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# Coastal Landscapes of Peninsular Malaysia: The Changes and Implications for Their Resilience and Ecosystem Services

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## Abstract

Coastal landscapes are not only supporting the most productive and ecologically valuable ecosystem but are also fast changing, caused by both anthropogenic and natural processes. Changes in the form of diminishing vegetation cover, water body and increasing urbanization in Terengganu, East Coast of Peninsular Malaysia, for the years of 2000 and 2017 were assessed using Moderate Resolution Imaging Spectroradiometer satellite (MODIS) product. Images were processed based on Erdas Imagine software and then projected to World Geodetic System (WGS 84) coordinates based on ArcGIS 10.0. Significant reduction is detected in vegetation cover, from 46.5% in the year 2000 to 26.6% in 2017, coinciding with an increase in urban areas (from 3.3 to 33.6%). Changes due to urbanization raise concern over the loss of coastal landscape and may impact its resilience, so it may no longer be able to provide key ecosystem services. This understudied ecosystem deserves to be conserved for its ecosystem services. The paper argues that looking at the data presented, the resilience or the capacity of the Terengganu coastal landscape in maintaining its ecosystem services in the near future might have been compromised. Recommendations on how these valuable landscapes could be best conserved for social and ecological sustainability are put forward.

**Keywords:** coastal ecosystem, coastal wetland, dune landscape, ecosystem service, land use change, resilience, socioecological landscape

## 1. Introduction

Sustainable development is a key agenda for present and future development and perhaps global concerted effort to reduce.

The concept of resilience in relation to ecology and ecosystem is defined as the ability of the ecosystem to absorb the disturbance without shifting to an alternative state and losing function and services [1]. It is often used to describe the characteristic features of a system that are related to sustainability, and the concept of resilience is used in various interdisciplinary works, particularly in addressing the interactions between people and nature. Resilience is also associated with the capacity of the

ecosystem to undergo disturbance and maintain its functions and controls [2]. For example, changes in grass species in the rangeland reduce its capacity to continue functioning ecologically (such as in water use and nutrient cycle) under heavy grazing by animals [3]. Ecosystem resilience can play a prime role in maintaining conditions that will sustain the provision of ecosystem services that contribute to the human well-being, in this case the well-being of coastal communities. The resilience of the ecosystem could directly affect the socioecological system. The objective of this chapter is to discuss the resilience of the coastal ecosystem of Terengganu, East Coast of Peninsular Malaysia, based on land use cover changes in Terengganu between years 2000 and 2017. Threats faced by the coastal ecosystem of Terengganu that may affect system resilience and ecosystem services are also discussed.

The ecosystem services concept was coined to address various benefits and values provided to humankind by ecosystems, which arise from ecological functions and biodiversity [4, 5]. The benefits and values could be direct or indirect, covering a wide range of vital goods and services that are classified into various ecological functions, for example, the provisioning service (such as providing goods or raw materials), regulatory services (such as air and water purification, water and nutrient cycling and regulation, soil formation and retention, atmospheric carbon sequestration) and supporting services. The last is the prerequisite for three other sets of ecosystem services (provisioning, regulating and cultural). However, the classification and typology of ecosystem services are varied and sometimes debatable in terms of application and relevance [6]. Nevertheless, ecosystem services as a concept are acknowledged to be an important tool to raise awareness on ecosystem's importance, particularly through identification of the goods and services made available by the ecosystem. The quantification of ecosystem services provide a monetary dimension, creating a potential link between biodiversity conservation and market value. In this chapter, we identify and discuss key ecosystem services of the coastal ecosystem of Terengganu and how it might have been interrupted by the changes.

Worldwide, coastal landscapes change tremendously due to urbanization and various other pressures both from anthropogenic-based and natural processes. Coastal landscapes are among the most densely populated zone as this zone provides enormous values and services to human population. Coastal ecosystem is commonly addressed together as 'estuarine and coastal ecosystems' (ECEs) due to their close connectivity and complexity in providing ecological services [7]. It not only holds high key economic values and vital ecosystem services but also supports integrated systems of social and ecological landscapes (SEL) [8]. At the global scale, coastal vegetation varies across geographical regions. In Malaysia and other tropical countries, there are three common vegetation types easily found in coastal zones, namely, mangroves, peat swamp forest and freshwater swamp. Coastal vegetation plays a significant role in stabilizing coastal ecosystems, for example, by modifying and stabilizing the physical environment [9]. The loss of coastal vegetation or changes in land use cover of terrestrial ecosystem could change the biomass and productivity leading to the changes in carbon cycling processes [10]. Coastal wetland reclamation causes loss in ecosystem services, for example, in Lianyungang Province in China [11]. Coastal wetland ecosystem varies in subtypes which comprises of estuaries, marshes, salt ponds, lagoons, mangroves, intertidal habitats and other coastal system subtypes. All wetland ecosystems vary in terms of unit value and ecosystem services rendered and even within the same eco-subtype; the unit value may vary with different space and time [4]. Thus, for the unit value of ecosystem services, different coastal wetland should be conserved and managed differently.

The East Coast of Peninsular Malaysia coastal plain is originated from marine-based deposit arranged in a series of ridge and depression parallel to the shoreline [12]. This soil formation is classified as "beach ridges interspersed with swales"

(BRIS) or locally known as *tanah beris* or *tanah bris*, where *tanah* is soil in Malay. BRIS soil formation is an oligotrophic type of soil, infertile and unsuitable for agriculture [13]. BRIS soil composes of more than 90% of sand (**Figure 1**). Despite that, it supports adapted and distinct vegetation formation which differs from common lowland tropical rainforest [14]. BRIS soil system occurs more abundant in the state of Terengganu relative to other states in the East Coast of Peninsular Malaysia, namely, Pahang, Kelantan and Johor. Coincidentally, Terengganu also poses the longest coast compared to the other east coast states. Being one of the main oil-producing states in Malaysia, the coastal plain of Terengganu is already well developed with coastal road, settlement and infrastructures. However, it is a worrying fact that about 30% of Malaysia's coastlines are exposed to erosion [15]. More worrying is the fact that coastline erosion or accretion is not only caused by large monsoon waves but also by a more complicated interaction of offshore bottom bathymetry and island shelters, whereby these two components become a site-specific factor that helps to focus or disperse the energy of the monsoon waves to localize erosion or accretion [16]. Coastal erosion further became more frequent, subsequent to major sea reclamation for an airport runway upgrading in 2008 [17].

In the past decades, Terengganu has rapidly developed its overall economy through the federal government's East Coast Economic Region (ECER) Master Plan that was launched in 2008 headed by the East Coast Economic Region Development Council (ECERDC) [18]. The development programs and projects, among others, aim to raise the income levels and reduce poverty of the Terengganu population by expanding employment prospects in the east coast regions. Many of the projects take place along the coast itself, for example, development of a new central business district (CBD) at the north and south estuary of the Kuala Terengganu town centre and the planned development of the 600-km east coast rail line (ECRL) planned for linking key industrial hubs in Terengganu with Kuantan Port in Pahang and Port Klang in Selangor, both to its south. Some developments in Terengganu are located on the shoreline itself, for example, hipster concept restaurants along the coast of Tok Jembal, in Kuala Nerus district. Looking at this trend, the future outlook for Terengganu coastal ecosystem is rather challenging based on the worrying fact that about 30% of Malaysia coastlines are exposed to erosion [15]. Terengganu coastline erosion or accretion is not only caused by large monsoon wave but also by a more complicated interaction of offshore bottom bathymetry and island shelters [19]. Coastal erosion then becomes more frequent as a result of major sea reclamation for an airport runway upgrading in 2008 [17]. Further development in the coastal



**Figure 1.**  
*Examples of typical soil series (Rudua and Rhu Tapai soil series) under beach ridges interspersed with swales (BRIS) system in the East Coast of Peninsular Malaysia compose more than 90% of sand.*

zone of Terengganu needs in-depth analysis on the current physical setting to reduce impact on coastal environment and community. This paper discusses coastal changes in Terengganu by looking at land use changes in terms of vegetation cover, urbanization and water body from the years 2000 to 2017 and the impact of these changes to Terengganu coastal ecosystem resilience and ecosystem services.

## 2. Changes in coastal landscapes and implications for ecosystem services

### 2.1 Ecosystem services of coastal landscapes

Among the most significant ecosystem services of coastal landscapes is perhaps coastal protection. The coastlines of eastern Peninsular Malaysia are directly exposed to the South China Sea's strong winds and dynamic coastal processes. Coastal vegetation acts as a first line of defence from physical elements of wind and wave due to exposure to the annually occurring northeast monsoon. At the same time, coastal vegetation holds together structurally loose coastal sandy soil. The Terengganu coast is also blessed with a prominent stretch of pure stand of *Melaleuca cajuputi* trees which barricade strong wind, protecting its coast and inland [20]. Having soil attributes of beach ridge system or BRIS, many parts of the coast of Terengganu also support a seasonal freshwater swamp or often addressed locally as *paya gelam* (in Malay) or gelam swamp as this swamp is dominated by gelam or *M. cajuputi*. This swamp is a seasonal wetland where its volume of water is contributed mainly by rain and to some extent by the overflow of small river tributaries during the monsoon season. Gelam swamp could support up to a 2–4 metre depth of water which is closely related to its function of mitigating flood in coastal areas and inland, particularly in the rainy season during monsoon months. Swale element in beach ridge soil of the East Coast of Peninsular Malaysia coastal plain acts as a sponge to keep subterranean water source, thus regulating local hydrological cycle [21]. Supporting one of the rarest type of wetland, a freshwater seasonal wetland (e.g. in Tasik Berombak of Setiu Coast and Jambu Bongkok, Dungun) [22]. The BRIS soil formation system plays a critical role in the local hydrological cycle, since it stores underground water and a deep layer of sand (~15 m below ground as recorded in Tasik Berombak, Setiu, Terengganu) which then act as a natural water filter and storage for clean freshwater—an important source for nearby areas becoming a part of a complex hydrological system of the coastal plain [21]. Although this kind of regulatory services carried out by BRIS soil ecosystem is hardly visible, the effect on social resilience on the local community is profound. It plays a critical role in providing adequate amount of good quality freshwater to support local economic activities of the coastal community, for example, in the district of Setiu, where the brackish lagoon is heavily used for aquaculture activities.

Other than the hydrological aspect, some part of BRIS soil ecosystem is comprised of newly developed peat, which is an important form of carbon storage [23]. Soil carbon together with above and below ground biomass of plants is a very important carbon sink. Even though above ground carbon in the biomass of *M. cajuputi* on dune landscape of Terengganu is much lower than other common Malaysian tropical lowland forests [24], *M. cajuputi* tree stand still serves as an important local carbon stock that could help in mitigating climate change effect. Carbon fixed in the above and below ground biomass of *M. cajuputi* could help reduce carbon being released to the atmosphere, thus reducing the effect of global warming. The benefit of conserving forest for carbon stock is well discussed as part of many ecosystem services of forest [4]. Sparse natural vegetation growing on

the coastal plain of Terengganu plays a vital role in stabilizing the loose structure of coastal soil, growing on both ridge (dry area) and depression (swales or water-logged areas) of sand dunes. On the ridge, vegetation is growing in the clump to optimize soil resources needed for growth and development. Removal of natural vegetation either by natural (e.g. wild fire) or anthropogenic activities (e.g. legal and illegal sand mining) may cause coastal erosion, leaving the soil prone to be invaded by exotic invasive species of *Acacia mangium* (Fabaceae) or indigenous species *Catunaregam tomentosa* (Rubiaceae) [25]. *Acacia mangium* is not yet declared as invasive species in Malaysia, but its ability to negatively affect and alter nearby plant composition in its presence, particularly through its allelopathic effect, is well known [26]. *Acacia mangium* can easily invade BRIS ecosystem due to open canopy and low stature of its vegetation that grows in clumping pattern. The abundance of *A. mangium* mother trees in and around the coastal ecosystem of Terengganu facilitates the dispersion of this species. The seed of *A. mangium* is dispersed by birds and wind and easily germinates underneath vegetation clump. Many degraded BRIS soil ecosystems along the coast of Terengganu are already invaded and totally taken over by this species [4, 20, 25]. It is well acknowledged that invasive plant species can decrease resilience by reducing the biodiversity in the ecosystem that is being invaded and eventually will interrupt key ecosystem services provided by one ecosystem [27]. However, for the coastal landscape of Terengganu, the lack of interest and awareness from local authorities may have contributed to the lack of research funding to address this issue.

Provisioning services of the coastal landscape of the East Coast of Peninsular Malaysia are closely related to support livelihoods of its fishery communities, for example, the utilization of the most abundant plant resources, *M. cajuputi* (Gelam) wood and other parts. Woods of *M. cajuputi* are processed for charcoal and poles which are used as construction material and in scaffolding for small-scale construction such as for fishing jetty and port. The bark of gelam is traditionally used to seal boat walls (caulking) [28], assisted by waterproof properties of the bark. Gelam tree is also widely planted as ornamental tree in urban areas and public parks throughout the country. The potential value of gelam in provisioning service includes the use of gelam in greening effort [29]. The tiny and abundant seed can germinate and grow well into seedlings, or vegetatively it can propagate easily using its root suckers [30]. Fire resistance of this tree provides an advantage for using this species in restoration effort. In the wild and on BRIS ecosystem disturbed habitat, postfire recovery of gelam is quickly taking place by regenerating coppice shoots, which originated from its apical buds underneath the bark [31]. Gelam provides a renewable resource of woods and poles and potentially can be used to produce *cajuput* oil, a secondary compound from its leaves which may be useful for pharmaceutical industry. The 'cajuput' oil industry is surviving well in Indonesia [32] and Thailand [33]. However, similar industry is still untapped in Malaysia or Terengganu, possibly due to low essential oil content in its leaves, about <1% of its dry weight [34]. Although *M. cajuputi* has low yield of essential oil, it is still a promising natural plant extract and is a far more environmentally friendly consumer product to replace chemical-based products [35].

Indirect use of pure Gelam stand supports healthy populations of bees and stingless bees, giving a source of sought after honey, collected by the local fishermen as their side income [36]. In swampy part of coastal plain, gelam trees act as a key species in the swampy part of coastal plain, supporting a healthy population of freshwater fishes that are commonly caught by the locals for their ornamental (e.g. tigerbarb) and also for nutritional values (e.g. catfish, snake head and climbing perch). The fishes are abundant during the monsoon season in Terengganu. There are more than 60 species of ornamental freshwater fishes recorded in the

riverine system and swamps of Terengganu [37, 38]. Other than supporting fresh-water fishes, gelam swamp provides habitat for hydrophytes (submerged, emergent, floating rooted) and woody and nonwoody associated plants. Carnivorous plants of *Nepenthes*, *Drosera* and *Utricularia* are also common at the fringe of the swamp offering a view of a montane or heath kind of flora on the lowland that is easily accessible for ecotourism or showcase [39]. A far more puzzling flora in the gelam swamp of Terengganu is the occurrence of an endemic sedge species of Peninsular Malaysia, *Websteria confervoides* (Cyperaceae), which is so far only recorded in Lake Bera (Pahang) dan Jambu Bongkok, Dungun (Terengganu). This plant depends greatly on the existence of the coastal wetland of gelam swamp and only abundant during high water level (0.5–2 m) [24]. The mechanism of how this plant could maintain its population in the dry swamp after a long drought in the dry season or non-monsoon months is still understudied and worth exploring. In Malaysia in general, intensive research on forest and vegetation are primarily focused on the dipterocarp forest for the inland forest and mangroves in the coast. It is worrying that lack of research in this similar kind of vegetation on the coastal plain of Malaysia will contribute to the poor understanding on how this ecosystem function provides key ecosystem services. Consequently, lack of knowledge about the ecosystem function may prevent us from building the resilience of this disappearing coastal ecosystem.

The ridge areas on the dune which are dryer due to its loose sandy structure surprisingly support quite a number of adapted coastal vegetation [25], including more than 30 species of wild orchids [40] (**Figure 2**). Thus, the Terengganu coastal plain could be an important gene bank for wild orchids that could support commercial orchid industry, one of the option values under the total economic valuation (TEV) [5]. The aesthetic value of this coastal ecosystem together with its natural flora, fauna and landscapes could potentially be conserved and highlighted as one of the many ecotourism products for Terengganu to add to the economic benefit to the coastal communities. This value could be a monetary trade-off for conserving Terengganu BRIS ecosystem. With all the outlined ecological values, services and potentials, gelam forest is no doubt a valuable premise for Terengganu's coastal ecosystem resilience. Maintaining healthy Gelam forests will help maintain their ecological services for the benefit of the coastal environment that supports the livelihoods of coastal communities. Rather than being seen as unproductive and unimportant, gelam forest should be conserved for their values and services. Awareness on the importance of gelam forests to the sustainability of coastal ecosystem and people should be intensified. Factors contributing to the risk faced by the Gelam forest are outlined in the next section.



**Figure 2.** Natural vegetation on dry part (ridge) of BRIS soil ecosystem on Terengganu coast with a clumping pattern of vegetation (left image) and wild orchid species, *Phalaenopsis pulcherrima*, thriving well underneath vegetation clump (right image).

## 2.2 Threats to gelam forest and coastal landscape of Terengganu

The coastal ecosystem of Terengganu is at risk of disappearing if there is no effort in conserving or managing this ecosystem in a sustainable way. Fragmentations of Terengganu coastal ecosystem are mainly due to reclamation for housing or settlement on a private land, or a development of new township and infrastructure on the state owned land. This is primarily due to its strategic location along the main coastal road, as well as on the lower terrain. Failure in seeing the values of natural ecosystem, shadowed by the lack of value for agriculture, and BRIS soil ecosystem is considered as a barren land and wasteland that deserve to be converted to other land uses. This ecosystem is also threatened by illegal chemical and solid waste dumping, as observed in many areas along the coast of Setiu (north of Kuala Terengganu) and Marang (south of Kuala Terengganu) (**Figure 3**). The lack of public knowledge about the values of BRIS soil coastal ecosystem and low civic mindedness are identified as primary causes to this problem. Lack of human presence and visible activities in the ecosystem itself also encourage the act of illegal dumping. Frequent monitoring by local authority could help reduce the incidence of illegal waste dumping [20, 25].

BRIS soil vegetation can easily catch fire, particularly in non-monsoon months or drought season (**Figure 3**) which can be of natural process and human induced. High incidence of sunray and high temperature of sandy soil surface may initiate fire naturally. Fire can also occur simply from human reckless behaviour, for example, by throwing cigarette butts into the dry and sparse vegetation on BRIS soil ecosystem. There was an extensive fire occurrence recorded along Terengganu coast [41] and several places along coastal road in Setiu experiencing fire in 2016, coinciding with low rainfall and drought in 2014–2016 [30]. Fire is one of driven factors for ecological succession [42] and sometimes needed for vegetation regeneration [43]. However, with the presence of fire-adapted species, ecosystem resilience is negatively affected [44]. This brings us to the next threat faced by Terengganu



**Figure 3.** Threats to coastal ecosystem of Terengganu, frequent fire occurrence particularly during drought or non-monsoon months (top row images), illegal sand mining (bottom row, left image) and illegal dumping (bottom row, right image).

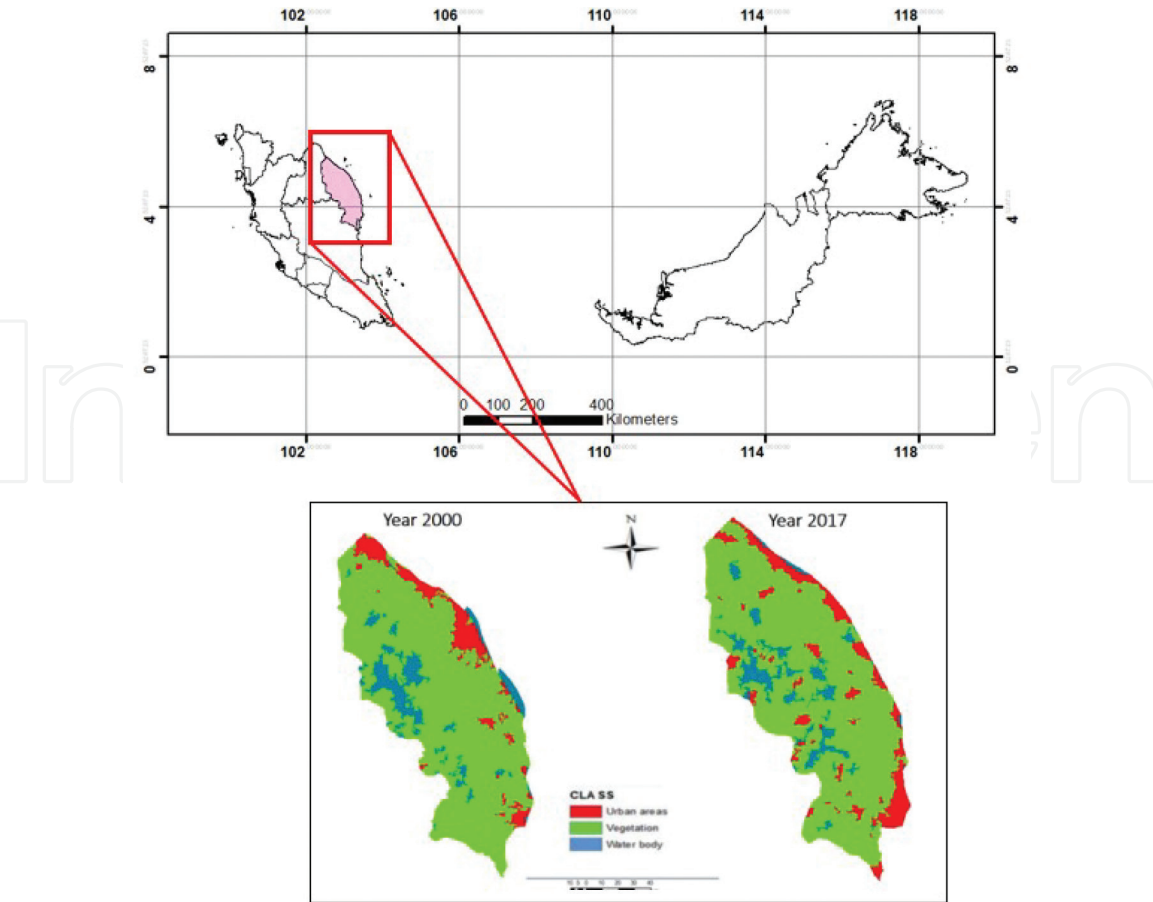
coastal ecosystem, which is colonization of *A. mangium*. It is well noted that a slight modification to BRIS soil ecosystem on Terengganu coast leads to colonization of invasive *A. mangium* [20]. Many sites of BRIS soil vegetation has been replaced totally by *A. mangium* with no sign of natural vegetation underneath. On the other hand, the natural vegetation could be replaced totally by the ferocious spiny shrub of *Randia tomentosa* (Rubiaceae). Changes in plant composition reduce the resilience of the ecosystem, whereby it is shifted towards less diverse in species [1]. This eventually affects many ecosystem services related to plant's roles, for example, in regulating soil nutrient cycle and supporting animal diversity.

The other major threat to BRIS soil ecosystem of Terengganu is sand mining, which commenced a few years back when there was a high demand for sand from the Terengganu coast as it contains high-quality silica. Sand is mined illegally and possibly being transported to the other states or countries to meet the demand. The illegal and small-scale sand mines operated by removing small patches of sand, usually not that far from the coast itself. However, there is one site being mined with the size as big as football field near Lembah Bidong in Setiu district (**Figure 3**). Experimental study at this degraded site indicates that regeneration of natural vegetation is low and occurs at a very slow rate. Thus, illegal small-scale sand mining could be interfering with key ecosystem services of the coastal ecosystem due to removal of sand and vegetation. In the case of legal and large-scale sand mining, currently Terengganu has two sites of sand mining, privately operated and declared as not detrimental to the coastal environment. However, it is doubtful that the impact of sand mining to the coastal ecosystem is low; rather, the extent of the impact is still uncertain and unknown, as the sand mining is a newly emerging economic activity in Terengganu. The hope is that this industry will be well regulated and monitored by the authority to minimize its impact on the coastal environment.

### 2.3 Changes in the coastal landscapes of Terengganu (Years 2000–2017)

Based on images of Terengganu vegetation cover for years 2000 and 2017, it is clear that the coastal area of Terengganu is changing due to urbanization (**Figure 4**). Urban area has increased from about 3.3% in the year of 2000 to 33.6% in 2017 (**Table 1**). Even though the outline data does not specifically indicate differences contributed by the reduction of coastal area, it is clear that there is an increase in urbanization areas along the coast of Terengganu in 2017. Major changes to the Terengganu coastline begin in 2008 when parts of the sea off Terengganu were reclaimed for an airport runway upgrading [17]. Such major reclamation not only caused erosion but also halted the natural accretion process by disturbing sediment transport along the coastline [45]. Consequently, episodic erosion occurred in the northern part of the Terengganu coastline, and the most recent erosion occurs in Kampung Mengabang Telipot, north of Kuala Terengganu state capital [46].

Erosion and accretion are natural processes and part of ecological coastal dynamic. However, severe erosion fundamentally indicates failure of managing coastal zone when longshore sediment transport is interrupted by engineering works such as construction of groynes and breakwaters along the northern Terengganu coast [47]; most possibly it is happening in recent breakwater establishment along the coast of Terengganu (**Figure 5**). Other possible causes of erosion are removal of natural vegetation that can dissipate the wave energy, reduction of sediment supply from engineering works in rivers such as dams and barrages, sand mining from river bed and unregulated or uncontrolled dredging and sand mining activities in near shore areas. All of these factors seem to be part of the contributing agents to Terengganu coastal erosion. It is a prime challenge for the authority of the state of Terengganu to find a creative engineering technique to solve this

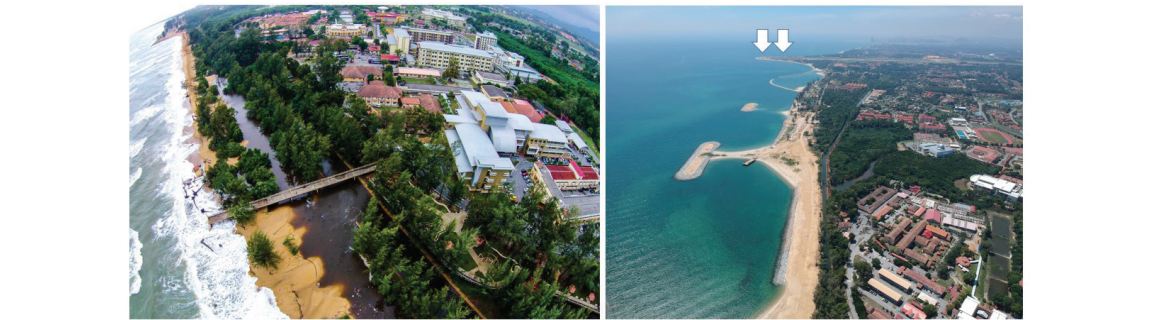


**Figure 4.** Map of Peninsular Malaysia (top row) and vegetation cover in the state of Terengganu, East Coast of Peninsular Malaysia, for the years 2000 and 2017 (bottom row). Image source: Land Process Distributed Active Archive Centre (LPDAAC).

Land Use Classification	Year 2000		Year 2006		Year 2017	
	Hectare	Percentage	Hectare	Percentage	Hectare	Percentage
Water bodies	15674.43	50.1	15477.64	53.2	13092.78	39.7
Vegetation	14547.42	46.5	15300.67	31.5	8787.50	26.6
Urban area	1038.49	3.3	4458.33	15.3	11094.25	33.6
Total	31260.34	100	29097.90	100	32974.53	100

Note: Data in hectare are extracted from satellite images obtained from the Land Process Distributed Active Archive Centre (LPDAAC).

**Table 1.** Vegetation cover for the state of Terengganu, Peninsular Malaysia, for years 2000, 2006 and 2017



**Figure 5.** Coastal erosion along the Universiti Malaysia Terengganu (UMT) campus in Kuala Nerus district, north of Kuala Terengganu (left image), and breakwaters constructed to solve erosion along north of Terengganu (right images). White arrows mark extension of airport runway in 2008. Source: Media Kreatif UMT (left image) and Mr. Mokhtar Ishak (right image).

complicated 'man versus nature' situation. To ensure the sustainability of the coast, significant efforts should be made to maintain ecological infrastructures or multi-functional network of ecosystem provided by coastal wetlands [11]. Considering the dynamics of the Terengganu coast, it is recommended that the coastal sustainable land use planning (SLUP) strategy be adopted. SLUP is evident to enhance coastal resilience, so that coastal ecosystem could continue to provide key ecosystem services, particularly for the benefit of the coastal community [8, 48, 49].

The reduction of vegetation cover in some parts of the coastal areas of Terengganu is possibly due to vegetation removal for aquaculture activities and settlement construction. In the coastal areas of Terengganu, apart from mangrove trees and associated plants, *M. cajuputi* (gelam) tree clearance is common. For example, in Kemaman and Setiu districts, pure stand gelam trees are cleared to make ways for township development and aquaculture complex, respectively. Vegetation clearance using heavy machineries is a common practice during land preparation for the construction of residential or commercial buildings. Should the sites happen to be on swampy or wet areas, sand or top soil is used to reclaim them before construction commence. In most of the state in Malaysia, regreening or revegetation of the developed areas is voluntary and not regulated. This could contribute to the loss of vegetation in newly developed urban areas. However, the reverse may happen whereby land is cleared for oil palm plantation, which then contributes to the increase in vegetation cover; albeit, oil palm plantations are a monocrop and not biodiverse. Therefore, oil palm plantations and natural stands of gelam may not be similar in quality and quantity of providing ecosystem services.

## **2.4 Impact of coastal landscape changes on ecosystem resilience and social environment**

An interesting shift that has taken place in resilience thinking that is of relevance to this paper. The premise in resilient thinking that ecological resilience is key to the management of changes occurring in complex and dynamic systems of people and nature cannot be understood if there is little understanding of the social drivers of change that contributes to that ecological resilience [50]. 'People do change the resilience of ecological systems' ([50]:p.428).

Complexity and diversity as well as fragility are deemed to be the characteristics of both social and natural systems so that responses to interventions or encroachments are unpredictable. Ecological resilience taken to mean the capacity for renewal in a dynamic environment is required in order for the system to respond to the social drivers of change, albeit in an unpredictable manner. The major social drivers of change that are most mentioned in the literature, because of their generalized presence in landscapes and regions around the world, are acknowledged to be unsustainable land use, abandonment and urbanization [51]. These some drivers are also occurring in the coastal landscapes of Terengganu, as mentioned in earlier sections of this paper.

The tendency to focus on man-made degradation of ecosystems in studies of resilience has been criticized. Instead, it is recommended that solutions should be focused on creative processes of accumulating natural capital developed and should include their intangible values. This is also due to the assessment practices that commonly focus on visible or tangible change (biodiversity loss, brittle stability, of 'an accident waiting to happen') [50]. Examples of intangible values are those associated with biodiversity conservation (for ecotourism, or for ecosystems services it renders to human populations).

Since human well-being is also linked to non-tangible (non-market values), there has been an increasing interest in cultural landscapes (heritage places, regions that

have iconic value for identity formation—nationalism—such as Mount Kinabalu for Sabahans of Malaysia, the pastoral landscapes of England and many more). These non-market values are broadly captured by the literature on ‘cultural values’ [52, 53]. We will focus on one element of cultural values, namely, identity strengthening, which is linked to a sense of place. According to [52] the concept of a sense of place ‘embeds all dimensions of peoples’ perceptions and interpretations of the environment, such as attachment, identity or symbolic meaning, and has the potential to link social and ecological issues’. An example of a sense of place, in this instance the link between the Terengganu coastal system and the identity of fishers, can be taken as an example as below.

Livelihood security of artisanal fishers of Terengganu depends on the sea—near shore and further in the open South China Sea. However, the sea provides more than livelihoods to fishers. Anecdotal evidence from newspaper clippings indicate that despite risks from coastal erosion, many local residents find it difficult to leave because they claim that they have nowhere to go [54]. As well, among artisanal fishers of the Setiu wetlands in Terengganu, despite risks from weather disturbances and being employed in more stable occupations such as in aquaculture, many fishers maintain their fishing trips out to at least three to four times a week except during severe monsoons [55]. This maintenance of their connection with the sea is what distinguishes those who consider themselves as ‘real’ fishers versus those who are not (including those who have boats and equipment but do not pursue fishing seriously). The sea then carries the intangible value of providing some fishers with a mechanism for strengthening their cultural identity. Similar findings on the effects of place (whether marine or terrestrial) and identity are evident in many studies around the world [56]. For example, in Sabah, Bajau fishers identify themselves with the inland sea surrounding the Banggi Island chain and their identity found strength in seaweed cultivation, despite the fact that fishing as an activity provided them with a higher return for hours worked than labour intensive seaweed cultivation [57].

The bio-security of Gelam forests depends on the degree of its resilience as well as the social resilience of the local communities that have lived alongside them or who are benefitted from the health of these forests. The ecosystem services provided by the wetlands and the dry swamp of Gelam forests are including uses in the construction of sea-going fishing boats. Freshwater fishes found in flooded lakes and riverine systems during the annual monsoon season provide extra source of nutrition to local communities as outlined in earlier sections of this paper. But the reverse provision of services by local communities, through their local knowledge in the sustainable management (through use) of natural resources from inland forests and seas, has not been well researched.

Consequently, a lot more research needs to be done on how local communities form knowledge about their landscapes. Secondly, given the understanding that throughout history there are very few landscapes in the world that have not been shaped by local communities [54], to what extent has local knowledge shaped the characteristics of the gelam landscape? These are valid questions to ask because despite the transformation of landscapes by drivers of development as the Terengganu coast has been, certain cultural values are not totally lost as viewed in fishers’ identity and place. As to why local knowledge research is important, there is a consensus that environmental degradation is not amenable for its solution to one body of knowledge alone but from a variety of knowledge types and disciplines.

### **3. Conclusion**

There is a reduction in vegetation cover in Terengganu from the years 2000 and 2017, and it coincides with the increase in coverage of urban areas. Even though our data do not particularly reflect specific changes to coastal areas, this reduction in

vegetation cover deserves to be addressed. It is time that the complexity of coastal ecosystem be valued as a social ecological landscape. Sustainable land use planning (SLUP) may be a good model to be adopted in managing coastal ecosystem of Terengganu. Sustainable solutions should be applied to aim for social, economic and environmental benefits. In-depth research on each component of social and ecological system and their connectivity should be enhanced to further understand coastal ecosystem resilience and assist the authority in the planning and managing of coastal ecosystem [58]. Better valuation of the landscape could be conducted to include general public perception analysis in the development planning [59]. Local knowledge of the ecosystem ought to be encouraged for their value to planning.

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## Conflict of interest

There is no conflict of interest in this publication.

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