2022)

In **Figure 5**, the TMC tourist attraction is clearly visible in the recorded imagery from the *PlanetScope* sensor *Dove-R* satellite, both in the west and east. The satellite imagery recordings are incorporated into the Avenza Maps software, generating plans through tracking processes such as digitization and delineation (refer to **Figure 6**). These plans are the outcomes of discussions with tourism managers and local government through FGD, along with structured interviews conducted with tourists (as illustrated in **Figure 4**). The resulting plans represent specific zones, distinguished by type and color, which are later integrated into the ArcGIS software. **Figure 7** depicts the visual representation of these zones within the TMC tourist attraction, with distinct layouts for both the west (top layout) and the east (bottom layout).

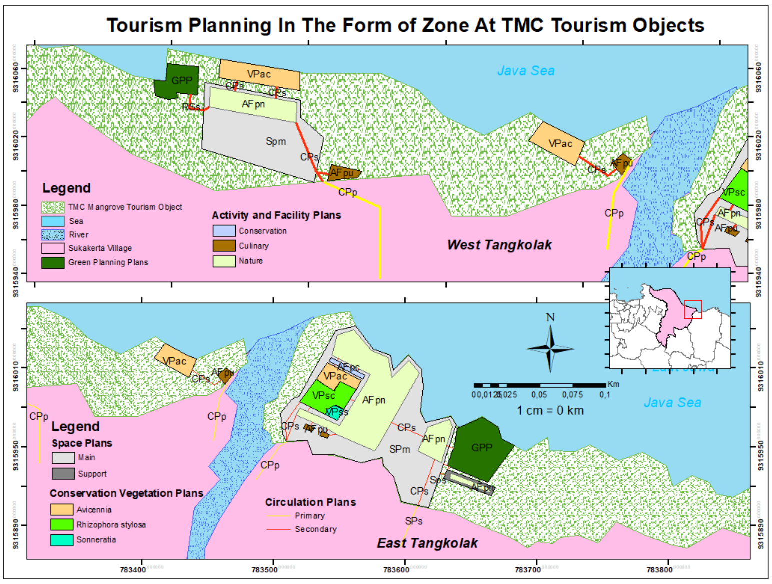

Figure 7. Zone Map on TMC Tourism Objects
Source: Processing Data (2022)

In West TMC, there are distinct Zones, each comprising various components. These include Main Space Plans (SPm), Primary Circulation Plans (CPp), Secondary Circulation Plans (CPs), Avicennia Conservation Vegetation Plans (VPac), Activity Plans, Natural and Culinary Facilities (AFpu), and Green Planning Plans (GPP). In East TMC, the Zone encompasses both Main and Supporting Space Plans (SPm and SPs), Primary and Secondary Circulation Plans (CPp and CPs), as well as Avicennia, Rhizophora stylosa, and Sonneratia conservation Vegetation Plans (VPac, VPsc, and VPss). Additionally, there are Plans for nature, conservation, and culinary Activities and Facilities (AFpn, AFpc, and AFpu), along with Green Planning Plans (GPP). Concerning their distribution, in West TMC, the Space Plans are situated in the western part, while the Circulation Plans are evenly distributed in both the western and eastern regions. The Vegetation Plans mirror the distribution of Circulation Plans, and the Activities and Facilities Plans are predominant in the western section. The Green Planning Plans align with the distribution of Space Plans. Meanwhile, in East TMC, the Space Plans are predominantly located in the western part, with Circulation Plans evenly spread across both western and eastern regions. The distribution of Vegetation Plans and Activities and Facilities Plans mirrors that of the Space Plans. The Green Planning Plans are centrally located in the eastern part.

Figure 8. Dense Mangrove In The Supporting Space Plan (left) and Less Dense Mangrove In The Main Space Plan (right)
Source: Documentation (2022)

There are distinctive zone characteristics between West and East TMC, with East TMC exhibiting greater diversity. This contrast is evident in the Space Plans, where the East TMC is subdivided into a primary area covering 0.86 hectares, constituting 26.06% of the total East TMC area, and a supporting area spanning 0.02 hectares, representing 0.61% of the total East TMC area. In contrast, the primary area of West TMC covers only 0.27 hectares, making up 8.44% of the total West TMC area. Based on the field survey, the Space Plans (SPs) in East TMC are designed to feature denser mangrove trees compared to West TMC SPs, catering to tourists (refer to **Figure 8**). The SPs in both locations are equipped with toilet facilities and gazebos situated on the north and east sides, fostering a conducive environment for tourist interactions. Meanwhile, the tourist-oriented Space Plans (SPm) in both West TMC and East TMC are designed to offer more comprehensive facilities than the Recreational Areas (RRp) in the two locations. For instance, in addition to gazebos, food and drink stalls, souvenirs, and toilets, these SPms also include amenities like swing facilities and a ship-shaped bridge. These additions provide tourists with opportunities to take selfies, appreciate the surrounding scenery, and capture panoramic views (see **Figure 9**).

Figiure 9. Swing Facilities (left), Wooden Bridge (right), Food and Drink Stalls and Souvenirs (bottom)
Source: Documentation (2022)

The SPm area is in proximity to the planting site of mangrove seedlings, making it an appealing destination for tourists. The mangrove seedlings, represented by dark or dense green polygons with the GPP symbology (refer to **Figure 7** for illustration), symbolize Green Planning Plans. This space is routinely utilized for planting mangrove seedlings, primarily through local government initiatives or academic grants (see **Figure 10**). In West TMC, the GPP covers an area of 0.03 hectares, constituting 0.94% of the total area, while the green open space in East TMC spans 0.15 hectares, representing 4.55% of the total area of East TMC. Notably, there is a discrepancy of 0.12 hectares or 1.85% in the TMC tourist attraction GPP area between West TMC and East TMC. This variance arises from the prevalence of programs related to planting mangrove seedlings being more pronounced in East TMC compared to West TMC. Additionally, the disparity in GPP is evident in the geographical positioning of each TMC. West TMC is situated in the northern part, near the shoreline, whereas East TMC is positioned in the west, slightly indented inland. Insights from focus group discussions with tourism managers and local governments reveal that the divergence in location between the western and eastern parts of the TMC is attributed to experimental seed-planting programs conducted in these areas.

This plan shares similarities with the Conservation Vegetation Plan, Activity Plan, and Conservation Facilities. However, a key distinction lies in the fact that the General Public and Tourists are restricted from entering this Green Plantation Project (GPP). This measure is implemented to preserve its aesthetic appeal and minimize the risk of potential damage to mangrove seedlings in the future. The execution of this plan is carried out internally by the local Tourism Awareness Group (TAG), specifically Kreasi Alam Bahari (KAB), in collaboration with the Regional Government. It should be noted that the initiatives outlined in this plan differ from the more widespread programs found in the Conservation Vegetation Plan, Activity Plans, and Conservation Facilities. In the West TMC region, the mangrove seedlings exclusively comprise the Avicennia species. Conversely, the East TMC region features a more diverse planting approach, including Avicennia, Rhizophora stylosa, and Sonneratia mangroves. The selection of mangrove species for planting is informed by the success record of previous plantings in each respective region. Notably, West TMC undergoes periodic Avicennia mangrove species planting, yielding fruitful results. Similarly, East TMC follows a periodic planting regimen, incorporating Avicennia, Rhizophora stylosa, and Sonneratia mangrove species, demonstrating success in seed growth (refer to **Figure 10**).

Figure 10. West TMC Green Planning (left) and East TMC Green Planning (right)
Source: Documentation (2022)

Based on **Table 7**, the Spatial Pattern metric (SPm) in East TMC is broader than that in West TMC, encompassing approximately 0.59 hectares or 26.06% of the total tourism area in East TMC, which amounts to 3.3 hectares. This difference is attributed to the higher frequency of visits to East TMC compared to West TMC. Consequently, the available space to accommodate tourists is more extensive by 0.1 hectares and exhibits greater diversity, encompassing both main and supporting areas. The Critical Point (CPp) of the longest tourism object in TMC is situated in West TMC, specifically in its western section, measuring a length of 131.59 meters. This length exceeds the CPp in East TMC by 59.15 meters. The rationale behind this contrast lies in the necessity for tourists to traverse residential areas to reach the tourist attraction in West TMC. Simultaneously, the longest Critical Points (CPs) are situated in East TMC, boasting a collective length of 161.56 meters, which surpasses the CPs in West TMC by 88.16 meters. This disparity is attributed to the diverse plans implemented in East TMC, enhancing accessibility between different programs.

In the VPac, it is observed that the widest area is situated in West TMC, comprising a total area of 0.09 hectares or 2.81% of the overall West TMC tourism area (3.2 hectares). This is 0.06 hectares wider than the corresponding area in Eastern TMC. The expansion in West TMC is attributed to the exclusive allocation of land in the CVP for the Avicennia mangrove species. In contrast, in East TMC, the VPsc and VPss cover 0.06 hectares and 0.01 hectares, accounting for 1.82% and 0.30% of the total East TMC tourism area, respectively. The *Avicennia* and *Rhizopora stylosa* mangrove species, locally known as *Api-Api* and *Bako-Bako* types, are predominant in the West TMC and East TMC regions, respectively. The planting of seedlings in West TMC is characterized by fires, while in East TMC, it is associated with the Bako-Bako type. The community around the TMC tourist attraction, including TAG and the local government, actively implements this Vegetation Conservation Plan. The variation in the CVP is rooted in the successful track record of previous mangrove seed planting programs, specifically Avicennia mangrove species in West TMC *and Avicennia, Rhizopora stylosa*, and *Sonneratia* mangrove species in East TMC.

Tabel 7. The Area of The Tangkolak Maritime Center Zone (TMC)

No	Zone	Spesification	Total Area	
			West	East
1	Space Plans	Main	0,27 Ha	0,86 Ha
		Support	0,0 Ha	0,02 Ha
2	Circulation Plans	Primary	131,59 m	72,44 m
		Secondary	73,40 m	161,56 m
3	Conservation Vegetation Plans	*Avicennia*	0,09 Ha	0,03 Ha
		Rhizopora stylosa	0,0 Ha	0,06 Ha
		Sonneratia	0,0 Ha	0,01 Ha
4	Activity and Facility Plans	Nature	0,06 Ha	0,37 Ha
		Conservation	0,017 Ha	0,004 Ha
		culinary	0,0 Ha	0,01 Ha
5	Green Planning Plans	Area	0,03 Ha	0,15 Ha

Source: Processing Data (2022)

The plans for Activities and Facilities (AF) at TMC tourism sites are divided into three aspects, namely nature (AFpn), culinary (AFpu), and conservation (AFpc), based on tourist interviews. The nature aspect includes activities like appreciating scenery, walking/tracking, photography/selfie-taking, and observing animals. Culinary activities involve eating and drinking, while the conservation aspect focuses on planting mangrove seedlings. Nature-related activities are consistently popular in both West TMC and East TMC, with 30.30% (10 people) and 69.70% (23 people) of encountered tourists engaging in these activities, respectively. Culinary activities are reported by 6.06% (2 people) at West TMC and 9.09% (3 people) at East TMC, facilitated by food and drink stalls around the TMC tourist attraction (refer to **Figure 9**). The conservation aspect is exclusive to East TMC, where 12.12% (four people) of tourists participate in planting mangrove seedlings through a program initiated by the local regional government, with guidance from TAG and local authorities directing tourists to contribute to managing the mangrove ecosystem. In contrast, all ten tourists encountered at West TMC reported never engaging in, nor receiving instructions to participate in, planting mangrove seedlings during their visits, resulting in no tourists being involved in conservation activities at West TMC.

According to interview data, the age range of tourists varied from 17 to 31 years old, with females comprising the majority (57.58% of total encountered tourists). Additionally, tourist origins were categorized into three regions: Bekasi, Karawang, and Subang. Notably, the Karawang region had the highest proportion of tourists, accounting for 81.82% of the total encountered. This suggests that the TMC tourist attraction has yet to capture the interest of many visitors from outside the Karawang area. Typically, tourists from Bekasi and Subang are families seeking quality time together, while those from Karawang are either individuals or small groups (twos/threes) looking to appreciate the mangrove views due to their proximity to the TMC tourist attraction. Furthermore, the field survey revealed a higher presence of tourists in East TMC (39.39% of total) compared to West TMC, resulting in a total visitation rate of 69.70%. Interviews indicated that this preference for East TMC is attributed to its better facilities, including gazebos, food and drink stalls, souvenir shops, maritime galleries, toilets, and other amenities.

Based on the findings of the field survey and map visualization, it is evident that the zones within TMC tourism sites exhibit distinct characteristics. Notably, there are areas that remain untapped and could be optimized for greater functionality (refer to **Figure 7**). For instance, the central part of West TMC could be designated for Special Purpose (SP) utilization. Upon selecting this location for SPs, subsequent plans such as Circulation Plans, Vegetation Plans, Activities and Facilities Plans, and Green Planning Plans would naturally ensue. Furthermore, in the eastern part of East TMC, there is currently no designated zone that could be earmarked for Vegetation Plans or Activity and Facility Plans. In terms of total area, TMC tourism sites still have 4.52 hectares available for utilization. Specifically, in West TMC, this constitutes 2.73 hectares, representing 85.41% of the total area of West TMC attractions. In East TMC, 1.79 hectares are available, accounting for 54.12% of the total area of East TMC tourist attractions. It is crucial to note, however, that a meticulous and thorough assessment is necessary to gauge the potential impact of these tourism activities on the mangrove ecosystem, both in the short and long term, in order to ensure sustainability.

3.3 Discussion

The findings in this study are consistent with the research conducted by Hasanah (2019) and the book by Kurniasih & Musdinar (2020) that map visualization can provide an overview of site location and site design. The study's exploration of planning underscores an understanding that certain facets of the planning process mirror components of current mangrove ecosystem management. Alternatively, the planning activities are implemented on established tourist sites with existing ecosystem management programs. It is widely recognized that TMC tourism sites already possess management programs, such as the cultivation of mangrove seedlings. The focus of this research is to enhance and augment existing management aspects by furnishing zone information. This endeavour aims to catalyse the development of more robust management practices, considering environmental, economic, and socio-cultural perspectives.

Numerous studies have explored tourism planning through the utilization of remote sensing instruments. One noteworthy study conducted by Nugraha et al. (2015) focused on ecotourism landscapes, employing Landsat 8 OLI satellite imagery to develop key concepts, namely Space Plans, Circulation Plans, and Green Plans. This development refers to Zain (2011) in the form of inventory, analysis, synthesis, planning, and design planning. Remote sensing uses an overlay technique to visualize inventory data in location and space plan size. Ambarita (2017) employed SRTM satellite imagery and Google Earth to assess the research area's condition, delineation, and slope analysis. The development of the planning concept also refers to Zain (2011) in the form of Space Plans (reception, service, support, and ecotourism), Circulation Plans, and Green Planning Plans. Pranatha et al. (2015) in their research using Google Earth regarding the description of the research area, developed the planning concept encompassed Space Plans, Circulation Plans, and Infrastructure and Facilities Plans. Wakyudi (2016) focused on tourism planning for ecotourism landscapes in conservation areas and employing remote sensing for land cover and land use inventory through mapping. The planning concept encompassed Ecotourism Area Plans, Space and Circulation Plans, and Activity and Facilities Plans. Gultom et al. (2019) employed Google Earth for visualizing the Kaliurang tourism area. This resulted in a comprehensive tourism planning concept, including Space Plans, Circulation Plans, Green Planning Plans, Activities and Facilities Plans, and Evacuation Plans. In the current research, tourism planning development will leverage remote sensing, specifically utilizing *PlanetScope* sensor *Dove-R* satellite imagery. This sensor offers updated capabilities in the realm of remote sensing for tourism planning. Remote sensing proves valuable in tourism planning by facilitating the identification of general information, collection of regional data, and regional visualization. The gathered data will serve as a crucial reference for the formulation of effective planning strategies.

This research aims to address various gaps identified in previous studies on planning in mangrove ecosystems. Notably, Nugraha et al. (2015) encountered shortcomings in visualizing all research locations separately and failed to include an inventory of non-physical data, focusing solely on community support within the tourism framework. Similarly, Pranatha et al. (2015) omitted an explicit explanation of the data types involved in the inventory process, both physical and non-physical, connecting them directly to the results of the inventory analysis. This deficiency is echoed by Muchibi (2015) particularly in the context of educational and recreational facilities. Furthermore, Wakyudi (2016) neglected to elucidate the interview data obtained through questionnaires, which were integral to gathering primary data for formulating tourism development zone plans. Additionally, there was a lack of segmentation of respondents in Wakyudi's study. Ambarita (2017) focused narrowly on planning development, specifically in terms of an activity space plan for tourism and a circulation plan. Juhariah (2017) provided only a concise explanation of the physical aspects during the inventory step, potentially resulting in a dearth of information on the research area's potential. Research conducted by Santos et al. (2017) primarily centers on enhancing local economies through livelihoods, neglecting the establishment of zones dedicated to community-driven ecosystem management. Brenner et al. (2018) employed Google Earth satellite imagery and ArcGIS software for environmental planning, yet the cartographic analysis of mangrove area loss lacks detailed explanation, showcasing only visible polygons. Planning by Gultom et al. (2019) lacks clarity regarding its origins, presenting a descriptive approach unsupported by field data or validation through interviews. Rakotomahazo et al. (2019) utilized participatory mapping, but fails to provide detailed numerical data for each of the 10 villages. Wijaya (2020), focuses solely on planning structures as tourist support facilities. Planning by Kasim (2021) is not specific to clearly describe the location and route of disaster evacuation. Planning by Rahayu (2021) only focuses on supporting tourist activity facilities and does not include plans for other spaces. Ramadhan (2021) limits its design focus to buildings within the mangrove zone. Villacrés (2021) states that there is no visualization of landscape planning from the results of satellite imagery workshops by community organizations. Finally, Cheris et al. (2022) introduces semi-private zones in their planning, potentially disrupting mangrove conservation research and the cultivation of snails and shellfish accessible to tourists.

The findings of this research directly support recommendations for several future studies in tourism planning. Brenner et al. (2018) emphasized the need to focus planning on spatial steps. Juhariah (2017) highlighted the importance of fostering collaboration among stakeholders, managers, and local communities in landscape arrangement to promote sustainable tourism. Basyuni et al. (2018) underscored that knowledge about mangrove tourism landscapes will enhance understanding of community-based mangrove management in the future. Additionally, Erlinda et al. (2022) suggested that developing tourism facilities and infrastructure is a key strategy for the sustainable management of mangrove ecosystems.

In the perspective of researchers, the tourism planning framework proposed by Zain (2011) is better suited for implementation in areas of the mangrove ecosystem that already host tourist attractions or have established walking tourism routes, such as TMC (e.g Muchibi, 2015; Nugraha et al., 2015; Pranatha et al., 2015; Idajati et al., 2016; Wakyudi, 2016; Ambarita, 2017; Juhariah, 2017; Wijaya, 2020; Kasim, 2021; Rahayu, 2021; Ramadhan, 2021; Santoso et al. 2021; Cheris et al., 2022). Conversely, this planning concept appears to be less suitable for areas within the mangrove ecosystem lacking tourist attractions, protected zones, or defined boundaries (such e.g., Abdullah et al. 2014; Purnomo et al. 2015; DasGupta & Shaw, 2016; Setiawan, 2016; Umilia & Asbar, 2016; Hutabarat, 2018; Damastuti & de Groot, 2019; Martínez-Espinosa et al. 2020; Miller et al. 2020; Valenzuela et al. 2020; Arumugam et al. 2021; Aulia et al. 2021; Ely et al., 2021; Handayani, 2021; Rakotomahazo et al. 2021; Suyadi et al. 2021; Wahyurini et al. 2021; Gómez-Ruiz et al. 2022: Nyangoko et al. 2022). This is because during the inventory phase, the study involves both physical and non-physical information about mangrove areas for planning purposes, serving as both supporting and primary data. Without existing tourist attractions in the mangrove area, obtaining physical and non-physical information becomes considerably challenging. For instance, physical information related to the area, mangrove density, and biota types is closely linked to administrative boundaries. Lack of knowledge about the administrative boundary of the tourist attraction hampers the collection of physical information, rendering it impossible for analysis, synthesis, and planning. Even if non-physical information can be gathered, its significance is limited when there is no existing tourist attraction, as it remains isolated data without specific meaning.

In addition, the development of this planning concept should take place at a step where more detailed information is accessible regarding the specifications of each scientific discipline. This includes both physical and non-physical data, with a predominant focus on spatial elements, intended for the utilization of remote sensing technology. For spatial data, whether dominantly spatial or not (e.g., categorization with coding), computerized techniques can be employed. This approach aligns with the perspective of Nurhayati et al. (2019), advocating for the use of information technology to optimize marine tourism through effective zoning and infrastructure enhancement. Furthermore, the development of the concept can involve zoning existing plans based on research objects as a form of standardization. For instance, in the case of coastal ecosystems, the research objects encompass Space Plans, Circulation Plans, Vegetation Plans, Activities and Facilities Plans, and Green Planning Plans. Similarly, for forest ecosystems, research objects include Space Plans, Circulation Plans, and Activities and Facilities Plans. However, the specific determinations can be adapted to the conditions of the research object in the field.

For example, if the research object is exposed to disaster risks such as tsunamis, volcanic eruptions, landslides, and others, an Evacuation Plan, as demonstrated in the research by Gultom et al. (2019) and Kasim (2021).

Conclusions

The TMC tourism objects are divided into Zones, comprising the Main Space Plan (SPm), Supporting Space Plans (SPs), Primary Circulation Plans (CPp), Secondary Circulation Plans (CPs), Avicennia (VPac), Rhizophora stylosa (VPsc), and Sonneratia (VPss) Conservation Vegetation Plans, as well as nature (AFpn), conservation (AFpc), culinary (AFpu) Activities and Facilities Plans, and Green Planning Plans (GPP). Each Zone exhibits distinct characteristics, and based on calculations, 2.73 hectares in West TMC and 1.79 hectares in East TMC remain available for utilization, with careful consideration for the sustainability of the mangrove ecosystem. This research identifies the need for future studies on tourism planning in mangrove ecosystems. Specifically, a more comprehensive examination is essential during the data inventory process, encompassing both physical and non-physical aspects, as the data is subjective. Moreover, deeper collaboration is crucial with the community, tourism managers, and local government to ensure the accuracy and depth of information. Additionally, the study underscores the importance of incorporating information on administrative boundaries at tourist attractions to effectively guide zone-based tourism planning.

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