THE BIOLOGICAL DIVERSITY OF SUNGAI MERBOK IN FULFILL REQUIREMENT OF CRITERIA FOR NATURAL TOURISM

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Abstract. The diversity of biodiversity recorded through academic studies reveals the importance of the Merbok River to the local ecosystem. Academic studies in the Merbok River area have been able to record a total of 39 actual species and 25 associated mangrove species in the Merbok River mangrove forest. Apart from that, this area is also recorded more than 35 species of fish, 9 species of shrimp, 80 species of permanent birds of Merbok mangrove, 30 species of migratory birds, 8 species of mammals and 13 species of amphibians which clearly reflect the biodiversity of the Merbok mangrove forest. If this scientific evidence can be preserved sustainably then it can be developed as a natural tourism product for the biological category in this district in particularly.
Keywords: *biodiversity, Merbok River, mangrove, flora, fauna, tourism*

Introduction

Biodiversity diversity in the Merbok River area North 5°25'-5°39' and East 100°19'-100°32' (Eong et al., 1992) has been proven through exploration and academic studies conducted by Nor et al. (2019), Ong et al. (2015), Suhaila and Che Salmah (2014), Amir (2006), Amir et al. (2006), Ong (2003), Khoo (1989) and Niger (1983) which clearly reveals the biological importance of this area for conservation. This is because the biodiversity in the Merbok River area itself which is within the Jerai Geopark area (*Figure 1*) is also assisted by the presence of eight other river branches (Nor et al., 2019) that irrigate the surrounding area contributing to the diversity of ecosystem flora and fauna involving the districts of Kuala Muda and Yan which covers an area of 816 kilometers square. This area covers the Limau River (north), federal roads F1 and F257 (east), Muda River (south) and the sea border covering Sayak Island, Bidan Island, Telor Island, Songsong Island and Bunting Island (west) (Komoo and Said, 2019).

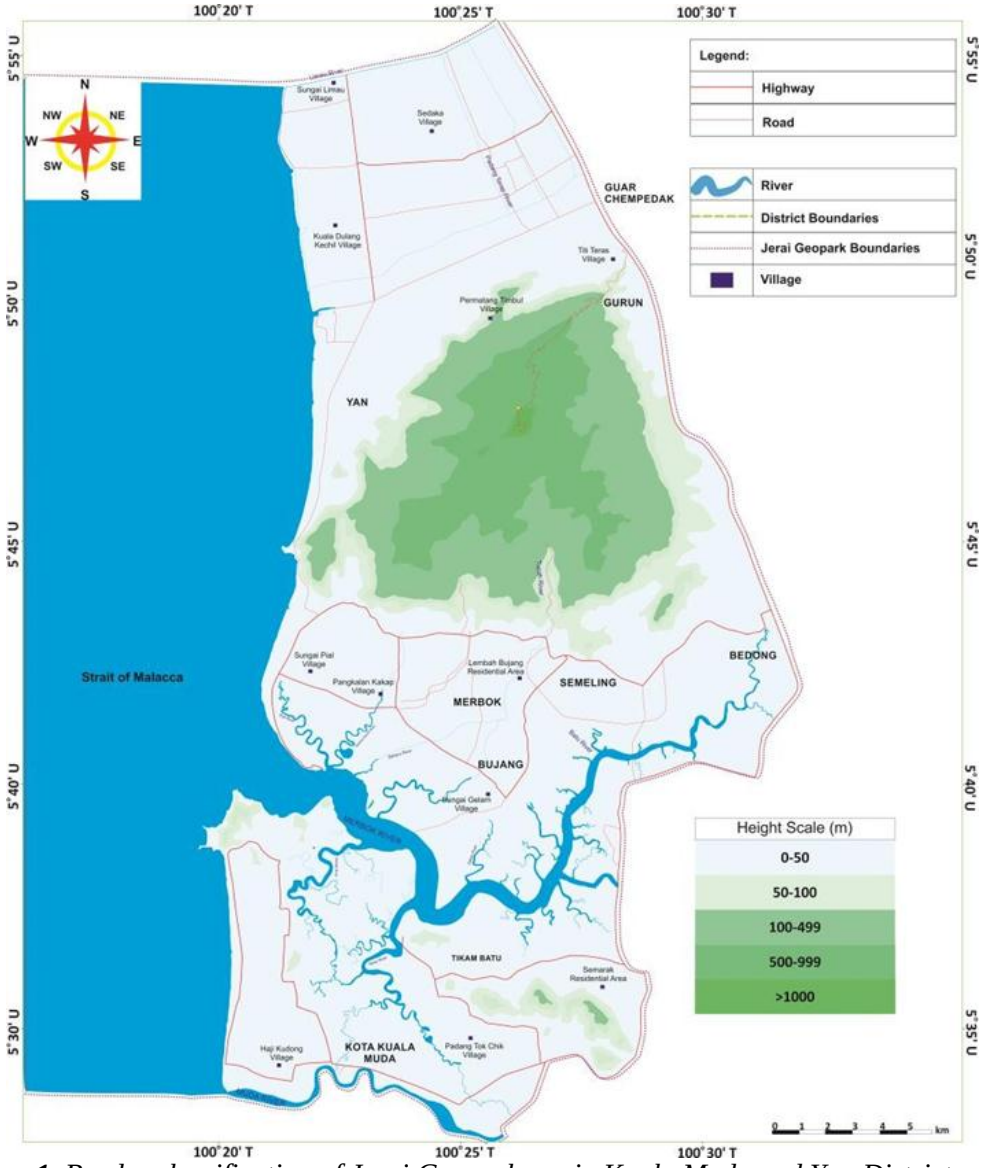

Figure 1. *Border classification of Jerai Geopark are in Kuala Muda and Yan District.*

Discussion

Flora species of Sungai Merbok mangrove forest

The sedimentation process that occurred during the Late Holocene in the Sungai Merbok area and its branches has played an important role in the formation of the natural panorama of this area today. The sedimentation process causes the mouth of the Merbok River to form an estuary. Those formation becoming an estuary means that the mouth of the Merbok River meet the sea and receive sediment and it contains from the ocean to the river (Hobbie, 2000). This will eventually affect the types of flora and fauna that grow around the river because estuary rivers reveal the most productive habitats in the world (Priya et al., 2012). Water flow of the Merbok River is directly influenced by the estuary flow allows the mangrove swamp forest (*Figure 2*) to thrive in its surroundings. This is because the river environment affected by the mixing of land and sea sediments that have a certain salinity rate allows mangrove swamp forests to

grow widely in the Sungai Merbok. Based on Figure 3, it proves that the distribution of mangrove swamp forest has reached more than 10 km away from current coastal line.

Figure 2. *Mangrove swamp ecosystem that thrives around Merbok River.*

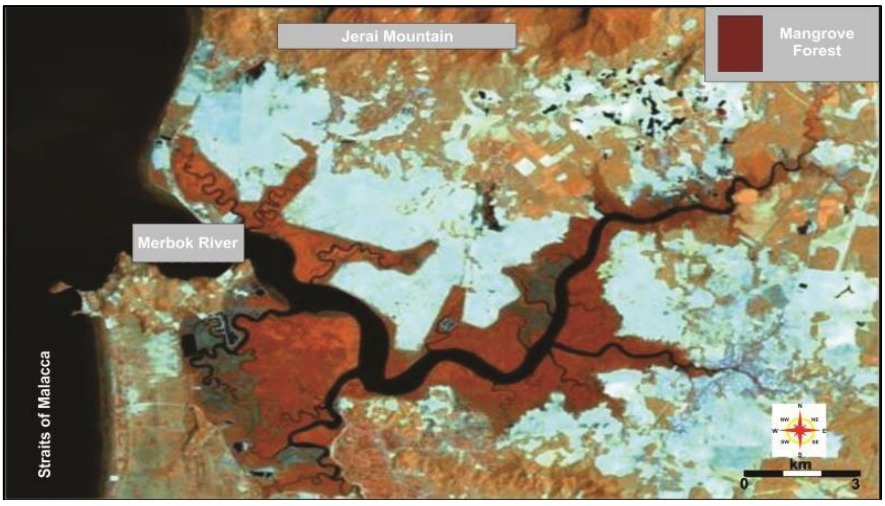

Figure 3. *Merbok mangrove forest along Merbok River, Kuala Muda.*

According to Amir (2006) and Nor et al. (2019) at the beginning of the gazetting of the Merbok River as the Merbok Forest Reserve it covers an area of around 6,016.27 ha of mangrove forest with 1,000 ha of waterways. However, at present, the area of Merbok mangrove forest is only up to 3,075.71 ha of mangrove forest affected only because the purpose of development, agriculture and livestock. Recent research reveals the only Sungai Merbok estuary in the world reveals the highest diversity of mangrove species recorded over 30 actual mangrove species. Spalding et al. (2010) in a scientific expedition also recorded a total of 39 real species and 25 species of mangrove allies have been found to thrive in the Merbok forest (*Table 1*). The record clearly illustrates that the Merbok River area itself has at least 78% of the world's total mangroves (Ong et al., 2015). In fact, this study also recorded for the first time the mangrove species *Sonneratia griffithii* and *Heritiera fomes* in Malaysia that thrive in Merbok River (Ong

et al., 2015). In addition, the existence of Perepat Merah (*S. caseolaris*) and Gedabu (*S. ovate*) species clearly reveals that the Merbok Mangrove Forest is also recorded have two thirds of the *Sonneratia* species population in the world (Nor et al., 2019).

Table 1. *Status of mangrove species in Merbok River, Kedah.*

No.	Spesis	Family	Conservation status	Merbok River
1	*Acanthus ilicifolius* (Jeruju hitam)	Acanthaceae	Less worrying	√
2	*Acanthus ebracteatus* (Jeruju putih)	Acanthaceae	Less worrying	√
3	*Acanthus volubilis* (Jeruju)	Acanthaceae	Less worrying	√
4	*Acrostichum aureum* (Piai raya)	Pteridaceae	Less worrying	√
5	*Acrostichum speciosum* (Piai lasa)	Pteridaceae	Less worrying	√
6	*Aegiceras corniculatum* (Kuku lang)	Myrsinaceae	Less worrying	√
7	*Aegiceras floridum*	Myrsinaceae	Threatened (Malaysia)	No
8	*Aglaia cucullata*	Meliaceae	Incomplete data IUCN GLOBAL	√
9	*Avicennia alba* (Api-api putih)	Acanthaceae	Less worrying	√
10	*Avicennia marina* (Api-api jambu)	Acanthaceae	Less worrying	√
11	*Avicennia officinalis* (Api-api ludat)	Acanthaceae	Less worrying	√
12	*Avicennia rumphiana*	Acanthaceae	Less worrying	No
13	*Brownlowia tersa*	Tiliaceae	Less worrying	√
14	*Brownlowia argentata*	Tiliaceae	Very Threatened IUCN Global Incomplete data	No
15	*Bruguiera ylindrical* (Bakau putih@berus-berus)	Rhizophoraceae	Worrying	√
16	*Bruguiera gymnorhiza* (Tumu merah)	Rhizophoraceae	Less worrying	√
17	*Bruguiera parviflora* (Lenggadai)	Rhizophoraceae	Less worrying	√
18	*Bruguira hainesii*	Rhizophoraceae	Very Threatened IUCN Global	√ (3Trees)
19	*Bruguiera sexangula* (Tumu putih)	Rhizophoraceae	Less worrying	√
20	*Bruguiera hybrids/sp nov (B X rhynchopetala)*	Rhizophoraceae	Threatened (Malaysia)	√
21	*Camptostemon philippinense*	Bombacaceae	Threatened IUCN Global	No
22	*Ceriops decandra*	Rhizophoraceae	Threatened (Malaysia)	No
23	*Ceriops tagal* (Tengar)	Rhizophoraceae	Less worrying	√
24	*Ceriops zippeliana*	Rhizophoraceae	Less worrying	No
25	*Cynometra iripa*	Fabaceae	Less worrying	√
26	*Dolichandrone spathacea*	Bignoniaceae	Less worrying	√
27	*Excoecaria agallocha* (Bebuta)	Euphorbiaceae	Less worrying	√
28	*Heritiera fomes*	Sterculiaceae	Very Threatened (Malaysia)	√ (40 Trees?)
29	*Heritiera globosa*	Sterculiaceae	Threatened IUCN Global	No
30	*Heritiera littoralis* (Dungun daun kecil)	Sterculiaceae	Less worrying	√
31	*Kandelia candel*	Rhizophoraceae	Less worrying	No
32	*Lumnitzera littorea*	Combretaceae	Less worrying	√

	(Teruntum bunga merah)			
33	*Lumnitzera racemosa*	Combretaceae	Less worrying	√
34	*Nypa fruticans*	Arecaceae	Less worrying	√
35	*Osbornia octondota*	Myrtaceae	Threatened (Malaysia)	No
36	*Phoenix paludosa* *(Kurma Laut)*	Arecaceae	Threatened (Malaysia)	√
37	*Pemphis acidula*	Lythracea	Less worrying	No
38	*Rhizophora apiculata* (Bakau Minyak)	Rhizophoraceae	Less worrying	√
39	Rhizophora murconata (Bakau Kurap)	Rhizophoraceae	Less worrying	√
40	Rhizophora stylosa	Rhizophoraceae	Less worrying	√
41	#R X annamalayana	Rhizophoraceae	Threatened (Malaysia)	√
42	#R X lamarckii	Rhizophoraceae	Increasingly Threatened	No
43	Scyphiphora hydrophyllacea (Cengam)	Rubiaceae	Less worrying	√
44	Sonneratia alba (Perepat)	Lythraceae	Less worrying	√
45	Sonneratia caseolaris (Berembang)	Lythraceae	Less worrying	√
46	*Sonneratia griffithii* (Perepat paya)	Lythraceae	Very Threatened IUCN Global	√ (20 Trees?)
47	*Sonneratia ovate* (Pedada)	Lythraceae	Almost Threatened	√
48	*#Sonneratia hybrid/sp nov*	Lythraceae	Threatened (Malaysia)	√ (50 Trees?)
49	*Xylocarpus granatum* (Nyireh bunga)	Meliaceae	Less worrying	√
50	*Xylocarpus moluccensis* (Nyireh batu)	Meliaceae	Less worrying	√
		Total		39 (78%)

Source: Ong et al. (2015).

Based on the study in the Peninsula area only revealed 17% of mangrove swamps while 57% in Sabah and 26% in Sarawak (*Figure 4*). In the state of Kedah until now, only the Merbok area represented by Merbok River after Langkawi mangrove has revealed evidence of mangrove swamp environment which reveals the special features of this area that need to be developed as a biological tourism product. Apart from being developed as a tourism product, there are also has great potential to be developed in the economic and medical sectors. Among the products obtained from mangrove swamps are crops used by fishermen as net preservatives for fishing purposes (Hong and San, 1993). *Avicennia germinans* can be processed into honey (Wafar and Untawale, 2001). In Java, a species of *Ceriops taga sp*. and *Xylocarpus sp*. has been extracted and widely used in the batik dyeing industry (Sukardjo and Akhmad, 1982). There are also mangrove species that are used as intensive timber as is done to the species *Heritiera fomes*, *Heritiera sp*. and *Xylocarpus sp*. (Tomlinsen, 1986) apart from being used as a medicinal material (Dawes, 1981) where almost all mangrove species thrive in the Merbok River area.

Figure 4. *Location of mangrove swamps in Malaysia.*
Source: Hamdan et al. (2012)

Fauna species of Sungai Merbok mangrove forest

According to Ong et al. (1991) Merbok River which is about 3-5 meters deep with a width of almost 35 meters has revealed the diversity of life around the river. The diversity of life in this area is closely related to the surrounding conditions which have mangrove swamp forests that can provide food resources, shelter and breeding (Nor et al., 2019) for living in the area. The results of the study (Amir, 2006) revealed that there are at least eight species of mammals, including Lutong Cengkung/Lutong Bercelak (*Trachypithecus*) and Lutong Kelabu (*Trachypithecus cristatus*), monkey (*Macaca fascicularis*), squirrel (*Callosciurus notatus*), otters (*Lutra perpicillata*), mangrove snake (*Trimeresurus purpureomaculatus*), vipers snake (*Calloselasma rhodostoma*), various species of lizards, crocodiles, monitor lizards (*Genus Varanus and Varanus salvator*) and rats (*Leopoldamys sabanus*) (*Figure 5*) recorded this area. Most of these species are endangered and require effort for their reproduction and conservation.

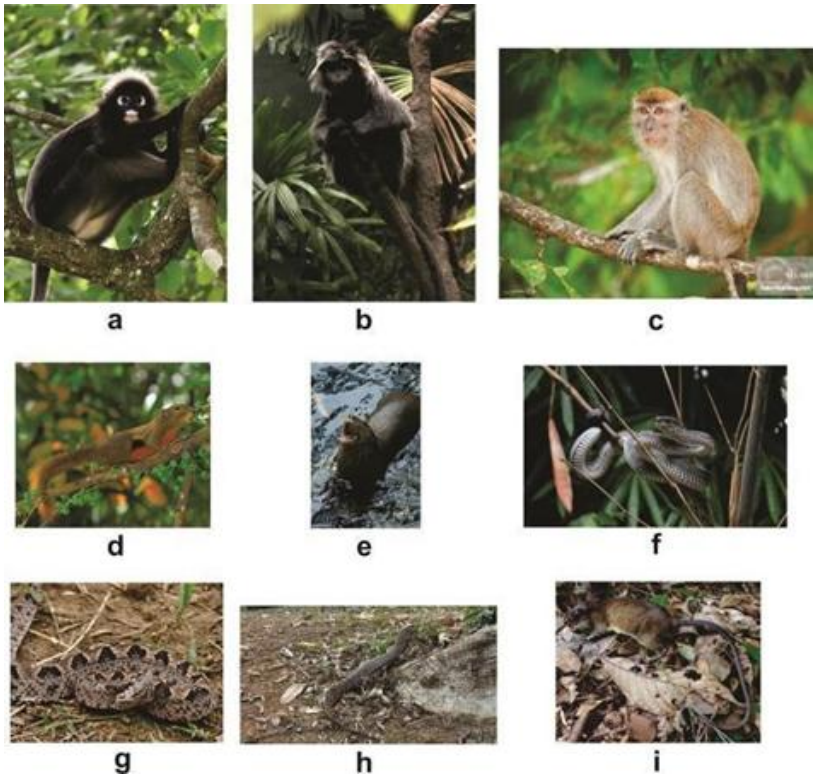

Figure 5. *Diversity of fauna species recorded through academic studies conducted in Merbok River such as (a) Lutong Bercelak, (b) Lutong Kelabu, (c) monkey, (d) squirrel, (e) otters, (f) mangrove snakes, (g) vipers snakes, (h) Asia monitor lizards and (i) long-tailed giant rat.*

Gregory-Smith (1994), Nor et al. (2019) and Darmaraj (2006) through a recent study have recorded several other species found around the Merbok River. Among the species recorded are 13 species of amphibians, 80 species of permanent resident birds such as *Nectarinia calcostetha*, *Zosterops palpebrosa*, *Spilornis cheela*, *Pachycephala cinerea* and *Picus miniaceus*, 30 species of migratory birds such as *Cyornis rubeculoides*, *Muscicapa daurica*, *Muscicapa raurugine cristatus, Dendronathus indicus, Ceyx erithacus, Hypsipetes criniger, Actenoides concretus, Chalcophaps indica, Lusciana cyane and Rhinomyias umbratilis and bats (Cynopterus brachyotis and Kerivoula intermedia).*

Other species also recorded in this area are beetles, fireflies, butterflies, grasshoppers, mudskippers, frogs (*Phryoidis asper*, *Microhyla butleri*, *Hylana nigrovittata*, *Microhyla heymonsi*, *Limnonectes blythii*, *Odorrana monjerai*, *Odorrana hosii*, *Duttaphrynus mel Pulchrana picturata*), tokay gecko (*Cnemaspis tiger*, *Cyrtodactylus macrotuberculatus*), python (*Malayopython reticulatus*) (Darmaraj, 2006), over 35 species of fish (*Table 2*) (Mohsin and Ambak, 1983) and 9 species of shrimp from three families namely *Penaeidae, Palaemonidae* and *Alpheidae* (Azizan, 2012 and Doroh, 2016). The matter shows the suitability of this estuary type habitat in the process of reproduction of several types of fauna that are among them in the endangered category.

Table 2. *Freshwater fish species recorded in the Merbok River and its tributaries.*

No	Family	Scientific name
1	Amblyciptidae	Amblyceps foratum

2	Aplochellldae	Aplocheillus panchax
3	Bagridae	Hemibagrus nemurus Leiocassis micropogin Mystur micracanthus
4	Balltoridae	Acanthocobitis zonalternans
5	Channidae	Channa striata Channa gachua
6	Clariidae	Clarias Leiacanthus Clarias batrachus Clarias macrocephalus
7	Cyprinidae	Carassius auratus Cylocheillchthys apogon Danio albolineatus Devario regina Hampala macrolepidota Neolissochilus hendersoni Osteochilus deauratus Rasbora paviel Rasbora trillneata Systomus binotatus Systomus Lateristriga Systomus partipentazona
8	Goblidae	Glossogobius giuris
9	Hemiramphidae	Dermogenys coriattei
10	Mastacembelidae	Macrognathus maculatus Mastacembelus cf. armatus Mastacembelus erythrotaenia Mastecembelus favus
11	Osphronemidae	Betta pugnax Betta belica Trichopsis vittata
12	Poecillldae	Poecilia reticulata
13	Suluridae	Ompok bimaculatus Silurichthys hasselti
14	Synbranchidae	Monopterus albus

Source: Mohsin and Ambak (1983)

Therefore, the results of continuous academic studies clearly show the potential of the Merbok River mangrove swamp environment to be developed as a biologically based tourism product in this district. The diversity of its ecosystems that have diverse flora and fauna, especially those in the endangered category, is very suitable to be used as a knowledgeable tourism product for the gaze and knowledge of the current generation.

Merbok River biological ecosystem as a Natural Tourism product

The diversity of flora and fauna ecosystems around Merbok River has been utilized by the authorities to make it an iconic tourism product of Kuala Muda district. Ongoing study by Mokhtar and Ibrahim as discussed in Komoo and Said (2019) allows the biological tourism product of Merbok River to be one of the geotrail tourism in Kuala Muda district. Through the study, the surrounding of Merbok River can be recognized Geotrail 2 as a tourism package named Sungai Merbok Estuary and Island (*Figure 6*).

To maximize the experience of tourists who take this tourism package, an informative information panel (*Figure 7*) is also available and set up in the tourist area.

Figure 6. *The diversity of the Merbok River ecosystem known as a biological tourism product as Geotrail 2, "Merbok River Estuary and Island" in Jerai Geopark which allows the conservation process and academic study to be carried out simultaneously and continuously in the area*

Figure 7. *Informative info panel provided and installed in the tourist area to maximize the knowledge of tourists.*

Re-mapping of tourism products in the district allows improvements to existing tourism packages. The result of these improvements allows the Geotrail 2 package of "Merbok River Estuary and Island" to be rebranded into new package 6 named as "Merbok River Mangrove". This package will generally start at Kuala Muda Tourism

Interpretation Center (PIPKM) which serves as a "One stop centre" for all tourism activities in this district. Through this tour package, tourists will enjoy the beauty of the natural panorama around Merbok River by using a taxi or water vehicle after a visit at PIPKM. After that, the tourists will be taken to several important locations of mangrove swamps around Merbok River and given a complete description related to the mangrove species.

Apart from that, tourists are also taken to visit the historical sites of the former palace of Pulau Tiga, Pulau Tiga British Fortress, Lubok Pusing, oyster breeding center, Merdeka Beach, Tanjung Dawai town and also to Sayak Island (*Table 3*) to further complete the tour offer in the package this tour. *Figure 8* is the water route that is proposed to be traversed by tourists while taking the Merbok River mangrove tourism package.

Table 3. *Tourist area offer provided in new tourism package 6 "Sungai Merbok Mangrove".*

No	Product
1	ONE STOP CENTRE - PIPKM -Views of various species of mangrove forests -Views of Sungai Merbok -Views of Gunung Jerai -PIPKM Gallery -Batik Merbok
2	BEAUTIFUL VIEW OF MERBOK MANGROVE -Diversity of mangrove and fauna species -Various scenery of human activities on the river -Visit 9 endangered and highly endangered mangrove species
3	PULAU TIGA PALACES FORMER - Looking at the remnants of the palace built as a sign of the government's efforts in the face of attacks from the Siamese which began to be built since 1820 and completed in 1821 during the reign of Sultan Ahmad Tajuddin Halim Shah II
4	MANGROVE CHARCOAL PRODUCTION CENTER - See the remains of charcoal furnace built since 1885 in addition to being able to see and learn how the process of mangrove charcoal production is done
5	LUBOK PUSING PALACES FORMER - See the remnants of the palace grounds erected for the purpose of royal marriage between D.Y.M.M. Tuanku Sultan Abdul Hamid Halim Shah with Y.M. Sharifah Seha binti Syed Hussein Shahabuddin
6	MERBOK RIVER OYSTER BREEDING CENTER -See how the oyster breeding process is carried out. -Enjoy the taste of oysters directly at the Oyster Breeding Center.
7	MERDEKA BEACH -See the beauty of the natural panorama at the Sungai Merbok estuary. -View the archaeological evidence of the Bukit Penjara site. -View the architecture of the British fort. -See geological evidence of red mud rock
8	NATURAL PANORAMA OF TOWN TANJUNG DAWAI -Beautiful view of the mouth of the Sungai Merbok into the Straits of Melaka.
9	SAYAK ISLAND -See the view of the island formed as a result of the sea erosion

process.
-Appreciate the white sandy beach environment with very clear water formed by the Mahang Formation which is about 450 million years ago.

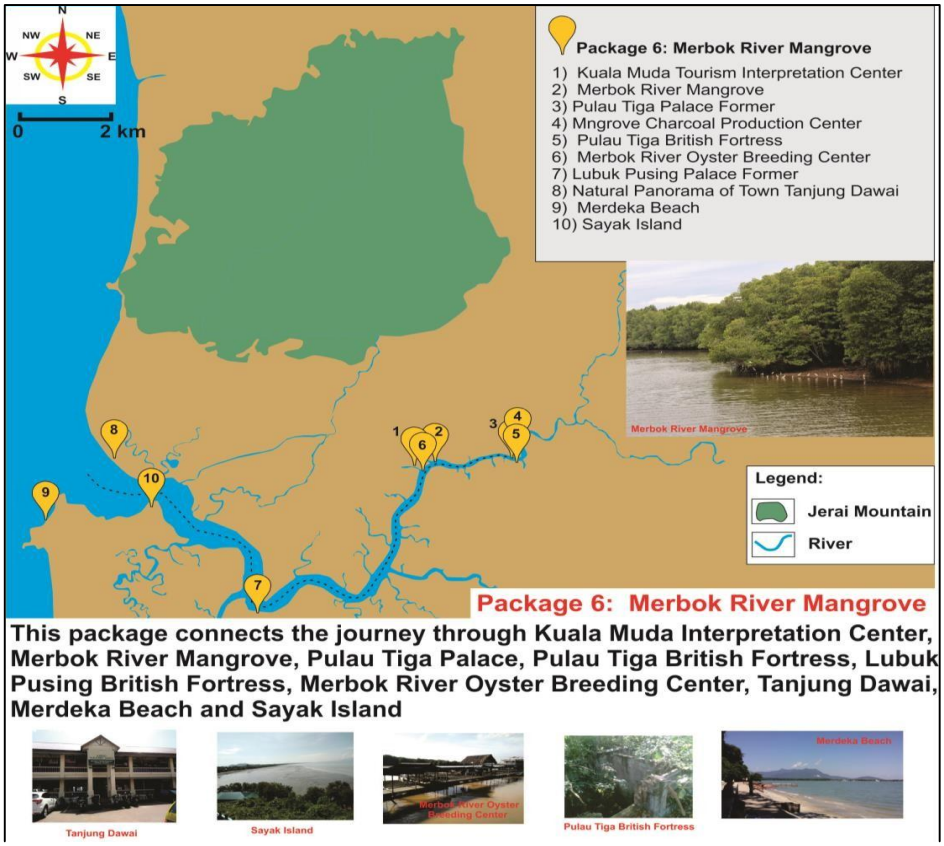

Figure 8. *The route for new tourism package 6 of Merbok River mangrove created to connect all tourist site location provided in the tourism package.*

Conclusion

The beauty of the natural panorama and the biodiversity around the Merbok River which consists of mangrove species, flora and fauna have great potential to be developed as biological tourism products in this district. Based on this privilege, the Sungai Merbok area can be recognized as a tourism product in package 2 "Merbok River Estuary and Islands" before rebranding to package 6 "Merbok River Mangrove". Understanding the need for the concept of conservation, ongoing research is actively carried out so that this biological tourism site can be nominated jointly with the geology of Gunung Jerai and the geoarchaeology of Sungai Batu as a UNESCO World Heritage Site under the concept of Jerai Geopark.

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Conflict of interest

The authors confirm that there are no conflict of interest involve with any parties in this research.

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