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ORIGINAL ARTICLE

An Integrated Geoproduct Development for Geotourism in Langkawi UNESCO Global Geopark: a Case Study of the Kubang Badak Biogeotrail

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Abstract
A geopark should develop continuous efforts towards the management and development of geoproducts based on integrated heritage resources in order to preserve them for future generations, provide geotourism activities and serve as a socio-economic catalyst for the local community. This paper describes the development of a geoproduct for tourism development in a marginalised area of the Langkawi UNESCO Global Geopark. The project described in this paper builds on the recognized need to develop community-based geoproducts in collaboration and consultation with multiple stakeholders. Using a developmental case study, this paper addresses the planning and development activities related to a bio-geo trail, including an important aspect of theming in the conceptualizing and development of sites, content, pit stops, interpretation and capacity-building activities. A new integrated heritage model for theme and interpretation formulation of a trail is proposed. The paper concludes with brief illustrations of the complexities involved with geoproduct development and suggests some ways forward. This paper contributes to geopark development literature by adding an Asian case, and by developing an integrated heritage model for a geoproduct. The case study's model, features, processes and lessons learnt can also be adapted to similar geopark locations, cultural contexts and communities.

Keywords Geopark · Geotourism · Geoproduct · Trail development · Developmental research · Malaysia

Introduction

The UNESCO Global Geopark (UGGp) is the latest global initiative celebrating geological heritage and geotourism in the context of regional sustainable development. A geopark is a single unified designated area that contains unique and significant geological heritage within a clearly defined territory, where the local communities empower themselves to develop the earth's heritage sustainably while improving their socio-economic status in social harmony. As one of the pioneers in the development and expansion of geotourism, geoparks promote understanding

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of earth sciences through appreciation and learning (Wang & Zouros, UNESCO 2020). This can be achieved through independent visits to geosites, geological trails (geotrails) and viewpoints, guided tours, geo-activities and geosite visitor centres.

The ability of a geopark to develop and provide products or geoproducts that can satisfy the needs and desires of tourists is key to success in developing geotourism and sustainable development. The development of geoparks driven by innovative geotourism products and enterprises encourages sustainable regional development and investment, creates new businesses and jobs, generates financial benefits to regional communities and provides stewardship through public education on the area's geological and natural heritage, the history and the local people (Komoo et al. 2018; Dowling and Newsome 2018).

This paper describes the development of a geoproduct for tourism development in a marginalised area of a geopark, a project under the aegis of the Langkawi UNESCO Global Geopark (Langkawi UGGp) activities. Geoproducts are defined as geological attractions, such as natural heritage sites (e.g. geosites/biosites), geotrails, and human-constructed products related to the cultural patterns and architecture of the geotourism destinations, such as services, souvenirs, food products, and arts (Compľová 2010).

Study Area and Rationale for Geoproduct Development

Langkawi UGGp is the first UNESCO global geopark in Malaysia and South East Asia. It is an archipelago comprising a cluster of 104 tropical islands in the Andaman Sea located off the northern section of the west coast of Peninsular Malaysia, bordering Thailand (Fig. 1). Situated 7° north of the equator, with a tropical climate and average yearly temperatures of 26–28°, the archipelago covers an area of approximately 478 km^2, with a total population of approximately 100,000. Its islands range in size from 0.01 to 328 km^2 and, for the most part, are covered by primary forest.

The Langkawi UGGp has a high geodiversity due to very long geological processes that have been taking place since the Cambrian time (550 ma) until the present. These processes have produced several rock formations in which various geological and geomorphological features making up components of geodiversity can be found. The rock formations are represented by the alternations of clastic and carbonate rocks; from the oldest to the youngest namely Machinchang Formation, Setul Formation, Singa Formation and Chuping Formation (Jones 1981; Tjia 1989; Hassan et al. 2013). The areas of geological diversity, protected geosites, geological monuments and permanent forest reserves

Fig. 1 Map of Langkawi UGGp

are found within three main geosites: Machinchang Cambrian Geoforest Park (43 km^2), Kilim Karst Geoforest (83 km^2) and Dayang Bunting Marble Geoforest Park (44 km^2) (Fig. 2). More than 30 geosites have been identified in the Langkawi archipelago to be developed as geotourism products (Leman et al. 2007).

Since the establishment of Langkawi UGGp in 2007, a new orientation in tourism has been favoured and promoted through the introduction of three main geoproducts in the three geoforest parks: Kilim Karst Geotrail, Dayang Bunting Geotrail and Machinchang Cable Car Geotrail. These three products in the form of trails or routes have successfully introduced geotourism in Langkawi UGGp as a new economic growth point that has improved geoheritage conservation, increased local revenue and employment as well as enhanced public awareness (Komoo et al. 2018). Nevertheless, in retrospect, while the novel initiative to develop an integrated approach to geotourism in Langkawi UGGp has been gradually accepted, and the development of geotourism products, particularly in Kilim, Machinchang and Dayang Bunting has proven successful, a few issues with the geotourism activities remain unresolved.

Firstly, community-based tourism development in Langkawi UGGp has concentrated on a small number of key destinations, leaving limited opportunities for the more marginalised areas/ community to benefit from the geopark. New geoproducts can help to spread tourist destinations elsewhere, i.e. to reduce pressure of high-volume tourist arrivals, especially at Kilim where key attractions and facilities have been fully developed for geotourism. This will help in dispersing income from the already booming tourism activities at Kilim to new areas/geoproducts by providing new opportunities for local entrepreneurs and creating additional employment for the marginalised communities elsewhere. Thus, more geoproducts and services need to be developed for equity purposes, i.e. to distribute benefits to a wider local

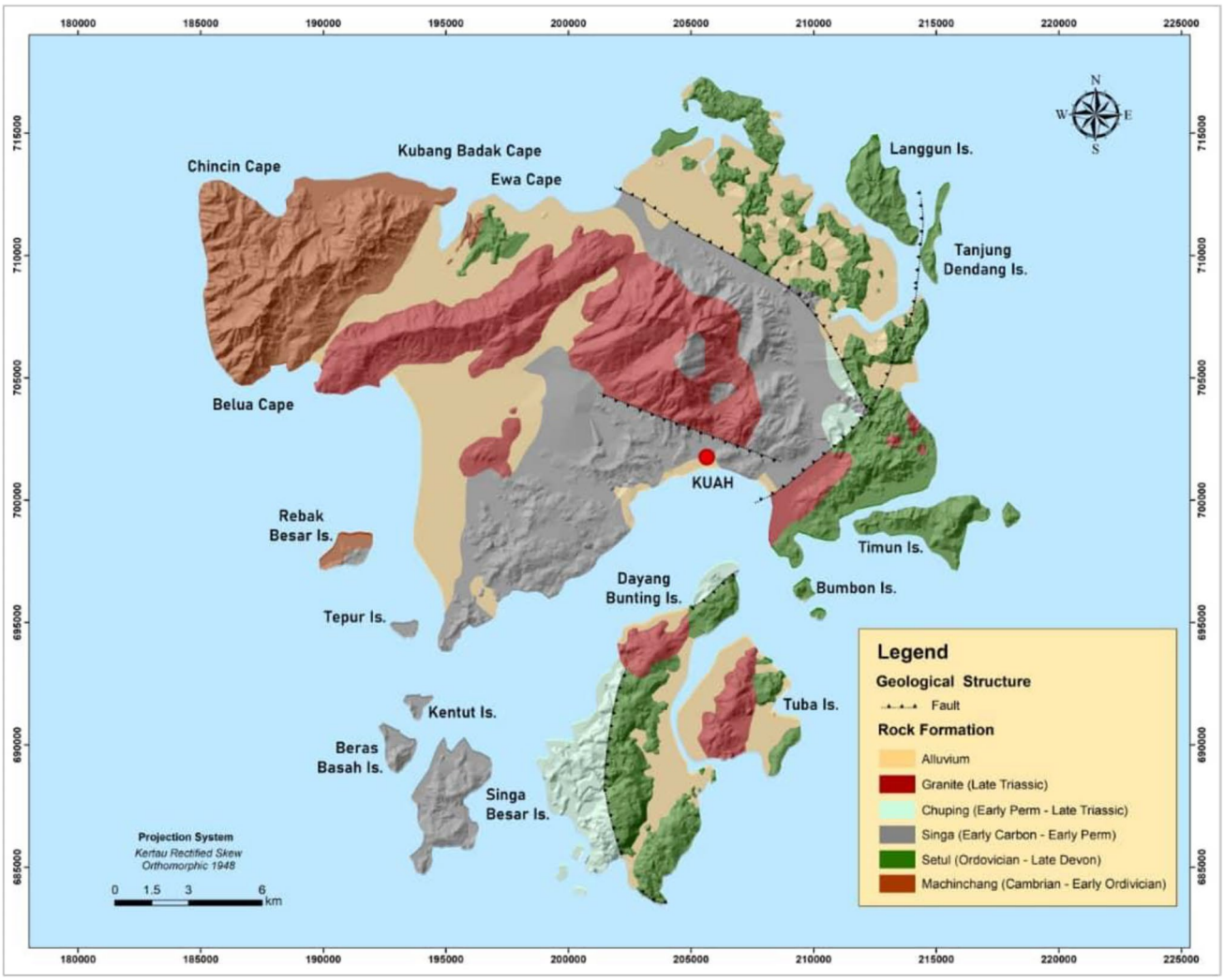

Fig. 2 A geological map showing various rock formations and the study area (Langkawi UGGp)

community while providing alternative opportunities for sustainable and responsible geotourism. Encouraging tourists to venture into the peripheries of a destination can stimulate the economy in those areas and provide income and employment through the development of new and exciting geotourism products (Farsani et al. 2013). To ensure that the new geotourism product promotes excellence in sustainable tourism practices, it must showcase and protect geoheritage, benefit the local people and encourage commercially successful and environmentally sound tourism operations (Dowling and Newsome 2018).

Secondly, the relative absence of proper analysis, planning and development, as well as geotourism project documentation in Langkawi UGGp and other geoparks in South East Asia can perhaps be considered as a general reflection of the situation in many developing countries in that the wider policy actions of sustainable development or geotourism do not consider the development of geoproducts as part of wider tourism planning and development strategies. This reflects the lack of knowledge about geotourism and its promotion, hence the need to address geoproduct development policies and strategic actions for geotourism, especially in a newly developed geopark in Asia.

The geotourism project described in this paper builds on the recognized need to develop geoproducts in collaboration and consultation with multiple stakeholders and is community-based. The purpose of the project was to develop a new geoproduct using a concept and structure deemed suitable for Malaysia. The aim is to showcase how concepts related to trail development are addressed, including the planning and development processes, and to clearly show how trails are designed.

This paper contributes to the development of a geoproduct and geotourism, specifically in a UNESCO Global Geopark in South East Asia. In particular, the case study is significant to those interested in developing an integrated geotourism product that includes knowledge, recreation, natural heritage and landscape conservation, human history and culture, environmental management and geoproduct planning, development and management. As geoproducts target tourists seeking to have the natural environment interpreted for them and expecting explanations of geology, biodiversity, history and culture, an integrated trail can create a holistic view of the ecosystems. This study makes an original contribution to geopark development literature by adding an Asian case, and by developing an integrated trail model that can be used to develop themes and contents of a geoproduct. The project's model, features, processes and lessons learnt can also be adapted to similar geopark locations, cultural contexts and communities.

Literature Review: Trails as Geoproducts

Geoproducts are defined as innovative, new or reinvented traditional products for purchase, which are related to or inspired by the geodiversity of a territory (Neto de Carvalho and Rodrigues 2017; Rodrigues et al. 2020). Geoproducts can also be considered geological attractions possibly involving products of human activities, such as built heritage, i.e., buildings, structures, monuments, installations or remains, which often create high value to geotourism (Compľová 2010).

Geoproducts can be distinguished as basic or complex types (MacLeod 2017). Basic types include any objects (printed materials, maps, interpretative panels, ex situ collections of materials); entities such as exhibition centres or museums; events (festivals, competitions and conferences) and services (geo-guide, geo-training). Complex geoproducts can be sub-divided into tourism packages (geo-tours, outdoor and indoor games); trail/routes (e.g. geotrail) and places (national Geopark, UGGp). In a geopark, geoproducts should blend the geological heritage features of a region with a cohesive story, incorporating the biodiversity and cultural components of the area or region.

Trails or routes are among the most important elements of geoproducts and geotourism. A trail is defined as an all-natural or human-made linear corridor designated as paths or routes for the use of tourists (Beeton 2006; Davies et al. 2012). The various kinds of trails are classified according to distance (short, long routes); intensity of use (mass, niche); purpose (relaxation, visit, education, travel); mode of transportation (footpaths, bicycle, vehicle tour, a network of transportation); function (culture, heritage, geo); setting (wilderness, marine, water, geo); and ownership and management (the administrative structures required on how the trails are managed—either by single ownership, partnership, top-down (Moore and Shafer 2001). Trails are considered a valuable component of recreation, quality of life amenity and source of economic development in a geopark.

In trail construction, a few principles need to be taken into account:

1. Themes: Theming is where points along the trail are linked together, to show that they are either representative of a period of time or illustrative of natural and cultural phenomena (Meyer-Cech 2005). Each trail must have clear objectives and focus on a theme or concept with a coherent story (Hayes and MacLeod 2017).
2. Associated sites: sites must be chosen to reflect the adopted theme, represent the natural heritage of the area, and the local culture. The trails should be linked to each site, and must be resilient to visitation, accessi-

ble, safe and well-managed. Inventories and quantitative assessment of the most valuable sites are necessary steps in establishing a trail (Wrede and Mügge-Bartolović 2012).

3. Mode of transportation: transportation in a trail is determined by the type of environment the route traverses, the area's geographical location or the main type of attraction featured in the proposed trail (Timothy and Boyd 2014). In planning a trail, the transportation mode should be considered, whether on foot, by bicycle, boat or car or a transportation network comprising a combination of roads, water or hiking trails.
4. Trail accessibility: these are new infrastructure (e.g. bridges, boardwalks), and remodelling built structures (e.g. gates, steps), hardening trail surfaces, or rerouting or widening an existing trail are examples where accessibility guidelines and compliance must be met (Timothy and Boyd 2014).
5. Trail services and amenities: a range of standard services for tourists should include transportation, public toilets, rest areas and restaurants. Services should also include museums and galleries, local attractions or events to enrich visitors' knowledge and experience. Necessary signage, information panels and printed material should be available on specific, strategic and suitable structures (Timothy and Boyd 2014).
6. Cooperation and collaboration: a collaborative approach to trail development and involvement of different stakeholders in decision-making, implementation and management of trails has a greater chance of ensuring sustainable outcomes (Bramwell and Lane 2011). Collaboration among various players can increase financial stability, involve greater grass-roots knowledge, strengthen marketing efforts, protect cultural and natural environments, enhance the local community's quality of life, and reduce cross-border socio-economic and ecological imbalances (Bramwell and Lane 2011; Mnguni and Giampiccoli 2017).
7. A complete route: besides having a clearly marked starting point and a clear end, a trail must also be interpreted with a variety of tools including signs, maps and leaflets, or by human guides. Interpretation, i.e. scientific and indigenous knowledge translated to the public, helps enhance public appreciation for heritage and boosts efforts at conservation (Timothy and Boyd 2014).

The development of the geoproduct in Langkawi UGG took into consideration all the above principles as well as a planning process involving multiple stakeholders to ensure trail development success and long-term sustainability. Trail development frameworks suggested by Hugo (1999) and McNamara and Prideaux (2011) comprising five phases: assessment or scientific study preparation, planning, evaluation, implementation, and monitoring, were implemented throughout the development.

Methodology

The work reported in this paper uses a developmental research approach which involves constructing a geoproduct in the form of a trail. The strategic partnership initiative was led by a group of researchers from the Langkawi Research Centre (PPL), Universiti Kebangsaan Malaysia in partnership with LADA Langkawi Development Authority (LADA), the Fishermen's Cooperative of Sungai Kubang Badak Langkawi Berhad, and multiple stakeholders, including the local community. The development of the trail was guided by three specific objectives:

1. To identify geological, biological and cultural heritage resources on which a new geoproduct should be based;
2. To develop the theme and concept appropriate for the site development, the content of interpretation and capacity building activities;
3. To determine the route's infrastructure, and management needed in the development of the trail through stakeholders' discussion and capacity-building activities.

Since the project involved critical design, product development and evaluation of a product limited to a setting, a qualitative research method in the form of a case study, involving document analysis, field observation and focus group interviews, was chosen to gather the data, to document the processes used and the conditions under which the product was tested for usability (Richey and Klein 2005; Creswell 2017). Also, given that social, political and historical contexts are important to developmental research and a case study, the researchers are considered key instruments in the data collection and analysis as they have specific knowledge of and information about the Langkawi UGGp. Data from both primary and secondary sources were integrated to compile a case description.

Study Site

The study site is mainly within the protected area of Kubang Badak Permanent Forest Reserve (KBPFR), covering a small area within the Machinchang forest reserve, with a small area of a quarry concession, and Kubang Badak village. From a geological point of view, the site lies at the boundary between the clastic rock of the Machinchang Formation of the Cambrian age (around 550–490 ma) (Jones 1981; Tjia 1989; Lee 2009) and the oldest limestone of the Setul Formation of the Ordovician–Silurian age (around 490–420 ma) (Ali et al. 2005; Leman et al. 2007) (Fig. 2), having mangrove forests with Permanent Forest Reserve

status, around the river of tidal influence (estuary ecosystem) and traditional fishing villages.

A village known as Kampung (meaning village) Kubang Badak is located outside of the KBPFR, in the southwest. Currently, it supports a total of 106 households with 559 residents, with only 4.7% of the population working full-time as coastal fishermen. The rest of the villagers work either in the industry (e.g. cement quarry) or service (hotels and restaurants) sector. A small group has been involved in business related to tourism, mainly ecotourism, and the minority work in small-scale farming. Kubang Badak has an active community and an entrepreneurial cooperation known as Sungai Kampung Badak Fishermen's Cooperative.

Research Design for Trail Development

In line with a developmental research design, this study utilized multiple sets of data gathered over three different phases:

Phase I: Information gathering and conceptualization

This first part of the project examined the existing trail network to ascertain the type/s and quality of heritage available along the trail. The main focus of the initial phase is to study the inventory on natural heritage to ascertain the theme and design of a new trail. The background research that maps existing trails uses data from existing inventory and through a series of fieldwork to survey and map the heritage sites.

Geopark documentation, especially the application and revalidation dossiers, was used as secondary data (organizational records, maps and charts, and survey data collected during the application and revalidation processes). These resources were assessed according to a matrix that considers their scientific and conservation values, educational content and relevance to be developed as tourist destinations. Based on the documentations and inventories, the geo, bio- and cultural sites and other resources needed for the trail were chosen and their scientific properties described. Additional field observations were used to confirm and triangulate the data from documents and identified resources.

A series of field trips to the study area were conducted in three sessions in 2018: 12–17 January, 4–9 February and 20–21 April, to ascertain the suitability of the site, the state of the current heritage resources, accessibility, and to collect additional information/data not available in the reference sources. Field notes and photographs of trail surface, signage, memorials, structures, special features, vegetation and landscapes were used to record observations. These data were also used to decide on artefacts and infrastructure needed for the trail.

The next step was to develop a trail design, identify priority tourist sites and to plan the hard and soft infrastructure needed for the trail. The development of the trail as a geotourism product necessitates the use of scientific information, in particular, the geological, landscape, biological and cultural heritage values, in an integrated manner; and to translate (interpret) them into 'stories for public consumption' as the basic material of knowledge-based tourism attraction. All the vital information collected on geosites, the forest reserve (mangrove) and fishing village is used as 'content-shaping material' for various products and facilities of public education and tourism.

A town hall discussion was conducted to verify the history of Kubang Badak and to obtain the community's feedback on possible themes, their opinions, wishes and vision. The local community's knowledge, traditional arts and lifestyle play a pivotal role in this trail development. The participants involved in the town hall included boat operators, nature tour guides, farmers, fishermen, and committee members of the Fishermen's Cooperative. The consultative approach ensured all stakeholders had an opportunity to understand what was being proposed and developed, how their lives would be affected socially and economically, and to offer their views to the planning processes. A management plan for the proposed trail was also discussed. The feedback/input from the participants was converted to a list of contents and needs towards the geoproduct attributes.

A series of product development workshops were conducted to build the concept of 'science/ knowledge for society' based on the geotourism approach. Finally, a discussion with a group of experts in various fields (geology, biology, social sciences and education) was held to discuss the theme, an integrated approach to the presentation of heritage information, to reach mutual agreement on a thematic story and interpretation priorities, and to conduct accurate scientific information verification.

Phase II: Development of tourism sites and infrastructure

The second phase was the trail construction or the implementation stage of the project. Construction of the trail into the landscape involved building infrastructure, while capacity-building activities were organized to build the knowledge and skills of the stakeholders. This was also the stage when information on the geosites, biosites and cultural sites were examined and evaluated for information critical to an interpretative plan. The process of preparing geotourism information or stories was completed in two stages: the first, based on suggestions from local tour guides and the community, and the next, from group discussions with various field experts, in order to build a connected story with 'added value'.

The process of developing physical geotourism infrastructure including buildings and structures such as public toilets, signage, information panels, pit stops and rest stations was

Table 1 Trail development and data collection process and outcomes

Phases/objectives	Activities	Actors/participants	Sources of data	Outcomes
Phase 1/objectives Information gathering and conceptualisation Inventorying existing trails through surveying and mapping Recognizing stakeholders' needs Conducting an environmental assessment Developing a trail theme and design	• Document analysis of Inventories • Landscape analysis through observations during field work • Experts discussion and town hall with stakeholders-local community, local agencies, tour guides • Discussion on theme and concept • Geoproduct development workshop	Researchers Local community Local administrative agencies Tour guides LADA (funder)	Secondary and Primary Data organizational records, maps and charts Field Notes and photographs of trail surface, signage, structures, vegetation, and landscapes Town hall notes Minutes of experts' discussion and geoproduct development workshops	A list of identified sites as tourist sites/pit stops with brief descriptions of their scientific properties A theme/concept and approach to trail A plan for artefacts and infrastructure Interpretation plan and construction
Phase II/objectives: Development of Tourism Sites and Infrastructure Development of trail and infrastructure Conducting training and workshops for capacity building	• Construction of the trail into the landscape • Building hard infrastructure—rest stations, toilets, interpretative plans and construction • Capacity-building activities with the local community and tour guides	Researchers Local community Local administrative agencies Tour guides LADA (funder)	Minutes of experts' and stakeholders' discussion	A constructed trail Infrastructure e.g Info panels Stakeholders' knowledge of geoproduct, geotourism and management of geotourism product
Phase III: Trial, assessment and verification	• Development of documents- map, guide book, pamphlets • Focus group discussion on trail usability • Series of training on management and tour guiding	Local community Tour guides Tourists LADA (funder)	Transcriptions from 5 FGDs	Guide book, map and pamphlet Stakeholders' perspectives of the newly developed trail

carried out between 2018 and 2019 by LADA. During this stage, the experts and researchers were constantly involved in the construction of the infrastructure and materials for geotourism activities.

Phase III: Trial, assessment, and verification

A series of usability evaluation and verification was carried out to examine the functionality of the trail. Users' design feedback via post-task interviews and workshops was employed to examine their experience and how well they could learn and use the trail to achieve the goals. The trail usability assessments with the stakeholders, i.e. Kubang Badak Fishermen Cooperative, tourist guides and LADA officers, also provided information on a number of important management needs, activity patterns and usability of infrastructures including enablers and barriers related to trail management. The recorded interaction data or user report was used to identify main usability issues and the subsequent development process. In addition, the findings from the users' feedback allowed the development team to assess the stakeholders' capacity development needs.

During the subsequent final phase, short training sessions were conducted and various documents such as maps, pamphlets and a training module were developed. Field visits and tour guide training were also conducted. Table 1 summarises the activities according to the phases together with data collecting procedures.

Presentation of Results

Characterization of Heritage Sites

Based on the document analysis of inventories, scientific reports, the Langkawi UGGp dossiers and town hall discussion, an inventory of in-situ resources of geoheritage, bioheritage and cultural heritage was created as resources for the trail (Fig. 3).

1) Geoheritage

Four main geological heritage sites were chosen from the inventory to be included in the trail (Fig. 3: 6, 7, 8, 9).

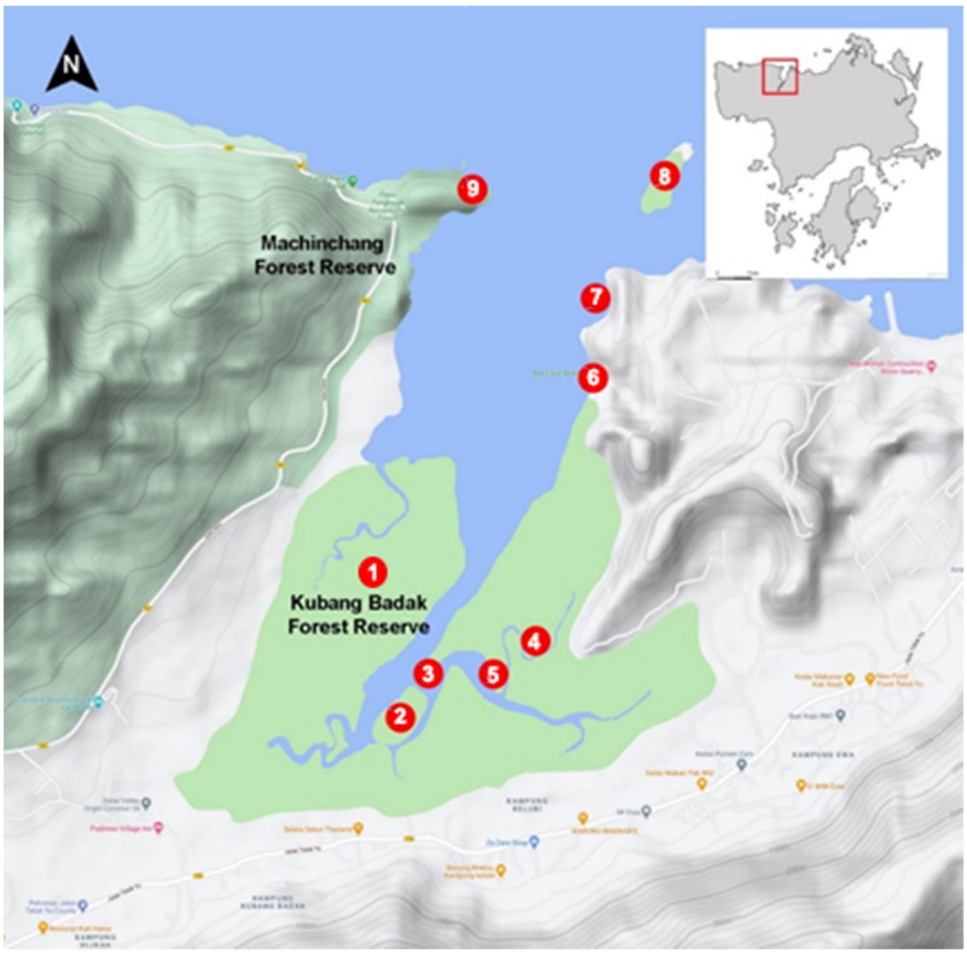

Fig. 3 Map of the study area and heritage sites: 1 = Kubang Badak Reserve, 2 = Kubang Badak Islet, 3 = Menora Hill, 4 = Siam Village, 5 = Siam River, 6 = Pinang Cave Geosite, 7 = Tanjung Mendidih Hot Spring, 8 = Pulau Jemuruk Geosite, 9 = Tanjung Buta Geosite

a) Tanjung Buta

The Tanjung Buta site is a promontory, made of layers of sandstone representing the lower part of the Jemurok member of the Machinchang Formation. A narrow rocky wave-cut platform at this site exposes several fossiliferous layers that yield trilobites and brachiopods of the Upper Cambrian age. Thus far, this is the only site where Cambrian saukiid trilobites can be found in Malaysia (Lee 2006, 2009; Leman 1997a, 1997b). Hence, it is considered to have a high geological heritage value of national significance and is included as one of the important sites in the Kubang Badak BioGeoTrail.

b) Jemuruk Island

Jemuruk island is the biggest island in the north-western part of Langkawi and it is occupied by a sequence of sandstone beds with minor occurrences of siltstone and shale with prominent hummocky crossbedding indicating that the sequence was deposited above the storm base. The site exposes the uppermost part of the oldest rock formation of Malaysia known as the Machinchang Formation. Some of the trilobite fragments found include *Dictyodora*, *Chondrites*, *Gordia*, *Neonereites*, *Diplichnites*, *Monomorphichnus*, *Dimorphicnus*, *Kinneyan*, *Phycodes pedum* Seilacher, *Teichichnus stellatus* Baldwin, *Palaeophycus*, *Chondrites*, *Paleodictyon*, *Arenicolites*, *Planolites*, *Thalassinoides*, and *Skolithos* trace fossils (Lee 2006, 2009; Leman 1997a, 1997b). The fact that this site represents the uppermost part of the Machinchang Formation qualifies it to be considered as a geological heritage of national significance.

c) Pinang Hill cave

The Pinang Hill cave geosite is a limestone cave located at the foot of a small isolated limestone hill on the right bank of the Kubang Badak estuary. Stratigraphically, the hill is the lowest part of the oldest limestone formation in Malaysia known as the Setul Formation, the age of which has been assigned to the early Ordovician Period (Jantan et al. 1989). This is the only site where one can observe a gradual contact between the Machinchang and the Setul formations, shown in the gradual facies change from the clastics of the Machinchang (Cambrian) to the calcareous of the Setul Formation (Lower Ordovician). Scientifically,

this site is considered a geological heritage of international significance as it marks the beginning of calcareous sedimentation in the SIBUMASU terrane. Geomorphological processes that took place after the rock had been uplifted produced the Pinang Hill cave which is the longest cave system in Langkawi, and which has become home to thousands of bats. An accumulation of seashells near the entrance of this cave marks an ancient sea level. From the correlation with other ancient shell deposits in Langkawi, its age can be deduced to be around 6000–7000 years old (Jantan et al. 1989).

d) Tanjong Mendidih Hotspring

Tanjong Mendidih is the site of an underwater hot spring. Geologically, the hot spring is related to a thrust fault that runs parallel to the Kubang Badak estuary which can be observed cutting across the uppermost part of the Machinchang Formation. This unique phenomenon holds a high heritage value of national significance.

2) Biological Heritage (Fig. 3: 1, 2, 5)
a) Kubang Badak Permanent Forest Reserve (KBPR)

The KBPR, a biosite consisting mainly of mangrove forest over an area of 419 Ha, is the third-largest mangrove forest on Langkawi Archipelago. From a total of 85 species of mangrove flora recorded in Langkawi, which represents more than 70% of mangrove species in Malaysia, 45% of the species are found in Kubang Badak (Norhayati and Latiff 2001; Nabila et al. 2012). Faunal diversity at the Kubang Badak mangroves includes 62 species of birds, 10 species of mammals, and 13 species of reptiles and amphibians (Wetlands International Malaysia 2005; Yeap 2005). Among the important bird species (Red List of IUCN Conservation Status) are the Mangrove pitta (*Pitta megaryncha*, near threatened), Green iora (*Aegithina viridissima*, near threatened), and the Brown-winged kingfisher (*Halcyon amauroptera*, near threatened), while mammal species include the slow loris (*Nycticebus coucang*, vulnerable), Malayan pangolin (*Manis javanica*, critically endangered) and the Island flying fox (*Pteropus hypomelanus*, near threatened).

b) Kubang Badak Islet

Kubang Badak Islet was formed by the process of deposition of fine silt alternating with mud, which is important for ecological succession to occur with pioneer species. This small island, located in front of the Kubang Badak fishermen's jetty, is covered with young mangrove forest dominated by the red mangrove (*Rhizophora* spp.).

3) Cultural Heritage (Fig. 3: 3, 4)
a) Traditional Siam Village

The traditional village is the earliest settlement of southern Thai residents who migrated in the eighteenth century. The immigrants carried out charcoal-making activities, planted rice and rubber for their livelihood. Visible remnants of Siam village include an old well and an air inlet of a charcoal kiln which are estimated to be 100 years old. The nearby Menora Hill (Fig. 3) was the centre for communal activities of the old Buddhist community in the Siam village. The hill was also used for medical practices to appease certain spirits for the purpose of seeking protection and expressing gratitude.

Trail Development

1) ***Theme and Concept of the Trail***

In the case of Kubang Badak, the uniqueness of the area is not based so much on the sum of separate elements, but rather derives from an organic context of spatial and non-spatial realities, shaped by the area's physical structure (geodiversity and biodiversity), human landscape and its history. Thus, a clear theme of the integration of bio- and geo- was agreed upon by the stakeholders. The name, BioGeotrail, is a new approach in the Langkawi UGGp geoproduct development for geotourism activities.

The rationale for using bio-geo trail and not 'bio-geo-cultural trail' is based on the importance of significant heritage values and marketing strategies. A name with 'bio' as a prefix followed by 'geo' means that the trail has extensive biological heritage values (typically, such areas use the term ecotourism), as well as geological heritage values. Moreover, the inter-relations between biological and geological heritage are closely linked and difficult to separate. Components of culture and tradition are rooted in time and place that define how people relate to nature and their physical environment as human beings need the services of nature. Thus, cultural heritage is considered an innate element of the theme and is implicit in the term 'bio-geo'.

2) ***The Content of the BioGeoTrail***

With its theme on biological and geological heritage, the geoproduct is named Kubang Badak BioGeoTrail which focuses on conveying a collection of diverse stories about the value of the environment and integrated heritage owned by an area within a geopark. The trail involves sightseeing and an expedition to explore the variety of heritage along the Kubang Badak river, small islands and coastal areas. The sites focus on the heritage values of geology, biology and culture, and the relationship between these components.

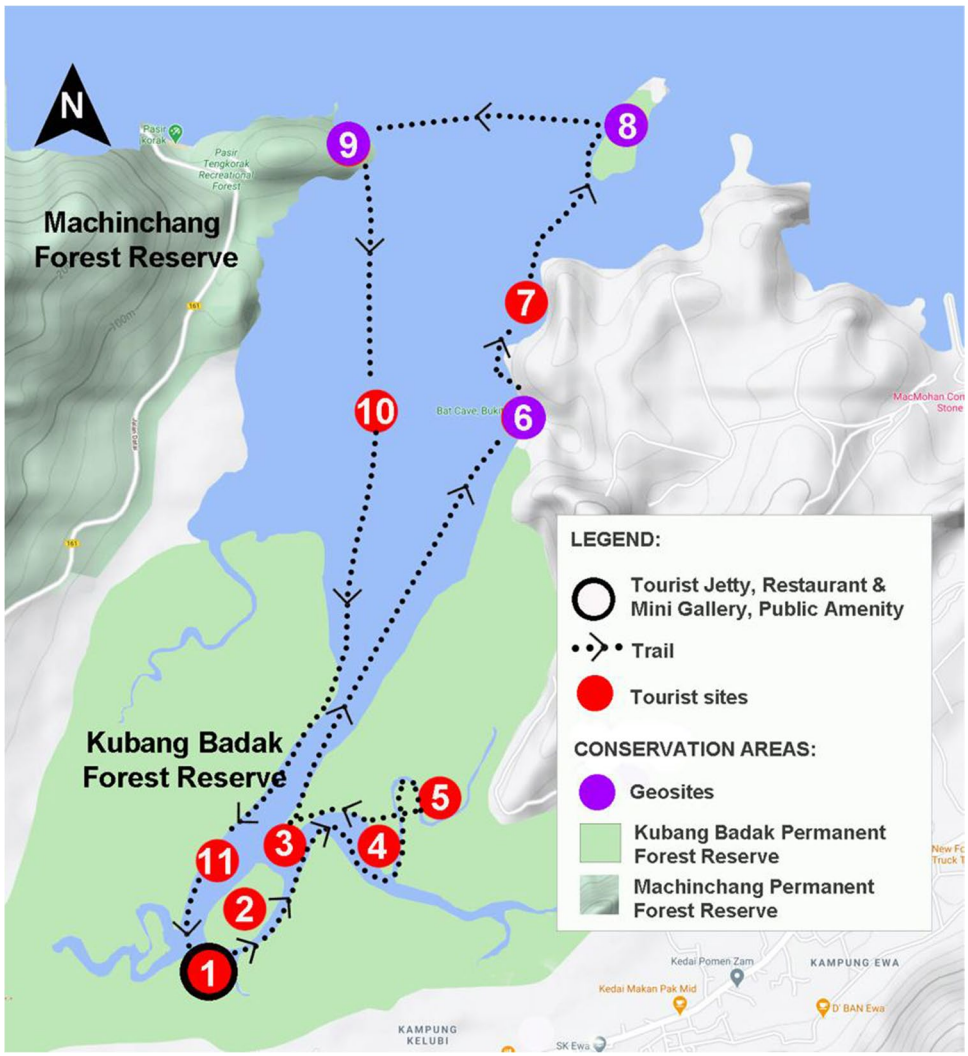

Fig. 4 Kubang Badak Bio-GeoTrail routes and pit stops. 1 = Kubang Badak Jetty Complex, 2 = Kubang Badak Islet, 3 = Menora Hill, 4 = Siam Village, 5 = Siam River, 6-Pinang Hill Cave, 7 = Tanjung Mendidih Hot Spring, 8 = Pulau Jemuruk, 9 = Tanjung Buta, 10 = Kubang Badak River Viewpoint, 11 = Sandbar

The geotourism/geopark story development was based on a single value or on multiple values, i.e. a combination of geological, biological and cultural values, recognised at each selected site.

3) ***Mode of Transportation***

The trail requires tourists to travel in boats, as well as on foot for short walks along a marked footpath of about 500 m with no significant altitude variations. The trail has 12 pit stops and takes between 2 and 4 h with twelve selected tourist sites to highlight the value of the integrated heritage and the beauty of its natural landscape (Fig. 4). In some locations such as Siam Village and Pinang Hill Cave, boardwalks are available to allow tourists to view the heritage resources more closely.

4) ***Pit stops and Stories***

a) Starting Point

The BioGeoTrail starts from the Tourist Jetty Complex (Fig. 4) which has basic tourist facilities and a place for boarding the boats. Only one entrance to the trail system has been established.

Kubang Badak Jetty (Fig. 5) is where tourists board the boat to explore the BioGeoTrail and it also provides an explanation for the setup and safety guidelines. The jetty is still used as a social area and a fish landing site. The fishermen's indigenous knowledge and traditions are among the stories shared with the tourists.

c) Kubang Badak Islet

The information given at this pit stop highlights the importance of Kubang Badak Islet (Fig. 6) and the mangroves (Fig. 7) in protecting the fishing jetty and the villages along the river from soil erosion, strong winds and waves from the open sea.

Fig. 5 Kubang Badak Jetty

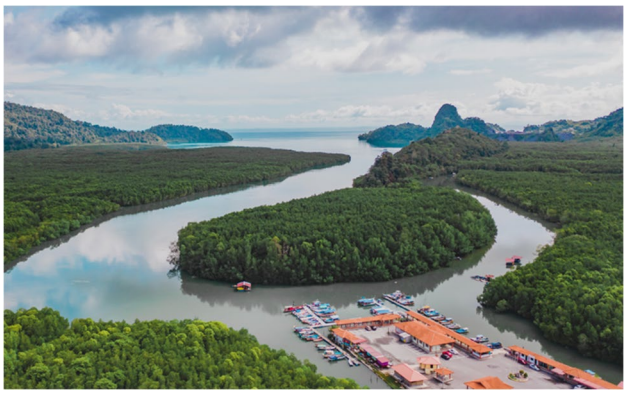

Fig. 6 Kubang Badak Islet

Fig. 7 Mangroves in Kubang Badak Islet

d) Menora Hill

Menora Hill (Fig. 8) is a steep hill with no landing point. Tourists can only view the hill while cruising along the river. The story relayed to tourists about this hill is its geological formation (an isolated hill with steep slopes formed by chemical weathering on limestone) and the history of the hill as a cultural centre in the eighteenth century.

Fig. 8 Menora Hill

e) Siam Village

At Siam village, the history of old charcoal kilns is promoted as an icon of the historical heritage of the early immigrant settlement on Langkawi Island (Fig. 9). A small jetty has been built for landing so that tourists can walk along a pathway to see several remnants of old charcoal kilns. The story relayed here is about charcoal as the main fuel for transport (by rail, or steam engine vessels), for the bread-making industry, and for metal smelting (tin, iron, and copper dating back to the eighteenth century). Basically, the information emphasises the first settlement and the culture of the Kubang Badak community.

f) Siam River

The trail takes the tourists along the Siam River (Fig. 10), located on a protected coastal area and estuary that is influenced by the high and low tides. This area displays mangrove forest ecosystems; hence, the key information communicated to the public is about the adaptations and unique ways mangrove plants operate and the diversity of their flora and fauna.

Fig. 9 Siam Village and remnants of charcoal kilns

Fig. 10 Siam River

Fig. 12 Tanjung Mendidih Hot Spring

g) Pinang Hill Cave

This pit stop requires tourists to walk along the 200-m trail from the boat to reach the cave entrance (Fig. 11). The storytelling in this cave focuses on the components of geological and biological heritage. Three main stories created for this pit stop are as follows: (a) the cave is what has remained of an ancient sea level formed by waves when the sea level was about 15 m higher than the current level, about 6,000 years ago. The layer of oyster shells found near the cave mouth is evidence of sea-level change; (b) cave animals are decomposers, or detritus feeders, feeding on dead organic matter. Animals adapted to cave life, with reduced vision, loss of body pigment, slower metabolism and lower reproductive rates; (c) guano is the excrement of cave bats that accumulate overtime on the cave floor. It supports the food web of almost all other cave fauna. Guano from Pinang Hill Cave is a major source of fertilizer for farmers in the surrounding area.

h) Hot Spring

At the Tanjung Mendidih Hot Spring (Fig. 12), the story to be related is on the rarity of a sea water hot spring and its formation.

Fig. 11 Pinang Hill Cave

i) Jemuruk Island

Although Jemuruk Island (Fig. 13) has a high geological heritage value, the site is also introduced to tourists for its beautiful landscape. Some of the main stories include the process of formation of the remnant islands, important geosites representing the basal layers of the Machinchang Formation (the oldest rock in Malaysia), the rock layering landscape, and the power of the waves that erode the rocks, depositing sand.

j) Tanjung Buta

This pit stop is introduced as a recreational and educational site on a rocky beach area (Fig. 14). Tourists can explore and learn about the layers and various features of Malaysia's oldest sedimentary rocks, wave processes, various morphological forms of coastal erosion and sedimentation, quartz minerals and fossils.

Fig. 13 Jemuruk Island

Fig. 14 Tanjung Buta

Fig. 16 Sandbar

k) Kubang Badak River Viewpoint

The last pit stop before the Jetty is the Kubang Badak River viewpoint that displays a landscape of terrain, biological diversity and natural elements of sea, mountain and river (Fig. 15). The view to the west is Mount Machinchang, a landscape formed of sandstone layers; to the south is the ridge of Sawar Hill formed from igneous rocks (granite intrusion); and to the east is a hill formed of limestone and mangrove forest habitat landscape. The story to be related here is that geology plays a role in producing an extraordinary and beautiful landscape.

l) Sandbars Viewpoint

Sandbars, locally known as *bohor*, are part of an interesting landscape in the course of the Kubang Badak River. Storytelling or interpretation at this pit stop involves the estuary ecosystem and the process of *bohor* formation (a nursery for various marine life, especially shellfish, snails and crabs) (Fig. 16).

The trail ends at the jetty where amenities such as restaurants are built and run by the fishermen and villagers. A journey from the jetty along the established route with visitors ideally walking deeper inside the cultural and geosites is approximately 5.5 km long.

5) Geotourism Infrastructure Development

The tourism infrastructure of the trail included a large number of services necessary to meet the needs of tourists and the service providers. The Biogeotrail development called for new construction and refurbishment of facilities which include the following:

a) Kubang Badak Jetty Complex

The jetty was constructed in 1973 using wooden planks tied to cylindrical drums by local fishermen who originally used them to berth their boats. In 1996, the Malaysian Fisheries Development Authority built a proper mini jetty for the fishermen. With the money allocated for the development of Langkawi UGGp, LADA upgraded the jetty and its facilities into a complex as required in the trail development proposal. Other upgrading projects included toilets, prayer rooms, the lobby, office space, food and beverage outlets, a parking space and two boardwalks in Siam village and Pinang Hill Cave sites. The whole project took a year to be completed.

Fig. 15 Kubang Badak River Viewpoint

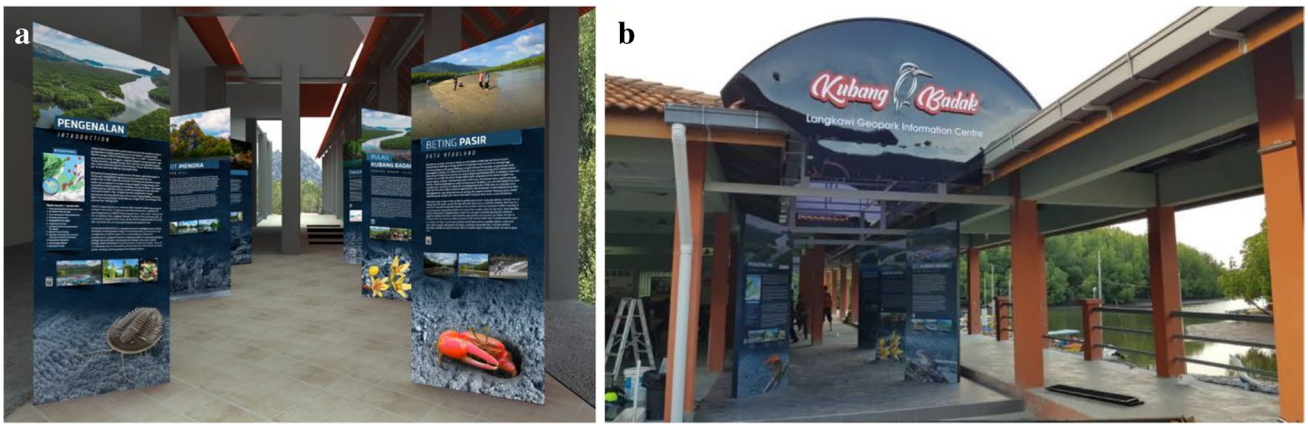

Fig. 17 **a**, **b** Outdoor mini gallery of Kubang Badak BioGeoTrail

b) Outdoor Mini Gallery, Kubang Badak

An open-air 'mini-gallery' displaying important information on heritage values, recreational opportunities and specialties of the Kubang Badak area was developed at the Jetty (Fig. 17a). This is intended to be a starting point for tourists to learn about the local Malay coastal community, culture and traditions of life in the area. This outdoor concept tourist centre was built on the banks of the Kubang Badak River, with the scenery of the river and mangrove forest as its background (Fig. 17b).

c) Entrance/ gateway

Since Kubang Badak is situated away from the developed main tourism areas in the Langkawi UGGp, it was considered important to develop a gateway as a means of defining the entry into the new tourism product with an identity. An arch gantry (Fig. 18) was constructed to serve as the first communication and introduction to the geoproduct and to provide a sense of arrival at Kubang Badak Biogeotrail. The arch was also complemented by a newly tarred road.

Fig. 18 Gateway to Kubang Badak Biogeotrail

d) Thematic Info Panels

These refer to the interpretative facilities, both on- and off-site, developed to convey educational or entertaining information about the heritage products. The BioGeoTrail is equipped with four thematic panels located on significant sites, plus a set of introductory panels at the beginning of the trail (at the jetty, Fig. 19a). The panels focus on three main heritage themes intended to pique the curiosity of the general public. For each site, one or more geological and geomorphological topics that best represent the site are chosen and explained in the simplest way, with the aim of conveying their scientific significance to the public (Fig. 19b). The panels have a consistent layout, so that tourists know what to expect at each site. The interpretation style aims to create a coherent identity, imparting knowledge with clarity, thus facilitating the tour of the trail. The info panels also serve as starting points for tourist guides from which they can easily elaborate with thoughtful and composed information.

e) Guidebook and Maps

A guidebook to exploring the Kubang Badak BioGeoTrail introduces geological, biological and cultural heritage sites in an integrated manner using simple language, accompanied by photos and diagrams (Fig. 20). Each of the twelve sites is described in the guidebook and maps. The guide book offers precise and detailed information on geological, biological or cultural aspects of the sites so tourists can review their understanding and revisit memories of their BioGeoTrail experience. The Kubang Badak BioGeoTrail map is considered a very important part of the trail system as it helps travellers to find their bearings and navigate the area.

Fig. 19 **a**, **b** Examples of Info Panels

6) Engagement and Community Empowerment Activities

Empowerment-oriented interventions were carried out to provide opportunities for the community to develop knowledge and skills, and to engage professionals as collaborators. Three formal training modules developed in phase II were successfully implemented. The modules focus on introducing the components of 'science knowledge for the community', the trail design and its environmental, social and economic values, and experiential learning. The experiential learning involved guided mock-ups on the trail (each participant presented their interpretation) to ensure that the message communicated is appropriate and supported by facts. Groups of tourists (with little or no basic knowledge of geoparks and geotourism) were also identified and invited to visit the BioGeoTrail with a trained tour guide. After each site visit, informal semi-structured interviews and focus group discussions were conducted to obtain the tourists' general perceptions and feedback on the geotrail/geotourism product. Feedback from the interviews with the local community, tour guides and selected tourists was used to update the content and presentation in the handbook, brochures and information panels.

A series of workshops were conducted with the Fishermen's Cooperative of Sungai Kubang Badak and the tour guides on the management of the trail. During the workshops, the stakeholders were taught how to develop standards to minimise disturbance to natural features along the trail, and also how to improve safety briefings and procedures, and communication skills. The workshops also discussed aspects related to the clarification of management and maintenance roles.

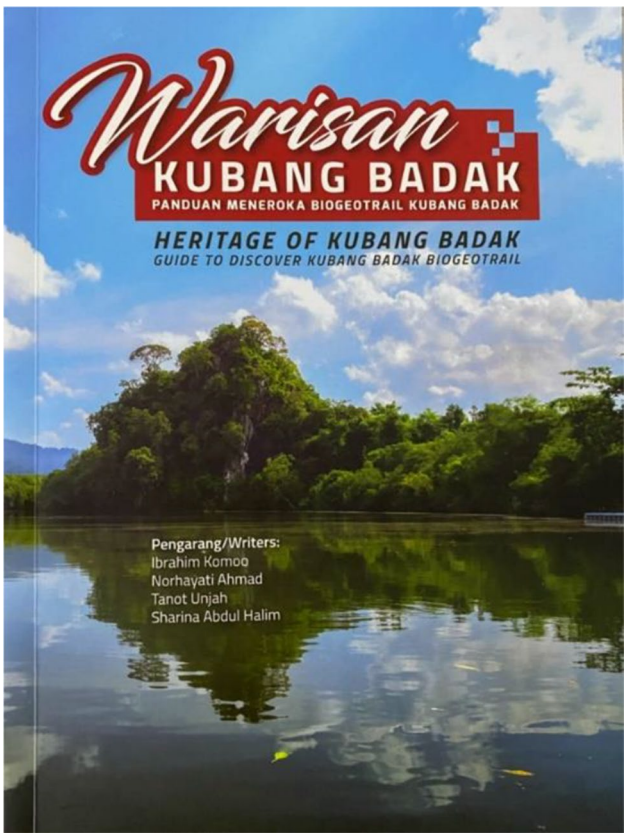

Fig. 20 Guide book on Kubang Badak BioGeoTrail

7) Management Approach

Once the geoproduct development was completed, the management and implementation of geotourism activities were left entirely to the Kubang Badak Fishermen Cooperative. However, an informal agreement has been made between the LADA Geopark Division and the Cooperative on matters relating to the co-management of the trail. The responsibility of the day-to-day operations of the BioGeoTrail was given to the Fishermen's Cooperative. The cooperative also monitors the tour company, tour guides and

visitors as well as maintains the public service amenities. LADA undertakes some of the activities related to promotion and marketing. As the BioGeoTrail infrastructural assets are placed under the LADA Geopark Division, monitoring and maintenance of those assets are under LADA's responsibility.

Discussion

The growth of geotourism has highlighted the importance of geoproduct development and competition among geoproducts; hence, the need to ensure that the creative development of geoproducts stays competitive and sustainable.

For the planning stage, the synthesis of research and inventories indicated that the Kubang Badak area has rich geoheritage and bioheritage values that can be packaged into a geotourism product. The trail has its own theme or concept, developed from the natural heritage covered by the many interesting sites. The concept of the trail emphasizes the conservation of geological and biological features while appreciating the connection to human history and development (Hayes and MacLeod 2017). The content then combines selected elements of geosites, biosites and cultural sites of Kubang Badak, which presents the tourist a combination of experiencing the integrated elements of nature and the distinctiveness of its locale, i.e. the history and the fishing village industry.

Each site displays information boards that provide accurate interpretation of the assets, and that explain the associated phenomena based on scientific evidence. As for the main mode of transportation, motorized boats are the vehicles best suited for the river cruise, with the inclusion of short walks along marked footpaths/boardwalks. The project which was completed in two years is an example of a community-based trail with minimum structural intervention to facilitate geotourism activity.

The Langkawi UGGp's new geoproduct confirms McNamara and Prideaux's (2011) view that building community support for a trail should be community-based, or participatory, and planning should advocate for holistic development that allows the local community to partake fully of the benefits of the geoproduct. Thus, an important part of the participatory approach in trail development is the involvement of the Kubang Badak community at the early stages of planning, and their engagement from the beginning to the end of the project. Ongoing information, education and communication keep the community involved and aware of what is going on and how the trail would benefit them. This aligns with an important manifestation of grass-roots development in a geopark, which is the value of indigenous knowledge and empowerment of the local community (UNESCO 2020).

Successful trail development includes building a broad-based stakeholders' coalition and forming a strong partnership with government agencies (David and Westrup 2020). The project undertook periodic educational workshops and training programmes to share with the government agencies the status of geoproduct development, the physical and sociocultural environment, its management, and approaches to sustainable tourism. Without the input of agencies (Forest Department, LADA), many issues regarding co-management would not have been resolved.

Through content analysis activities and multi-expert discussions, we have developed an integrated heritage model for theme and interpretation formulation in the development of a geoproduct (Fig. 21). The analytical model is proposed to be used as a guide in the process of theme formulation or conceptualization as well as site/content interpretation. In principle, the analytical model uses the contents of existing geological, biological and cultural heritage values (Fig. 21a) as the basis for developing geotourism themes, sites and content/interpretation. This model also proposes that the content and interpretation of a geoproduct be based on multidisciplinary knowledge that can relate all heritage values in an integrated manner (Fig. 21b). Domains 1, 2 and 3 show that the body of knowledge/ information for each tourism site is based on the understanding of sectoral heritage value, namely geological, biological and cultural heritage (domains 1, 2 and 3 in Fig. 21). Additionally, the connectivity of two heritage values, namely geo-bio, geo-culture and bio-culture (domains 4, 5 and 6 in Fig. 21) must be identified and used in theme and content development as well as interpretation. An example of connectivity or an integrated theme is the relationship between limestone hill and limestone forest (geo-bio), the use of sandstone blocks to construct charcoal kilns (geo-culture), or the use of mangrove trees as charcoal (bio-culture). Finally, content or interpretation that relates geological, biological and cultural values in an integrated manner (domain 7 in Fig. 21) should be as an ideal story/ interpretation for public education.

A visual indicator in the form of three coloured bars was created to determine the main and supporting heritage contents for an interpretation or 'story-telling' for public consumption. The red bar represents the value of geological heritage, the blue bar represents biological heritage values, while the yellow bar is on cultural heritage (Fig. 21c). Thus, for each tourist site or geoproduct, the bars are used to guide the emphasis level given to thematic interpretation and story-telling.

A comprehensive content analysis using the model enables each of the proposed tourist sites to introduce a thematic story reflective of its relationship between each type of heritage based on their respective values, importance and interesting stories. In other words, the new analytical model takes into account the interdependent nature of the

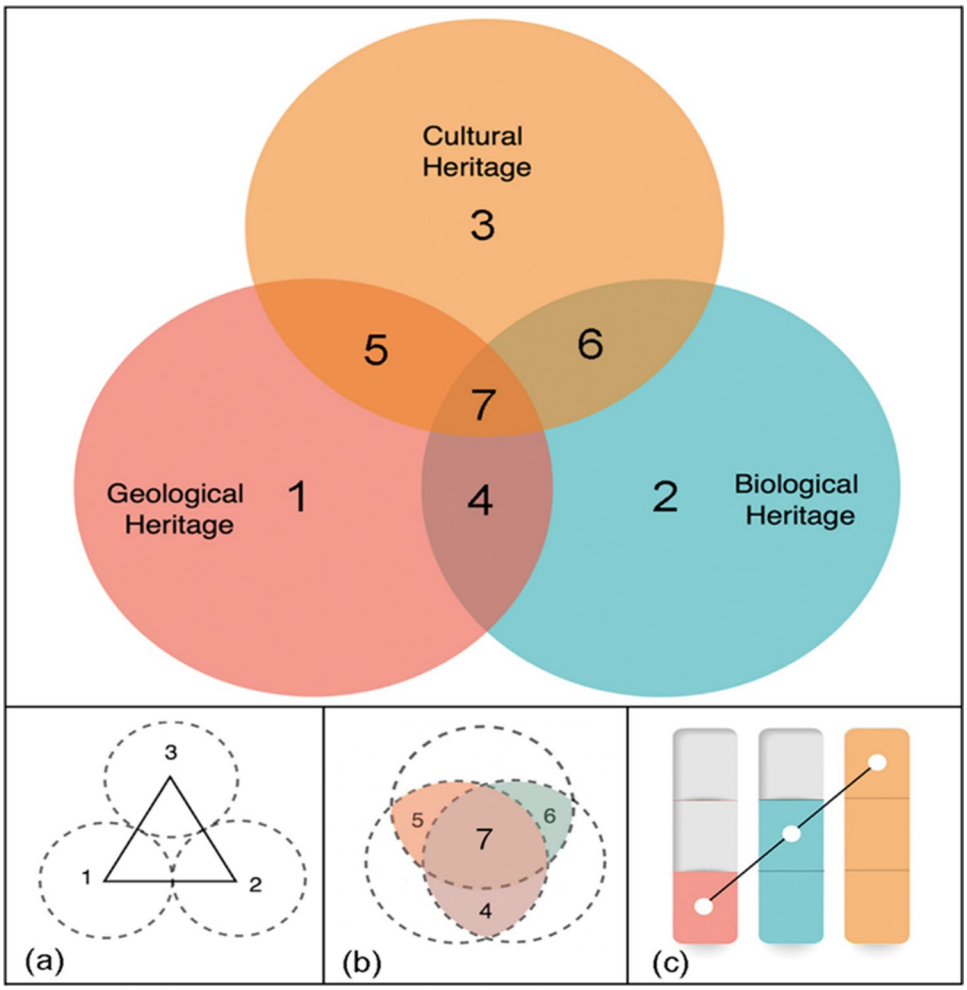

Fig. 21 Model for geotrail content development. 1, 2 and 3 are geological, biological and cultural heritage respectively; 4 = geo-bio-culture; 5 = geo-culture; 6 = bio-culture; and 7 = geo-bio/ bio-geo. Inserts: (a) current approach, in which geological, biological and cultural heritage are developed sectorally; (b) future and integrated approach for content development; and (c) indicators signifying main and supporting heritage content

three heritages of the local resources, interpretation, and the visitor experience. The outcome of the theme, concept and interpretation would be considered as more audience-centred as the tourists' perspective is emphasised within the model to ensure that the theme of the trail, content formation, and the end result of interpretation reflect the meaningful connection among the types of heritage themselves, rather than merely a branding strategy or an interpretive opportunity. Arguably, this model moves beyond mere service quality into experience quality.

Conclusion

This paper concludes by highlighting some of the complexities involved in the process of geoproduct development and proposing a way forward based on three perspectives. For LADA, the main challenge is to ensure that this innovation benefits the community as widely as possible. Thus, once a project is funded, the main goal is to achieve financial sustainability: on the one hand, more basic infrastructure and facility investment need to be made in the area, but on the other hand, the provision of long-term subsidies can undermine the ability of the local people to manage tourism projects on a proper business footing. In most trail destinations, it is crucial for management to be as financially independent as possible, especially in lean times with public budgets. Currently, no formalized agreement has been made on the management of the newly developed trail. A proper management plan needs to be formally documented in the near future for reference, detailing who is responsible for what, i.e. the responsible agencies for funding further extension and maintenance as well as the monitoring requirements to ensure that the users and service providers preserve the functionality of the infrastructure and that the services provided have clear and appropriate standards using sustainable principles.

Even with the best facilitation practices, issues that relate to the local community include the following: long-standing mistrust, fear, antagonism and disinterest, all tending to create substantial barriers for achieving meaningful and equal participation. In addition, mistrust among

the various factions of a community is endemic since any potential economic activity may be seen to benefit one subgroup of the community more, simultaneously marginalizing the others. Only through sustained communication and more collaborative efforts will most of these concerns usually be removed. This requires sustained communication and engagement to reduce conflict, while developing trust and teamwork.

In addition, although Kubang Badak BioGeoTrail was developed to be different from other trails available in the Langkawi UGGp, the community management must continue to focus on unique selling propositions so that they stay away from competing with existing trail products in other areas, e.g. Kilim and Dayang Bunting. This means that innovative forms of community participation coupled with a unique selling proposition that goes beyond marketing and selling 'the obvious' need to be initiated to create a sustainable geoproduct that can sustain benefits to the previously marginalized communities.

For the researchers, effective communication is considered necessary especially when dealing with government agencies in relation to decision-making styles, i.e. bottom-up or collegial decision making. Moreover, researchers need to expend energy on educating the community and tour operators who are more familiar with mass tourism and ecotourism than with geotourism. The greatest challenge is in sustaining a collaborative approach and inter-institutional/sectoral co-management via a common vision, identification of team members' roles, clearness of strategies, and renewal of commitments in developing a project with multiple stakeholders.

This paper has highlighted the practicality of developing a trail that meets the needs of geopark management, the community and sustainable development principles. The geoproduct development along with the stakeholders' feedback and lessons learned are documented and translated as models for future reference, especially for geoparks in developing countries. This documentation is important because while the essence of a geoproduct development, such as a geotrail may seem simple and universal in nature, different communities with different cultural contexts, sizes, climates and environments need to apply a range of trail planning strategies and developmental approaches to fit their socio-political and cultural needs. Geoproduct projects are context-sensitive and are specific to the community that envisions and creates them. In this case study, while a development authority of Langkawi UGGp, the Kubang Badak Fishermen Cooperative and a group of researchers from a national university advocated for and shared the main responsibilities in developing the product, the required planning and design of the geoproduct fully addressed the needs and vision in collaboration with the other local communities and government agencies.

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Data availability Secondary data, i.e. dossiers, reports and inventories, are available from the Langkawi UGGP office and from the respective authors. Primary data from workshops, focus group and town hall discussions is only accessible on request.

Code Availability Not applicable.

Declarations

Conflict of Interest The authors declare no competing interests.

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