

## SPATIAL MAPPING OF ENVIRONMENTAL SENSITIVE INDEX IN PULAU HUJUNG AND PULAU TENGAH, JOHOR

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### ABSTRACT

This paper addresses the necessity of sea spatial mapping for valuable natural resources of the island ecosystem in Pulau Hujung and Pulau Tengah, Johor. These islands are located in Johor Marine Park, rich with a diversity of marine life, resources, valuable ecosystems, and historical and cultural values. As an environmental asset considered as Environmental Sensitive Areas (ESA), the spatial mapping of its different zonal uses by using the Environmental Sensitive Index (ESI) is crucial in planning and managing natural resources within protected areas. By integrating the data of ESAs into the GIS application via the ESI, the generation of its outcome of digital mapping is easier to understand and applicable in managing the planning of the islands. The indices of ESI comprise of biological and human resources, and shoreline classification. Besides, the research refers to international guidance, namely the IUCN Guideline 2008, where the requirements of ESA protection were clearly stated. The results of the spatial mapping demonstrate that the islands could be categorised as preservation zone, habitat protection zone, general use zone, and buffer zone, in which each of these sea zonal use reflects both its characteristics and importance. The division of clear zones helps the relevant authorities to manage and monitor this special area so that these natural resources, marine life, and ecosystems can be sustained as the natural heritage of the nation. In conclusion, it is evident that the spatial sea zonal use map is very significant and may benefit many stakeholders involved in planning and managing the waters of the eastern part of Johor.

**Keywords:** Environmental Sensitive Index (ESI), Marine Protected Area (MPA), sea zonal use, preservation zone, habitat protection zone.

### INTRODUCTION

The rapidly increasing rate of pollution that occurred to the ocean causing this issue became a serious matter that must be mitigated and control immediately. This is because it can become threats and affect the fisheries sector. Pollution will cause the productivity of the ocean to become lower, and eventually, it also affects economic growth (Jahi, Aiyub, Ariffin and Awang, 2009). Malaysia is one of the countries that have a high contribution to the fisheries sector because its location was surrounded by ocean water bodies, namely the South China Sea and Strait of Malacca. Therefore, as the ocean pollution rate increase, this has become a major concern to the government in combating this issue. Based on Agamuthu, Fauziah, and Khairunnisa (2012), marine pollution is a serious matter to Malaysia because its economy depends on productivity related to coastal resources, such as fisheries. Their research found that debris that contributes to marine pollution is plastic and rubber, which contributes about 50% and 35% respectively. Rapid development in coastal areas like infrastructure works also becomes a concern as it also gives a negative impact on the surrounding ecosystem. Lee (2010) reported that the development improves the national economic' growth, however, due to the lack of information and education, and less awareness on the impact of coastal development on the marine ecosystem somehow have become the challenges in coastal management. Fortunately, a lot of efforts and actions have been taken by both government and non-government sectors in combating this issue.

The Malaysian government has taken several initiatives to preserve and conserve

environmental resources. Presently, the National Policy on Biological Diversity 2016-2025 is the key guidance, in which Target 11 of its 'Strategic Goal C' addresses that by 2020, at least 17% of the terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures. Many islands in Malaysia have been gazetted as Marine Park by the Department of Marine Park Malaysia and many laws and regulations also have been established to protect these marine parks from any possible threats especially from human activities. In August 2012, another nine islands in Peninsular Malaysia were gazetted as Marine Park by the Department of Fisheries (DOF) through Establishment Marine Park Malaysia (EMPM) Amendment Act 2012 which include Pulau Hujung, Pulau Tengah, and Pulau Besar in Johor. Besides, the Structure Plan of Johore (2030) also announced these islands as marine environmentally sensitive areas (ESA) under the strategy of S27.3 (The preservation of marine biological diversity in Sultan Iskandar Marine Park and eastern coastal areas of Johor) (PLANMalaysia, 2018). Since ESA included valuable ecosystem, habitat, wildlife, and areas of natural hazards, the generation of the Environmental Sensitive Index (ESI) map helps to indicate such things to help the public and authorities understand more and aware of the ESA.

### **PROTECTED AREA AND MARINE PROTECTED AREA (MPA)**

Based on the International Union for Conservation of Nature (IUCN) 2008 Guideline, to be eligible as one of the IUCN categories, a few criteria or requirements must meet the IUCN definition of the protected area.

*"A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"*, (Day J., Dudley N., Hockings M., Holmes G, and Laffoley, M., 2012).

Hence, the Marine Protected Area (MPA) refers to protected areas related to the marine environment. Many factors should be revised before considering an area as one of MPA. This is because the gazetting of the island as MPA affects the indigenous peoples, local communities, and communities conserved territories and areas (ICCAs) livelihood. In the local context, National Physical Plan-3 (NPP-3) classifies marine parks as Protected Areas (PA), including islands in the eastern part of Johor (*Jabatan Perancangan Bandar dan Desa Persekutuan*, 2015).

### **ENVIRONMENT SENSITIVE AREAS (ESAs)**

Environmental Sensitive Areas (ESA) refer to the area that is protected from any activities. Based on Chen and O'Yang (2006), ESA is an area that needs special management to protect habitat, wildlife, ecosystem, natural process, important scenery, historical and cultural interest. The fringe features between the land and water-based areas determine the type of coastal landscape. For instance, the coastal areas can be found in the forms of sandy beach, muddy beach or rocky beach. It also requires well-defined planning, policy, and map that restrict any activities. A study by Asmawi, Ibrahim, Abdullah, and Paiman (2016) on a spatial analysis of ESA in Kuala Selangor, Malaysia indicated that the spatial mapping using the GIS technique is essential in generating the distribution of the ESA spatially. In National Physical Plan-2 (NPP-2), ESA refers to areas that are of critical importance in terms of the goods, services, and life-support systems they provide such as water purification, pest control, and erosion regulation (*Jabatan Perancangan Bandar dan Desa Persekutuan*, 2010). In Malaysia, ESA can be categorised into three ranks based on NPP-3 (Table 1). The rank is categorised based on land use management, whether no development, only certain development, or only controlled development is allowed.

**Table 1** Environmental Sensitive Areas (ESAs) Rank Criteria

Environmental Sensitive Areas Rank	Description
ESA Rank 1	No development, agriculture, or logging shall be permitted except for low-impact nature tourism, research, and education.
ESA Rank 2	Physical development or agriculture is not allowed. Sustainable logging and low-impact nature tourism may be permitted subject to local constraints.
ESA Rank 3	Controlled development whereby the type and intensity of the development shall be strictly controlled depending on the nature of the constraints.

\*Source: *Jabatan Perancangan Bandar dan Desa Persekutuan (2015)*

**1) Environment Sensitive Index (ESI) Map**

ESI Map has been established in 1979, where it was used as an integral component of oil-spillage contingency plans and emergency response in the US (noaa.gov; Tri, Don, Ching and Mishra, 2015). With the help of an ESI map, any marine areas that required protection priorities can be identified, and planning management can be done to protect sensitive areas. According to Doan (2016), the ESI map can be shown on the map by symbols, marking, and standardised colour-coding. The classification scheme can be based on the physical, biological, or any other significant characters of the environment. These characters help to create a good ESI map that presentable and easy to understand. Nowadays, ESI maps widely used to create awareness among the public community.

**2) IUCN ESI Map Guideline**

IUCN ESI Map Guidelines were introduced in 2008 to provide details on the usage and application of categories, especially for Marine Parks. Based on the guidelines, IUCN has seven categories (IA, IB, II, III, IV, V, VI) where each zone has their description regarding the area cover by the zone and what activities are allowed or prohibited to commence within the marine park (Day et al., 2012). All IUCN zones categories can be useful and applied to all protected areas, whether its terrestrial or marine.

**Table 2** Definition and Primary Objectives of IUCN Protected Area Categories

IUCN Category	Definition	Primary Objective
IA	Category IA is strictly protected areas set aside to protect biodiversity and possibly geological/ geomorphological features, where human visitation, use, and impacts are strictly controlled and limited to ensure the protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.	To conserve regionally, nationally, or globally outstanding ecosystems, species (occurrences or aggregations), and/ or geodiversity features: these attributes will have been formed mostly or entirely by non-human forces and will be degraded or destroyed when subjected to all but very light human impact.
IB	Category IB protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which is protected and managed to preserve their natural condition.	To protect the long-term ecological integrity of natural areas that are undisturbed by significant human activity, free of modern infrastructure and where natural forces and processes predominate so that current and future generations can experience such areas.

II	<p>Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational, and visitor opportunities.</p>	<p>To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation.</p>
III	<p>Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine caverns, geological features such as a cave, or even a living feature such as an ancient grove. They are generally quite small, protected areas and often have a high visitor value.</p>	<p>To protect specific outstanding natural features and their associated biodiversity and habitats.</p>
IV	<p>Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.</p>	<p>To maintain, conserve, and restore species and habitats.</p>
V	<p>Category V protected areas are where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural, and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.</p>	<p>To protect and sustain important landscapes/seascapes and the associated nature conservation and other values created by interactions with humans through traditional management practices.</p>
VI	<p>Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.</p>	<p>To protect natural ecosystems and use natural resources sustainably, when conservation and sustainable use can be mutually beneficial.</p>

Source: Day et al. (2012)

## METHODOLOGY

### 1) Study site

Pulau Hujung (2°29'29.8"N, 103°57'05.5"E) and Pulau Tengah (2°28'37.6"N, 103°57'36.6"E) is located in a protected area of Johor Marine Park at the east coast of Mersing, Johor, and approximately 130km away from Johor Bahru. The pristine water that surrounds the islands is home to both coral reefs and a variety of marine life. From March to October, many Green Turtle and Hawksbill Turtle landing on the islands to lay their eggs

(marinepark.dof.gov.my). Hence, this beautiful event becomes the attraction of tourists that visited Pulau Hujung and Pulau Tengah. There are two diving sites and one snorkelling area in Pulau Hujung. Whist at Pulau Tengah, it has four diving sites and two snorkelling areas within its waters.

Batu-Batu Resorts, which is situated at the southern end of Pulau Tengah Island, is the only resort that provides facilities for tourists. With the collaboration with PADI Diving & Activities Centre, tourists able to enjoy diving and snorkelling activities around the islands. Tourists also able to appreciate the beautiful view in the jungle trekking on the remote island and take some breathtaking scenery of the archipelago's other islands from several lookout points.

**2) Setup of index**

The setup of the index followed the steps made by the National Oceanic and Atmospheric Administration (NOAA) and Chen and O'Yang (2006), which include biology resources, human resources, and shoreline classification. This dataset contains the present marine resources of that islands in the spatial form.

**1) Biology resources**

The existence of various biota in Pulau Hujung and Pulau Tengah must be protected from any potential threats. The sensitivity of habitats depends on few factors such as 1) the population of species or several individuals in the areas, 2) threatened or endangered species, 3) life stages, 4) migration, and 5) a percentage of animal or plant that exposed to risk such as oil spill. Besides, the presence of biota also helps to determine the sensitivity of areas because different species of animals or plants have a different adaptation to changes. Table 3 shows an example of a biota related to the level of impact and sensitivity.

**Table 3** The proposed degree of impact and sensitivity concerning biological resources

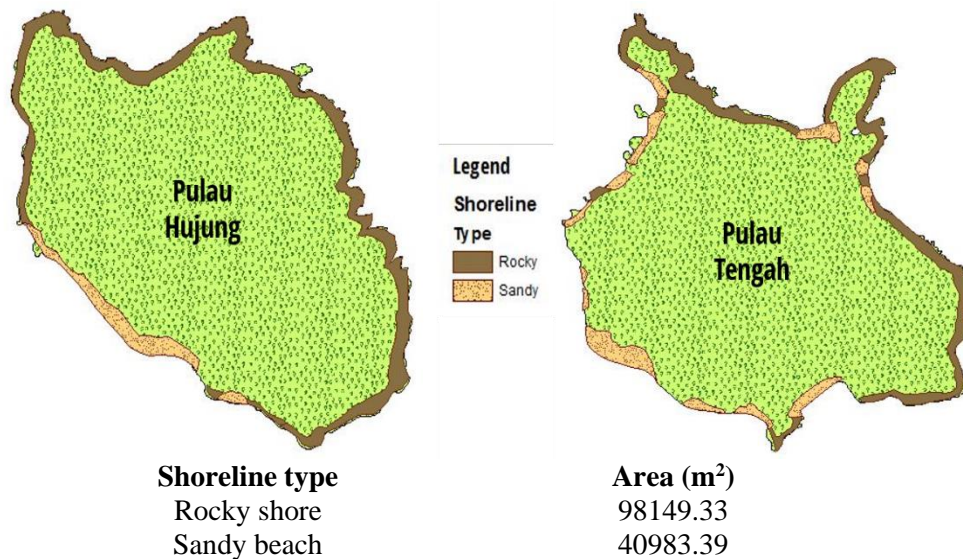
Level of impact	Representative biota	Sensitivity
Little or no long-term effects	Annelids, gastropods, copepods.	Low
Medium effects	Macrophytes, barnacles.	Medium
Long-term effects	Corals, bivalves, decapod.	High

**2) Human resources**

Human activities and interference also include in the sensitivity index as both actions change the environment. There are four categories or known as socio-economic that include in the ESI Ranking. These categories are 1) high-use recreational and shoreline access area (ferries, jetties, recreational beach), 2) protected areas or natural resources (national park and wildlife refuges), 3) resources site (aquaculture) and 4) marine-associated historical and cultural site (ship wreckage). Human activities such as diving, snorkelling, boating, and fishing are also considered as factors in the ESI Ranking because these activities affect the surrounding areas, for example, overpopulated tourists in coral areas would increase the stress on corals growth.

**3) Shoreline classification**

According to Chen and O'Yang (2006), habitats sensitivity on the shoreline is depend on five factors which are 1) shoreline type, 2) exposure to wave, 3) biological productivity, 4) the natural presence of oil on the shoreline and 5) ease of cleanup without posing more damage. Hence, there are 28 of ESI shoreline ranking ranges from Rank 1 to 10, which represent low to high sensitivity.



**Fig. 1** Shoreline type in Pulau Hujung and Pulau Tengah

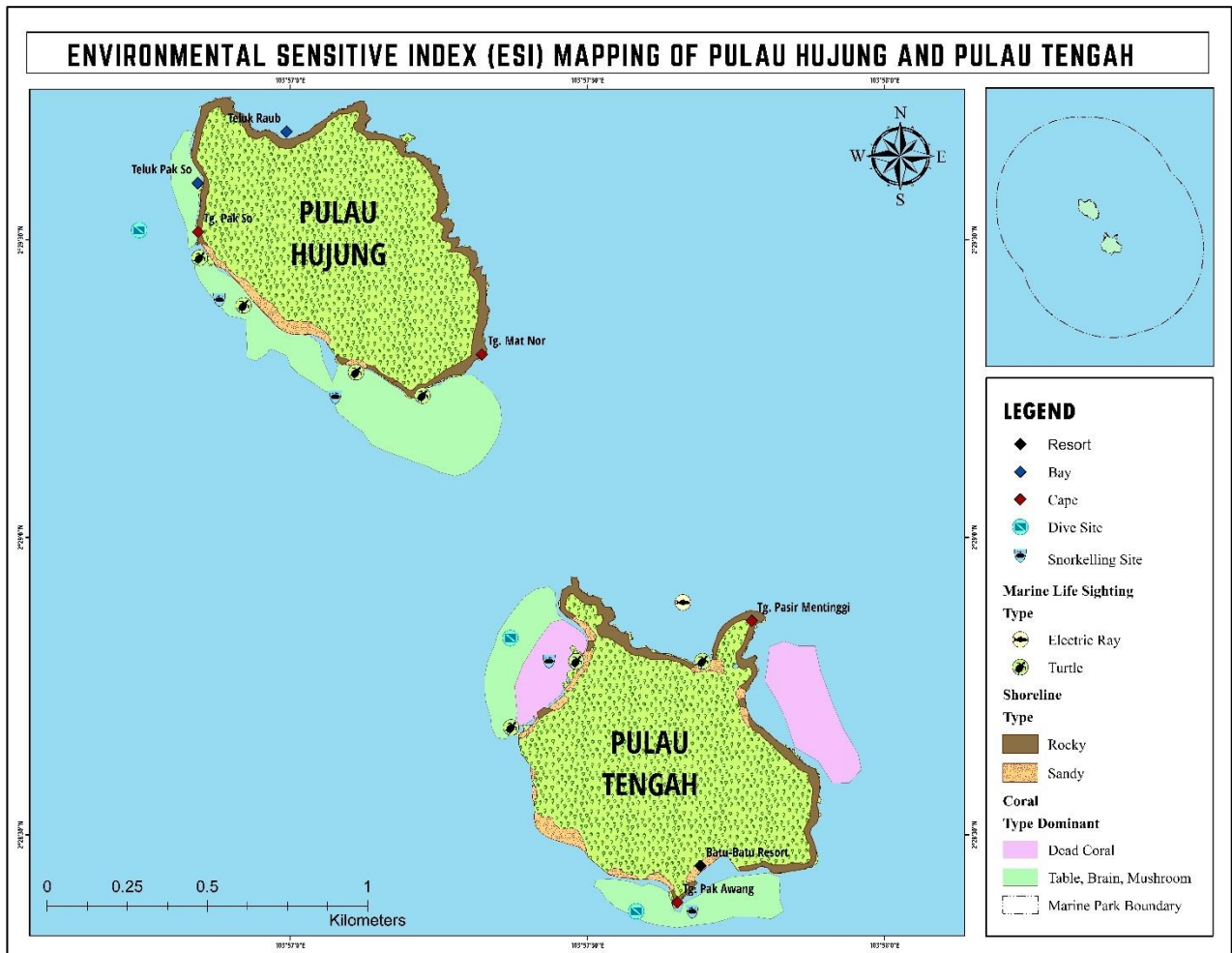
The major shoreline in Pulau Hujung and Pulau Tengah is dominated by the exposed rocky shore and followed by the fine-grained sandy beach. Fringing coral reefs are also considered in the shoreline classification due to susceptible stress from sediment in shallow areas in the intertidal areas.

**Table 4** Shoreline classification based on ESI Ranking in Pulau Hujung and Pulau Tengah

No	Sensitivity ranking	Shoreline type	Sensitivity
1	10	Coral reefs	Highest
2	3A	Fine-to medium-grained sandy beach	
3	1A	Exposed rocky shores	
			Lowest

## RESULTS AND DISCUSSION

Figure 2 represents the ESI Map of Pulau Hujung and Pulau Tengah, where the map follows the IUCN Guideline 2008. Under the definition of MPA of the IUCN Guideline, both Pulau Hujung and Pulau Tengah were included and gazetted as the marine protected areas in Johor Marine Park by the Marine Park Department Malaysia (MPDM) of Department of Fisheries Malaysia (DOF) in August 2012. Both islands are rich with a variety of marine life, valuable marine treasure, and habitats such as coral reefs, turtle landing, and special ecosystems that have aesthetic value. Therefore, the introduction of these islands as protected areas was necessary to ensure the sustainability of these valuable resources. The existence of an abundance of marine resources has become the tourism product that attracts the arrival of tourists in these two islands. Scuba diving and snorkelling are the main eco-tourism activities for the tourists. The spatial mapping indicating the local distribution of natural terrestrial and marine resources are essential for planning and managing these sensitive areas.

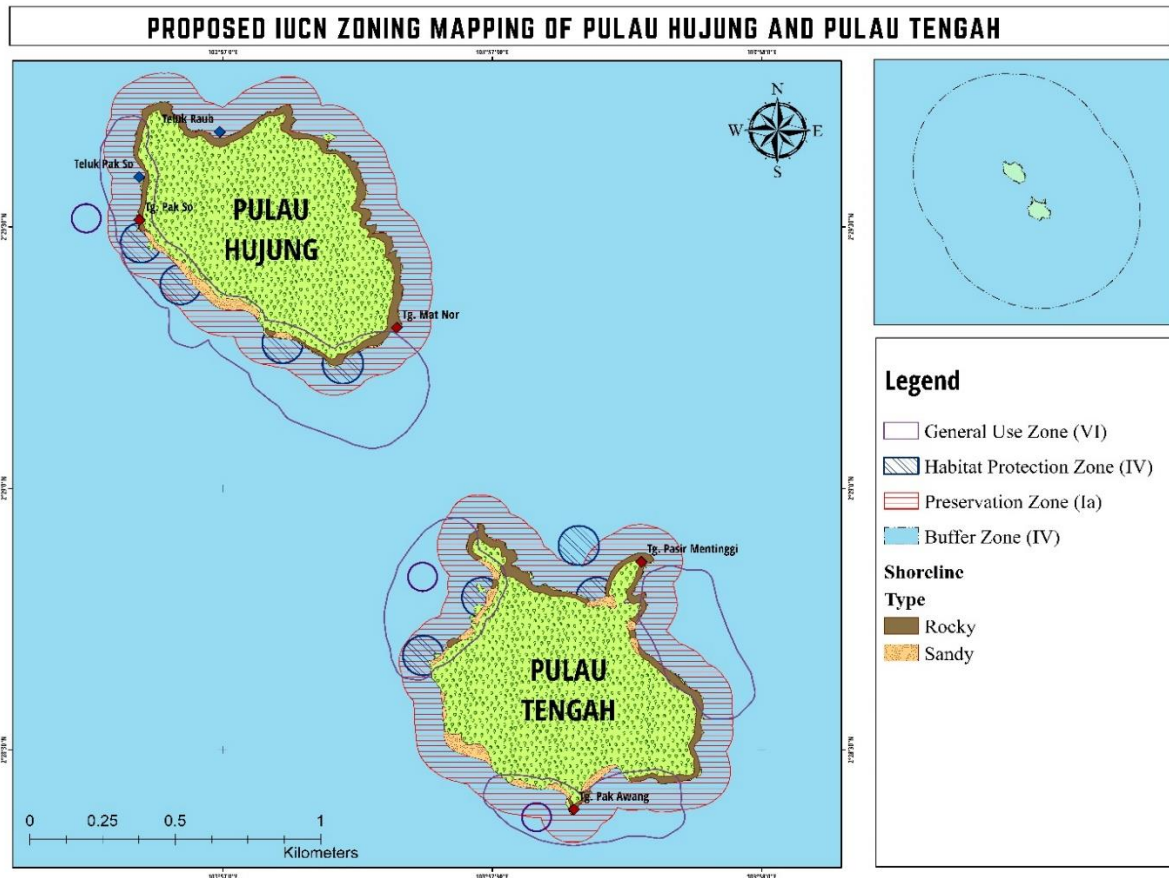


**Fig 2** Environmental Sensitive Index (ESI) Mapping of Pulau Hujung and Pulau Tengah

Meanwhile, Figure 3 shows the results of sea zonal uses for both islands, which followed the ICUN 2008 Guideline. Generally, the areas are divided into four: preservation zone, habitat protection zone, general use zone, and buffer zone.

### 1) Preservation Zone (IA)

In the IUCN Guideline 2008 for zones within the Great Barrier Reef Marine Park, Preservation Zone is considered as Category Ia. In this zone, all the resources such as coral reefs are strictly protected to sustain the biodiversity within the zone. The objective of this zone is to provide and ensure the preservation of natural resources, ecosystems, and values of surrounding areas of Marine Park, which mostly undisturbed by human activities. In this zone, all human activities, visitation, use, extraction, harvesting, fishing, and impacts are strictly limited to guarantee the protection of the areas. However, there is a limited exception for this zone for scientific research purpose with several strict conditions should be complied.



**Fig 3** Proposed IUCN Zoning of Pulau Hujung and Pulau Tengah

## 2) Habitat Protection Zone (IV)

The main purpose of this zone is to provide areas for conservation in Marine Park by protecting and managing the sensitive and vulnerable marine species from potential threats that damaged the habitats. The habitat protection zone is considered as IUCN Category IV. In this zone, several reasonable use or activities are permitted with the condition where it does not disturb the existing ecosystem, habitats, and species. In the IUCN Guideline, Category IV focused on the protection of particular species from human intervention. This includes seasonal species such as turtle for breeding, qualify as Category IV. In the case of Pulau Hujung and Pulau Tengah, the sites for turtle landing seasonally and the sight of the electric ray is worth to protect these areas as habitat protection zone to sustain the population of both species of marine life.

## 3) General Use Zone (VI)

This zone provides conservation of areas in Marine Park while allowing certain activities which do not impose high impacts on the environment. The primary objective of this zone is to sustain and protect natural ecosystems and resources where both conservation and sustainable use can be mutually beneficial. Generally, to promote the sustainability of the social and economic of local communities in this zone, it can be done through traditional management practices such as awareness campaigns.

## 4) Buffer Zone (IV)

A buffer zone is equivalent to IUCN Category IV, which the purpose of this zone is to provide and support the protection of natural resources, ecosystems, habitats, and values of the surrounding area. Generally, no heavy human activities such as construction, extraction, and mining are allowed within this zone. The primary purpose of Zone IV is to conserve and maintain the habitat species within the zone.



## CONCLUSION

The application of the GIS technique on generating marine ESI mapping and IUCN zoning mapping contributes to major efforts in the planning and management of Marine Parks. By integrating all the information into a single key visual, it helps many stakeholders to understand easier, and this provides a great help especially in planning and managing marine areas, apart from education and awareness purpose. The public, visitors, and local communities able to grasp the information in audio through the help of visualisation in the form of a map. The distribution of sea zonal use divides the marine areas according to its characteristics and ability to accept and adapt to the changes from its surroundings. This spatial map is essential in planning and managing to ensure marine sustainability continues in the future. This should be used as a guiding principle for the relevant stakeholders.

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