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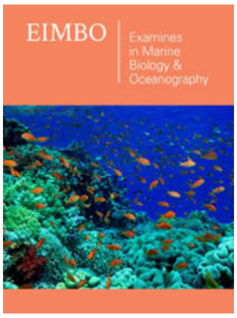
Field Based Molluscs Sampling in the Klang Mangrove Coastal Ecosystem: Baseline Observations to Support Coastal Management

Chee Kong Yap*, Tze Yik Austin Hew, Muhammad Ammar Ramlee and Mohamad Izzuddin Mohd Hadir

Department of Biology, Faculty of Science, University Putra Malaysia, Malaysia

ISSN: 2578-031X



***Corresponding author:** Chee Kong Yap, Department of Biology, Faculty of Science, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

Submission: May 12, 2026
Published: May 26, 2026

Volume 8 - Issue 2

How to cite this article: Chee Kong Yap*, Tze Yik Austin Hew, Muhammad Ammar Ramlee and Mohamad Izzuddin Mohd Hadir. Field Based Mollusc Sampling in the Klang Mangrove Coastal Ecosystem: Baseline Observations to Support Coastal Management. Examines Mar Biol Oceanogr. 8(2). EIMBO. 000683. 2026. DOI: 10.31031/EIMBO.2026.08.000683

Abstract

Mangroves are complex systems along the coastlines that offer significant ecological services while meeting human needs; however, they are being increasingly subjected to human impact in the rapidly developing areas. This narrative report outlines the physical field trips and the identification of *molluscs* undertaken on 1 November 2025 in the Klang mangrove coastal ecosystem in Selangor, Malaysia, for a Master's dissertation. The research employs an observational approach, involving the field collection of data on mangrove environment features, molluscs presence, and human activities to develop baseline ecological information necessary for coastal management. Fieldwork was done through a rented motorized boat from a local Klang jetty. The observation included mangrove fringe, tidal creek, and inland forest parts. Molluscs, including *Nerita* spp*., Telescopium telescopium*, arboreal snails, and slugs, were collected from muddy substrate, mangrove trunks, mangrove root, and woody debris, demonstrating their affinity to microhabitat structures and sediments. Parallel observations of shoreline alterations, vessel passage, industrial structures, and debris deposition provided an appreciation of the impacts of human actions on mangrove ecology. By presenting detailed field observations supported by photographic documentation, this study demonstrates that basic ecological fieldwork remains a prerequisite for understanding mangrove condition and informing sustainable coastal management. The paper argues that narrative, ground-level observations complement spatial and policy-level analyses by revealing fine-scale ecological realities essential for effective decision-making in complex coastal landscapes.

Keywords: Mangrove ecosystem; *Molluscs*; Field observation; Coastal management; Klang, Malaysia

Introduction

Mangrove systems exist in the highly dynamic boundary area between land and water and have been acknowledged to be amongst the most productive and versatile coastal ecosystems found in the tropics. Mangroves offer crucial roles in the stabilization of coastlines, sediment deposition, nutrient recycling, and the breeding habitat of various aquatic species [1]. Besides their environmental services, mangroves are crucial in regulating climate conditions via high carbon storage in living tissues and sediments, which frequently surpasses that of terrestrial tropical ecosystems [2,3]. Despite the significant benefits associated with mangroves, mangrove loss and degradation remain prevalent across the globe, especially in Southeast Asia, as a consequence of coastal construction, port enlargement, and urbanization. Under such circumstances, there is an increasing demand for practical ecological information regarding mangroves at fine spatial resolutions that can effectively depict not only the distribution of mangrove coverage but also its ecological condition. Among the many organisms inhabiting mangroves, molluscs are especially noteworthy. The roles of gastropod and bivalve molluscs in the ecosystem include processing organic debris, herbivory, bioturbation, and as prey for higher-level predators [1]. Early ecological research on Malaysian mangrove intertidal zones highlighted zonation within macrofaunal groups including molluscs influenced by tidal regime, substrate, and vegetative features [4]. Further work has emphasized the importance of mollusc communities as bioindicators, highlighting their response to alterations in mangrove structure and sedimentation [5]. The species *Nerita lineata* and *Telescopium telescopium* are pertinent to the Southeast Asian mangrove forests in particular, based on their broad range, sediment associations, and environmental sensitivity [6].

Besides being an integral part of ecological processes, *molluscs* are also intimately tied up with human activities. Many species of mangrove molluscs are collected for local consumption and use by coastal populations of Malaysia and the entire Southeast Asian region. On the other hand, some of these organisms may become the source of human contamination, depending on the environmental pollution. Indeed, previous research conducted in Malaysia has proven the ability of mangrove snails, like *N. lineata*, to bioaccumulate heavy metals and mercury in sediments and water, indicating local pollution problems and associated risks [7-9]. The relation between the concentration of metals in molluscs and its connection to human health has been explored in one Malaysian study, confirming the necessity of combining biological samples and environmental assessment when evaluating pollution threats [10]. One such coastal ecosystem where the three components mentioned above are strongly intertwined is the Klang mangrove system situated in Selangor, Malaysia. As such, this area is affected by heavy coastal development, which encompasses shipping, industrial facilities, small scale fishing, and even urbanization -all of which make the Klang mangrove system important for discussing how basic ecological fieldwork observations can impact conservation policy. While more spatially based studies have gained popularity in recent years, a need still exists for grounded case studies which will provide detailed narratives about what one can observe about living organisms directly from their habitat -the surface of mud flats, trunks of trees, and water channels. To fill in the gaps within current research, this paper provides observations from physically based sampling expeditions and the harvesting of molluscs during field work done as part of a Masters study.

Methodology

This narrative study is grounded in direct field observation and physical sampling conducted on 1 November 2025 at the Klang mangrove coastal ecosystem (Figure 1). The work formed part of the Master's research activities of Mr. Austin Hew, under supervised academic guidance, and was designed to document *mollusc* occurrence, habitat characteristics, and visible anthropogenic pressures as a foundational ecological baseline for coastal management discussions. The methodology emphasizes field realism and contextual accuracy rather than experimental manipulation, consistent with the objectives of a narrative ecological assessment.

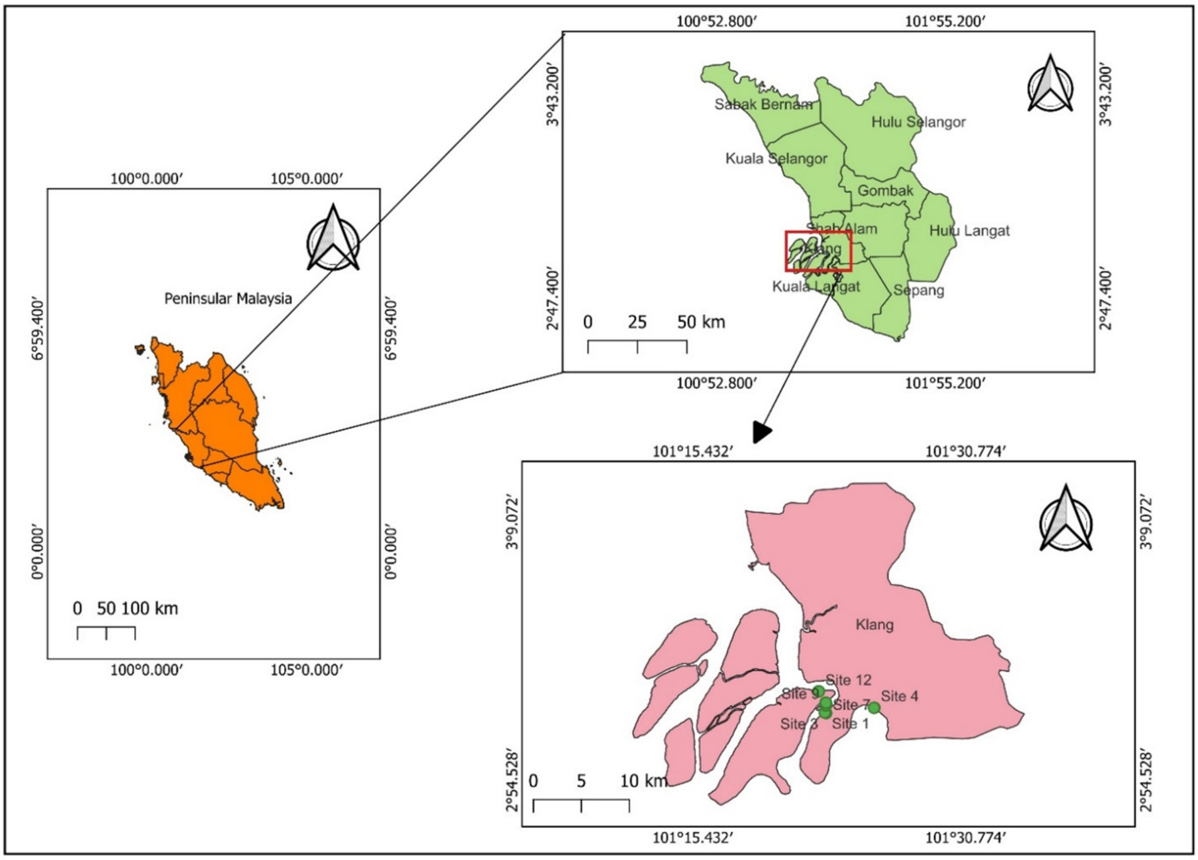


Figure 1: Observation study area in Klang mangrove area.

Study design and approach

This study employed an observational and descriptive methodology that relied on visual inspection, opportunistic biological collection, and documentation of sites via photography. The methodology was chosen due to the spatial diversity of the mangrove ecosystem and the actual circumstances in which the molluscs live in varying microhabitats such as mud, mangrove trees, roots, pneumatophores, and dead woody material. Instead of setting up transects and quadrats, observations were done in representative areas accessible using boats or foot travel, consistent with the actual process of conducting a field survey in mangroves.

Field access and logistics

Access to the study area was possible through the use of a rented boat taken from a local jetty in Klang. With the aid of this boat, the researcher could travel along the tidal channels and mangrove borders that are not accessible on foot. The use of the boat made it possible for the researcher to observe the seaward boundary of the mangroves, as well as the borders of creeks, and the areas around human-related activities such as jetties and boats. Once at a suitable landing site during low to medium tide levels, the researcher would exit the boat and enter the mangrove forest.

Mollusc observation and sampling

The sampling of the molluscs involved non-destructive and minimal intrusion techniques that were aimed at identifying and collecting the organisms using visual inspection. The molluscs targeted during the process included mangrove gastropods and slugs, which include species like *Nerita* spp. and *T. telescopium*. The arboreal snails and other soft-bodied slugs found in moist environments were also included in the target group. The molluscs were identified through visual inspection by carefully inspecting the tree trunks, exposed roots, moist soil surface, and log wood. During their collection, the molluscs were gently collected by hand after visual inspection, photography, and then kept in plastic bags with labels.

Habitat and anthropogenic observation

Parallel to the biological observations, physical and anthropogenic components were carefully noted. These consisted of sediment type, presence of waterlogging, existence of pneumatophores, forest cover density, erosion or compacted sediments. Anthropogenic influences including boat passage, construction at the shoreline, industrial presence, floating structures, and accumulated waste materials were carefully documented through photographic evidence and descriptions. The result was that ecological observations pertaining to the molluscs could be examined in the greater context of the environment and its socio-economic setting, which was consistent with the goals of the project.

Documentation and ethical considerations

Field notes and high-quality photos served as the basis for the photo documentation in this narrative work. Photography served as one of the main tools in documenting observations in order to keep track of the spatial relationships, scales, and habitat affiliations of the observed objects. Fieldwork was carried out in accordance with ethical standards of conducting research in nature, implying non-destructive treatment of the organisms and the environment, appreciation for the natural setting, and clear indication of the purpose of sampling. The nature observation served as an activity within the context of Master's studies.

Result

Figure 2 illustrates the Klang mangrove ecosystem viewed from its seaward limit, highlighting features such as shoreline morphology, plant structure, sediment characteristics, and human interaction. In the upper left figure, the mangrove shoreline can be seen as a gently curved coastline featuring an extensive and connected canopy. The trees grow slightly towards the sea, while there is evidence of water coverage on the intertidal mud, implying that the area is at mid to high tide levels. There is also little movement of waves, which means that it is a sheltered zone with mangroves acting as natural buffers along the coast to reduce hydrodynamic forces. In the upper right figure, exposed root systems appear to dominate. The roots of the mangrove species are seen growing out of compressed muddy sediment and forming a complex matrix near the surface level of the sediment. This demonstrates that the area is actively involved in trapping sediment and organic material. The lower left figure shows another section of the coastline, which reveals erosion along the mangrove bank. The shoreline is characterized by exposed muddy slopes extending into the water surface. Additionally, the sediment near the water shows signs of recent displacement. The mid-right image depicts a more lateral view of the mangrove forests lining the waterway, creating a continuous green corridor that has an even canopy height. A darker strip can be seen near the base of the trunk and sediment zone, which shows the shift from the wet substrate environment to the aerial plants above. Lastly, the lower-left image captures the appearance of mangroves located right next to the water's edge, where the lower parts of the tree trunk and roots are partially covered by water. The water is slightly murky, suggesting that there are fine sediments suspended in the water, and this is characteristic of the estuary environment.

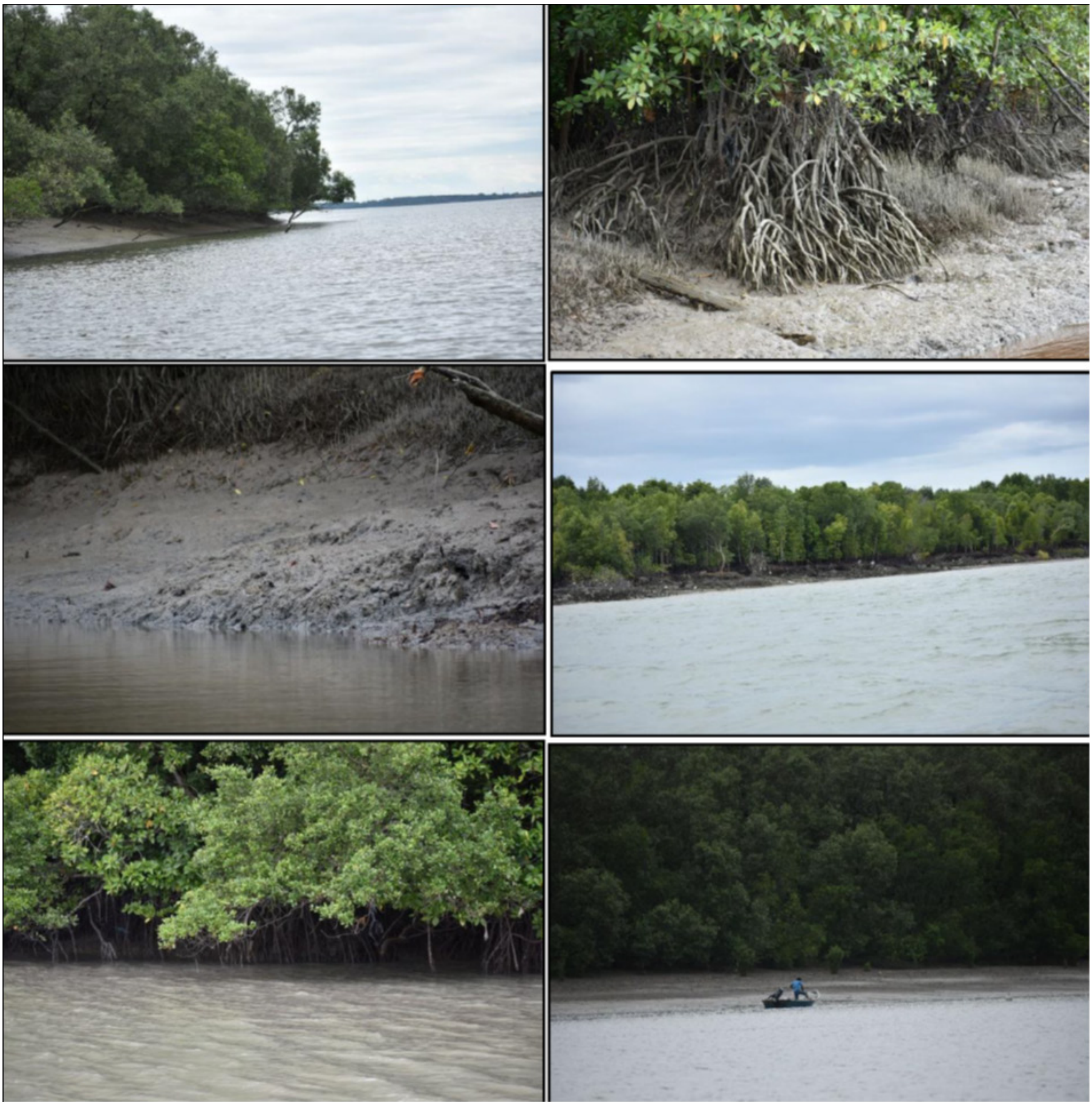


Figure 2: Klang mangrove tree ecosystem from the sea view.

Finally, the lower-right image shows a boat sailing along the mangrove border as a form of scale reference for human use of the ecosystem. The shallow water level and mudflats are evident near the mangrove boundary, thus confirming that it is currently low tide. Figure 3 demonstrates the variety of molluscs collected within the Klang mangrove habitat, showing the relationship between them and various substrates as well as vertical zones in the mangroves. A sessile gastropod is shown firmly attached to decaying wood in the top left picture. The appearance of the encrusted shell points to prolonged contact with the tidal water and deposition of sediment on the shell, which suggests that decaying fallen logs of the mangroves constitute stable microhabitats where molluscs can attach to and establish themselves. A dark-colored mollusc in the top right picture is seen on the exposed bark of mangroves. Such compact form of the shell combined with attachment to the bark suggests an adaptation for life on the surface and desiccation resistance; micro-crevices of the bark would be suitable hiding places during low tide periods. A conical gastropod buried in the mud along with pneumatophores is seen in the middle-left picture; its body posture and partial embedding suggest that this is an actively moving species that emerged from the mud recently. A bivalve shell seen in the middle right picture is used as a scale. This finding points towards the existence of benthic infaunal communities inhabiting fine sediments, and it shows the ability of the mangrove molluscs to be collected not only by scientists but potentially even by locals.

Figure 3: Molluscs found and collected at Klang mangrove ecosystem.

In the lower middle left picture, a snail is fixed in the upright position on a mangrove branch in relation to the muddy bottom. It can be seen that such positioning is an adaptive strategy aimed at ensuring the animal's survival during the tides, which will allow it to stay out of the water and avoid excess silt accumulation. This kind of vertical zonation can be considered evidence of niche specialization in the mollusc community within the mangrove system. The lower middle right image depicts several bivalves situated in a group around the roots of a mangrove tree in mud. Lastly, the lower left photograph captures a gastropod that has a ribbed structure, which is clinging to the bark of a mangrove trunk; the prominent shell ribs can provide better attachment and prevent dislodgment by the tides. The shell-bark contrast illustrates the structural complexity of living substrata formed by mangroves. The bottom right photograph captures a dark-colored, flattened mollusc, which is clinging on to a mangrove trunk lying flatly, thus creating a permanently moist microenvironment. Its flattened shape is an adaptation to cope with water currents and sediments in its environment. Figure 4 shows the sampling points of the Klang mangrove ecosystem where the molluscs were sampled, showing the various interior, transition and fringe habitats that have been sampled during the field work. The first picture on the left shows an interior mangrove forest with thin trunks, intertwining branches and thick undergrowth. The forest floor consists of muddied ground covered with a number of pneumatophores rising out of water saturated sediments. This is representative of a typical mid-intertidal forest habitat, which served as the collection point for the samples collected on the surface and on the tree trunks and exposed roots.

Figure 4: The sampling sites at Klang Mangrove ecosystem where the *molluscs* were collected.

The second image on the right shows a pneumatophore dominated microhabitat where many root protrusions can be seen emerging out of compressed soil. Young mangrove saplings can also be seen as well as some low branches that extend horizontally. This is an active mangrove habitat that has developed adaptive characteristics to allow oxygen exchange. On the panel located on the middle left, there can be seen the high density of juvenile mangrove stands growing underneath a fully-grown canopy cover. Given the high number of young plants, it can be inferred that there is active regeneration going on in the area. In terms of mollusc collections in this habitat, the emphasis was made on sampling molluscs in muddy grounds and lower parts of the stems because they provide suitable habitat conditions owing to accumulation of organic matters and low energy of water flow. As for the middle right panel, it depicts the forest floor with an accumulation of dead trees and roots which act as natural barriers preventing erosion of soil. In the lower left picture, a narrow tidal creek cutting across the mangrove stands is shown with dense prop and stilt roots on both sides. The presence of shallow water and muddy substrates suggests regular flooding. Molluscan sampling was conducted in areas near the edges of the creek and root bases, where nutrients can easily be exchanged between the water and the sediment. In the final picture at the bottom right corner, there is a fringe of mangroves facing towards the sea, giving way to intertidal mudflats beyond. Driftwood and debris litter the fringes of the mangrove area.

The image presented in Figure 5 depicts the process of conducting sampling within the Klang mangrove ecosystem in respect of the method adopted and conditions associated with collection of molluscs. For example, in the top left-hand in Figure 5, the scientist is depicted walking through the interior of the mangrove forest wearing protective clothing. The muddy, rugged floor with numerous fallen tree limbs and vegetation provides evidence of challenging physical conditions necessitating careful footwork and controlled movements in order to reach the sampling microhabitats within the mangrove. The image on the top right-hand corner depicts the researcher walking farther into the interior of the mangrove while carrying sampling tools. The tall vertical tree trunks and open understory suggest the mid-intertidal mangrove forest region. The middle-left photograph shows an example of close-up manual inspection of a mangrove tree trunk. The body position and hand orientation of the researcher suggest that they are carefully inspecting the bark surface for any crevices that could harbour molluscs attaching to them at low tide levels. This photograph underscores the importance of the mangrove trunk as a vital vertical microhabitat for epifaunal molluscan organisms. In the middle right photograph, a probing or measuring tool is used on the mangrove tree trunk, representing a uniform method of sampling used throughout the study. This method helped achieve standardization and minimized physical harm to the tree.

Figure 5: Sampling of molluscs activities at Klang mangrove ecosystem.
Note: Collectively, this well documented the field-based sampling workflow carried out by Mr. Austin Hew, whose dedication and physical effort were essential for obtaining representative molluscs samples from the Klang mangrove ecosystem. The panels highlight both the ecological complexity of the mangrove environment and the disciplined methodology required for reliable molluscan sampling under challenging field conditions.

In the lower left photograph, a set of collected molluscs is observed lying on a gloved hand. It can be seen that the shells of these molluscs have been covered in mud, showing their recent detachment from their natural substrate. Gloves are used to protect researchers' hands in the field from potential hazards while allowing them to easily inspect and identify the molluscs' morphological features. Lastly, the lower right photograph shows collected molluscs being placed inside a labelled plastic bag hanging from the sampling apparatus. Figure 6 below shows various examples of human-induced changes that have been noted within the immediate vicinity of the Klang mangrove ecosystem. In the upper left box, human intervention is noted in the form of active land modification through the use of mechanical equipment within the mangrove boundary. An excavator is clearly illustrated in action in what seems to be sediments at the fringes of the water body, which indicates dredging or even reclamation operations. It is clear from the image that there is an effort to remove and redistribute the sediments from the shorelines. On the other hand, in the top right box, there is noted the presence of power transmission lines alongside some industrial facility located at the fringes of the mangrove system. This indicates the presence of an industrial complex and a clear alteration of the natural shoreline by the construction of artificial barriers in the form of embankments. As shown by the middle-left panel, there are some floating objects within a mangrove-lined waterbody. This clearly shows that there is direct human habitation within or around the mangrove ecosystem, thereby implying that the area has been used for multiple purposes, although the presence of such floating objects brings about disturbances within the habitat caused by human beings.

Figure 6: Anthropogenic activities observed near the Klang mangrove ecosystem.
Note: Collectively, this well illustrates a gradient of anthropogenic activities ranging from small-scale traditional livelihoods to large-scale industrial and infrastructural development occurring in close proximity to the Klang mangrove ecosystem. These observations provide important environmental context for interpreting ecological conditions, including potential stressors affecting molluscan communities and mangrove health.

From the middle-right panel, it can be seen that there is some small fishing boats tied up close to simple stilted structures along the muddy shore. From the wooden poles used to tie the boats, it is clear that there have been traditional practices within the area that involve fishing, especially in mangrove-related areas. This shows a minimal human impact on the mangroves. Finally, from the lower middle-left panel, a boat with different materials sailing down the waterway can be seen. On the middle right image, the huge cranes and other equipment used for constructions take over the shoreline, indicating significant industrial activity or development in the region. The level of such constructions indicates the high level of coastal modifications and possibly some impacts that could be expected in the form of alteration of water quality, increase of noise pollution and sediments movement in the surrounding mangroves. On the second image at the bottom left corner, we see an industrial dock area with cranes and ships at the river banks where built-up structures have replaced the natural shoreline. The third image on the bottom right corner shows us the cargo ship near the port facilities close to mangroves.

Discussion

Mangrove environment and *molluscs*

Figure 7 illustrates the conceptual framework of the relationships between the functional aspects of the mangrove ecosystem and the molluscs community. The essential ecosystem functions like sediment stabilization and nutrient cycling are classified as ecosystem services, indicating the importance of the mangrove ecosystem in substrate stabilization and biogeochemical cycles. The physical factors like tidal circulation and bank erosion result in the development of heterogeneity in the habitat mosaic, leading to the creation of a variety of micro-habitats along the intertidal zones. The molluscs are considered as the important biological element in the system playing the ecological role, serving as an indicator and demonstrating contaminants present in the sediments and water. Thus, all these interrelated factors indicate that the functioning of the mangrove ecosystem cannot be detached from the fauna of the ecosystem, particularly the molluscs. Mangroves are not just vegetation zones, but ecosystems that play an integral role in sediment dynamics, nutrient cycling, and shoreline stabilization, all while sustaining food chains. The provision of ecosystem services by mangroves depends highly on factors such as structure, hydrology, and sediment dynamics, leading to a mosaic of micro-habitats along the intertidal zone [1]. This is particularly important for mangroves in Southeast Asia since they typically border commercial ports, fishing hamlets, and fish farms. Physical controls like sediment grain size, organic matter content, and oxygenation are highly relevant due to their effects on the composition and function of the intertidal zone, affecting intertidal macrofauna such as molluscs [4].

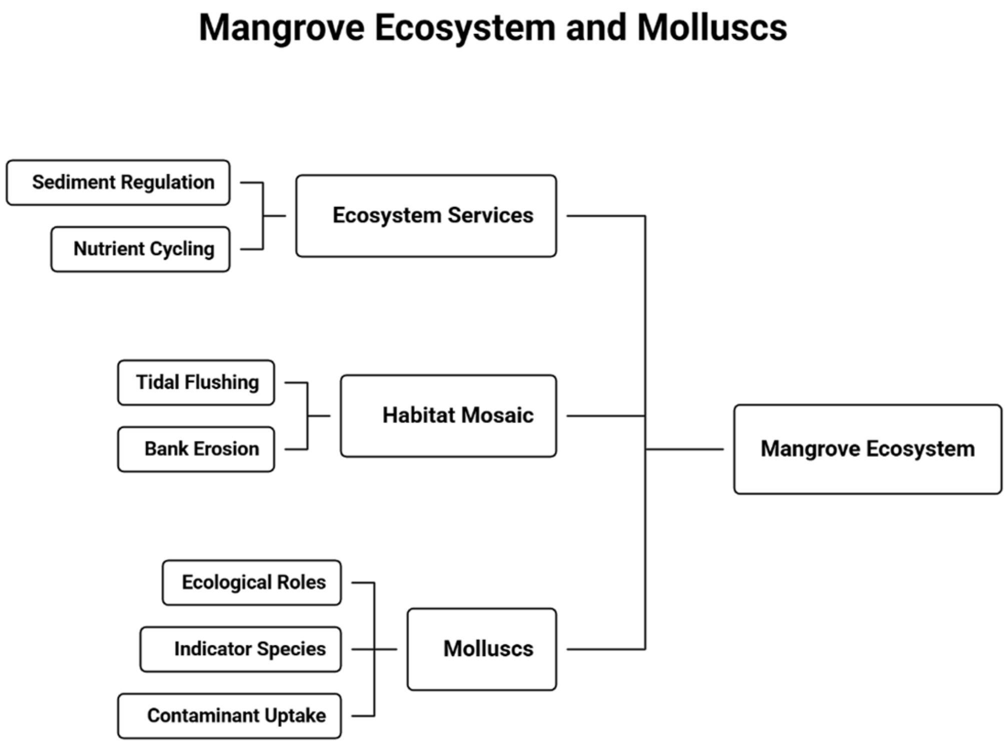


Figure 7: Conceptual framework illustrating the relationships between the mangrove ecosystem and molluscs.

It is crucial to understand the importance of the field photos and samples of the mangrove habitats in the Klang mangrove area because they depict the real situation of the substrate in which the molluscs live, feed, and reproduce, rather than considering the mangroves as simple green patches on a map. In the mangroves, molluscs play roles in the ecosystem through grazing, decomposition of detritus, bioturbation, and prey items for fish and birds. Ecological baseline studies done at mangroves almost considered as pristine conditions have proven over time the importance of using crab and molluscan macrofaunal species richness and assemblage patterns as important biological indicators of mangrove status and change into the future [5]. The classic study by Sasekumar [4] of Malayan mangrove shores also proved the existence of a predictable vertical distribution pattern of macrofaunal assemblages. Clearly indicating that the "where" part of field surveys and sampling are an integral part of sound science. They clearly depict the vertical zonation cues, prop roots, pneumatophore fields, soft muddy substrates, and compacted banks that influence the distributions of gastropods and bivalves. The mangrove gastropods depicted in the figures are ecologically significant based on the fact that they are widely distributed, intertidal, and highly connected with the sediment and detrital fluxes. The *T. telescopium* has been regarded as a typical gastropod in mangroves in Southeast Asia. Several ecological studies have shown that their populations correlate with changes in mangrove habitats [6].

From the standpoint of surveillance, the use of such snails is practical since they link sediment habitats to biological transport pathways. The latter point is especially significant since in mangroves, contaminants tend to be held in fine sediments and organics, and the divide between "environment" and "food web" takes place on the surface of the mud itself. In Peninsular Malaysia, for example, studies involving *N. lineata* have proven its effectiveness in identifying metal availability and distribution in the intertidal zone [7]. Further studies have additionally revealed that *N. lineata* is capable of accumulating various metals and methylmercury, and the patterns of such accumulation depend upon sedimentation and environmental factors at specific sites [8]. All of this corresponds to the logic described above: Field surveys and targeted biological sampling are necessary prerequisites of coastal management since they provide an evidence base derived from biological interactions. In short, mangrove *molluscs* are not "add-ons" to mangrove studies. They are living recorders of habitat quality and stress, and they make the basic science of field sampling directly relevant to management decisions [1].

Socio-economy

The role of nexus thinking as an effective tool for connecting ecological insight with the process of governance to resolve problems related to mangrove management is highlighted in Figure 8. The conflict amongst the stakeholders regarding their different priorities for using the mangroves is considered a crucial factor that constrains the governance process, whereas the desirable goal of sustainable mangrove management involves the maintenance of ecological sustainability, equity among individuals, and economic sustainability. Nexus thinking holds the critical place between the two opposite sides by focusing on the importance of integrating ecological insights and stakeholder collaboration. Together, these elements underscore the need for interdisciplinary and evidence-based approaches to reconcile competing demands and achieve long-term sustainability in mangrove ecosystems. Mangroves have sustained human activities in the form of fisheries, harvesting, protection of shorelines, and cultural practices. Valuation studies of ecosystems point out that there is significant variability in the services provided by mangrove ecosystems, depending on the ecology as well as the socio-economic profile of the people living around them [11]. The variability in the case of Southeast Asian mangroves is not purely theoretical; it can be seen from the differences between the areas where artisanal fishing and harvesting of shellfish occurs versus the restructured areas due to the presence of ports, industries, and fish farms. Hence, while listing the "services," socio-economic issues should take into account field observations.

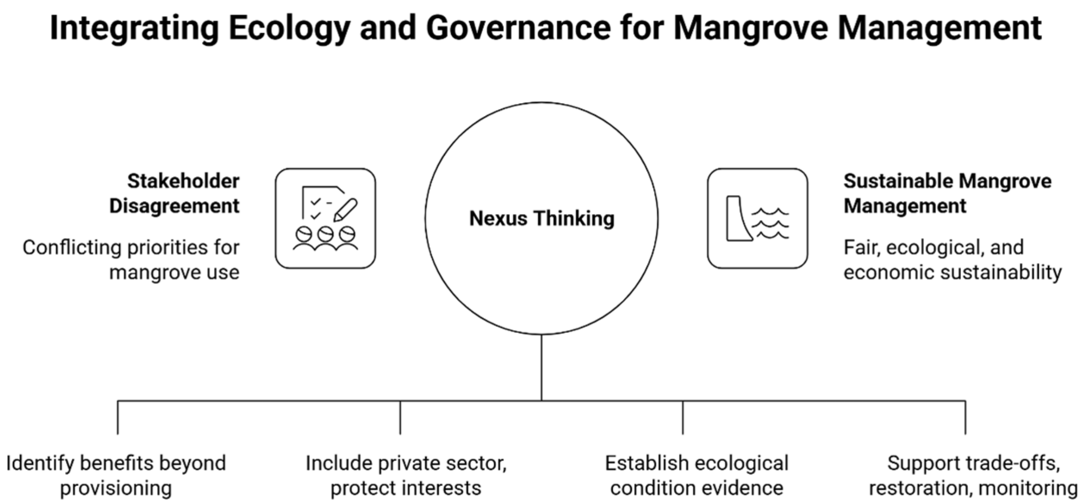


Figure 8: Conceptual framework for integrating ecology and governance in mangrove management through nexus thinking.

The application of nexus thinking in framing mangrove management as interactions between resources, stakeholders, and alternative paradigms is one such instance from the Klang. In the case of the Klang Islands, stakeholder consultations revealed that the community could find additional advantages apart from providing provisioning services, and the need for managing resources efficiently entails incorporating high-influence agents like the private sector without compromising the welfare of high-dependency groups with low-influence capacity [12]. The underlying theme in this narrative paper is that sampling and displaying species and habitats using figures forms part of compiling the scientific knowledge base necessary for engaging different stakeholders. If there is any divergence of opinion among communities, agencies, and the private sector on resource use priorities, there is a need for a ground truth on ecological status. For the broader region, research into livelihoods indicates that mangrove modification and shifts, particularly those involving aquaculture growth, may alter the vulnerabilities of households and diminish the common pool resources available to poor communities [13].

This is relevant for Klang because the evolution pattern of urban coastlines frequently converges several drivers into one environment, encompassing land use modification, engineering of shorelines, and modification in access rights. In these circumstances, molluscs acquire social significance not merely as biodiversity components but as food sources and livelihood activities. Whenever gastropods and bivalves are collected for subsistence or commercial purposes, habitat deterioration and contamination take on a direct correlation with household well-being and risks. In terms of governance, international assessments have found that mangroves managed by local communities may prove feasible if sustainability principles from an ecological and economic perspective are taken into account, as well as benefit distribution [14]. This becomes particularly important for Malaysia since there are instances where there will be overlapping jurisdiction and many stakeholders involved, from the fishing community to port authorities. The paper thus allows the trips to be used as a mediator in governance issues, with the ecological data gathered about molluscs and sediment as tangible evidence that can facilitate discussions about trade-offs, restoration, and monitoring of compliance [12,14].

Anthropogenic impacts on the Klang mangrove ecosystem

The diagram shown below (Figure 9) presents the most important routes by which human actions exert their effect on the Klang mangrove ecosystem. The extension of coastal development and engineering practices is associated with habitat modification. This is directly related to physical changes and decrease in the size of mangrove ecosystems. Boats and changing patterns of land use contribute to changes in hydrodynamics. They include variations in tides, waves, and sediment transport in mangrove habitats. The natural ability of mangroves to trap sediments is combined with the ability to retain contaminants. This leads to sediment alteration. Moreover, human activities in the form of discharges from urban and industrial sources provide contaminants, which enter the system of mangrove sediments and water. Anthropogenic stressors within mangrove ecosystems frequently act through a limited number of physical mechanisms: habitat loss, hydrodynamics alteration, changes in sediment composition, and pollutants input. In numerous Malaysian coastal regions, development pressures do not act independently but form part of a series of actions, such as coastal development, shoreline alteration, boating, and changing land use patterns within adjacent watersheds. There is strong evidence based on remote sensing and site level research in Malaysia that coastal development can result in a reduction in mangrove vegetation over time, and more than one agent may cause degradation [15]. Klang will have its specific setting, but the agents remain similar. Once the mangrove edge has been disrupted, the ecosystem loses its ability to retain sediment, hold coastlines together, and create suitable niches for intertidal organisms.

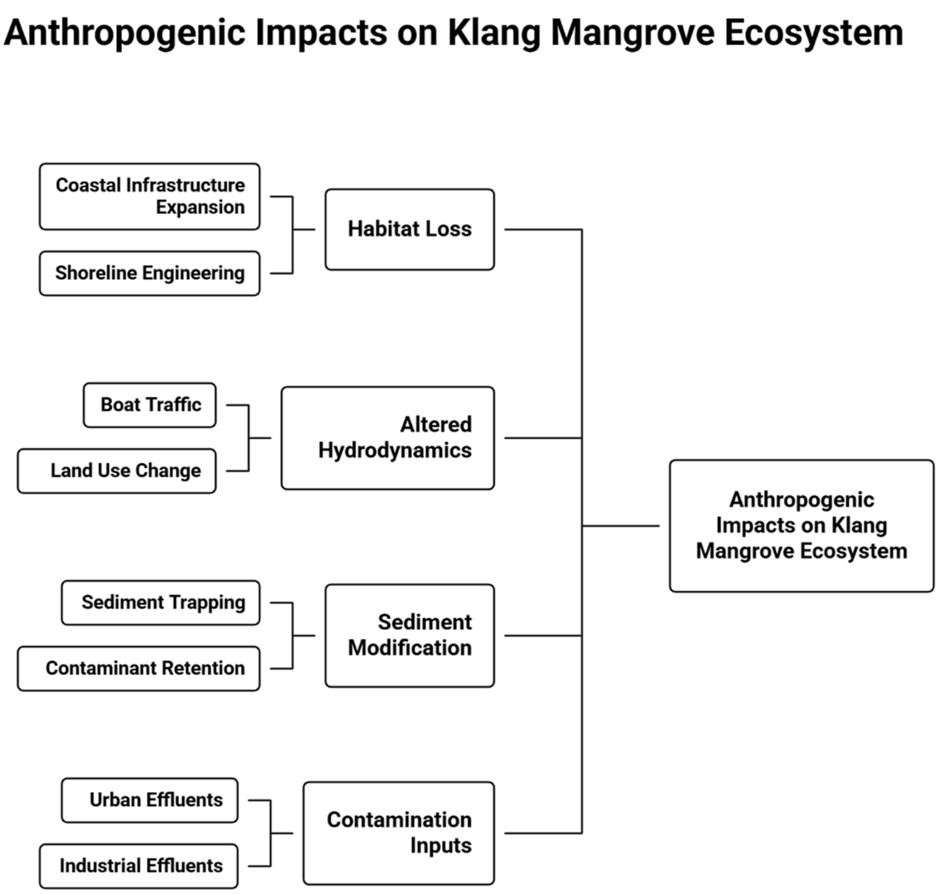


Figure 9: Conceptual framework illustrating major anthropogenic impacts on the Klang mangrove ecosystem.

The effects of urbanization and heavy utilization of the coast make it more likely for the area to receive continuous inputs of pollutants, such as metals, and these are known to settle in sediments. The mangrove ecosystem acts as an effective sediment trap, and while this is advantageous in terms of coastal stabilization, it can also become an effective pollutant trap when effluents from industries and cities get into the ecosystem. The diagrams illustrating the muddy substrates, tidal channels, and sampling stations are crucial in that they provide evidence of the compartments that are responsible for retaining pollutants. The ecological importance of this finding is that the quality of habitat could deteriorate without affecting the visible canopy of the mangroves. The climate change-induced threats could serve to magnify human effects by exposing them to hazards and disrupting sediment dynamics, but in most of the mangrove environments, the biggest threats arise from the local threats themselves, which erode their ability to withstand shocks. The ability of the mangroves to protect coastlines and stabilize shorelines arises when they remain at sufficient coverage and health, thus making their preservation a realistic means of protecting coastlines instead of just being a catchphrase [1]. When the coverage of the mangroves is threatened through deforestation and fragmentation, such benefits cannot be sustained. In the case of Klang, it assumes added importance due to proximity of settlements to the coastline. Lastly, the long-term benefits of mangroves are being increasingly evaluated from a carbon perspective as well, thus giving yet another reason for the conservation of mangrove ecosystems. Mangroves have been found to store high amounts of carbon, and their destruction results in huge carbon emissions along with other ecological consequences [2,3]. While the narrative paper emphasizes sampling and molluscs, the carbon component can be used to further substantiate the claim that "basic field ecology" is not a secondary matter.

Anthropogenic impacts on *molluscs* communities

Figure 10 shows how human-induced environmental changes result in biological effects in mangrove-associated mollusc populations. Environmental change as a result of erosion, compaction, and water flow alteration leads to habitat alteration that impacts the availability and quality of substrate for slugs, *Nerita* snails, *Telescopium* snails, and other mangrove-associated *molluscs*. Furthermore, molluscs are viewed as important bio monitors because of their proximity to sediments and surface water, which means that they can provide information on the condition of the environment and the bioavailability of contaminants. The diagram also underscores the connection between metal contamination and food security, pointing out that pollution in molluscs may have adverse health implications in the case of harvesting and consumption of these animals. Changes in the abundance, size distribution, species composition, and contamination load of molluscan communities represent a response to anthropogenic stress. If there is physical modification of the habitat by means of erosion, compression of sediments, or modification of the water flow, the populations of snails and bivalves could be reduced or relocated since their resources for food and shelter are affected. In baseline studies conducted in mangrove forests in Malaysia, it was found that the indices derived from the macrofauna community are useful tools for monitoring purposes because these measurements include the condition of the habitat itself [5].

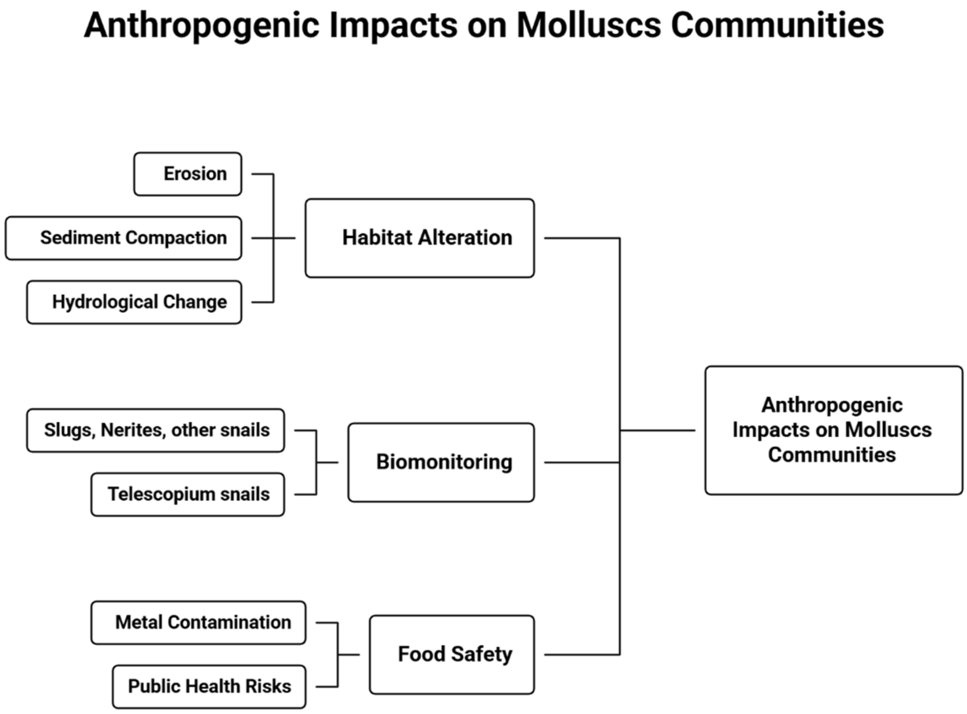


Figure 10: Conceptual framework summarizing anthropogenic impacts on molluscs communities in the Klang mangrove ecosystem.

Regarding *N. lineata*, Malaysian studies are especially strong at proving the utility of the species for metal biomonitoring and bioavailability assessment at intertidal habitats [7]. Such research is significant for Klang due to the fact that anthropogenic influences usually involve industries and maritime transport near the coastlines, which leads to metal contamination becoming a problem in sediments. The more recent publications confirm that *N. lineata* is able to accumulate several metals and methylmercury, and their accumulation can vary according to particular sites, making *N. lineata* a reliable biological indicator [8]. Within the framework of a narrative sampling essay, such references can be used to argue that sampling *N. lineata* is justified not only from the standpoint of biodiversity preservation but also from a scientific viewpoint. Regarding *T. telescopium*, from ecological studies conducted in Southeast Asia, the association of this species with features of the mangrove habitat has been documented, showing their capacity to describe habitat conditions depending on whether an area is disturbed or not [6]. This finding corresponds well with the focus on snails and mangrove mud in Figure 2. Given the detrital nature and sediment connection for T. telescopium, it follows that any effects related to alteration in quality of the organic matter, microbial processes, and sediment itself can be manifested at population levels. In other words, variations in distribution of this snail species cannot just be seen as “natural variations.” Other human-induced stressors include impacts on molluscs via food safety and perception pathways. The case of contamination when the mangrove snail is consumed as food illustrates how contamination not only affects the environment but also creates a trust issue among consumers. Research linking metals found in mangrove snails to human health risks is a useful example of how mollusc testing can be justified as a practice that has implications for public health [10]. This is even more applicable in Klang where routine sampling and reporting should be supported by information dissemination to the communities harvesting the molluscs.

Recommendations for Klang ecosystem management

Figure 11 below shows a stage-by-stage mangrove management approach showing the progression from the present situation, where there is disorganization in using and developing the mangroves, towards a managed and sustainable Klang mangrove ecosystem. The steps shown show the creation of the initial infrastructures through biomonitoring and habitat mapping. Next is the involvement of all stakeholders through a mangrove management platform. Further on in the process is the incorporation of ecological thresholds and safety measures within any coastal development plans, along with presenting the economic case for conservation efforts that also contribute to sustaining the livelihoods of communities living around the mangroves. All these aspects, when viewed together, show that mangrove management is a process that involves gradual growth. First, field sampling and biomonitoring of selected species need to be considered an essential part of the infrastructure for decision making rather than an optional scientific pursuit. A practical suggestion is to develop a monitoring program that would integrate habitat delineation with systematic sampling of target mollusc species and sediment at representative zones. This is underlined by baseline ecological reasoning in which the distribution of macrofauna is dictated by shore level and microhabitat requirements [5,7]. Thus, the implementation in Klang requires sampling on gradient locations close to human interference and reference sites with regular sampling times in each season. Using *N. lineata* as a biomonitor of metals bioavailability is supported by scientific evidence from Peninsular Malaysia [7], while other tests could be included when methylmercury and multi-metals are suspected [8].

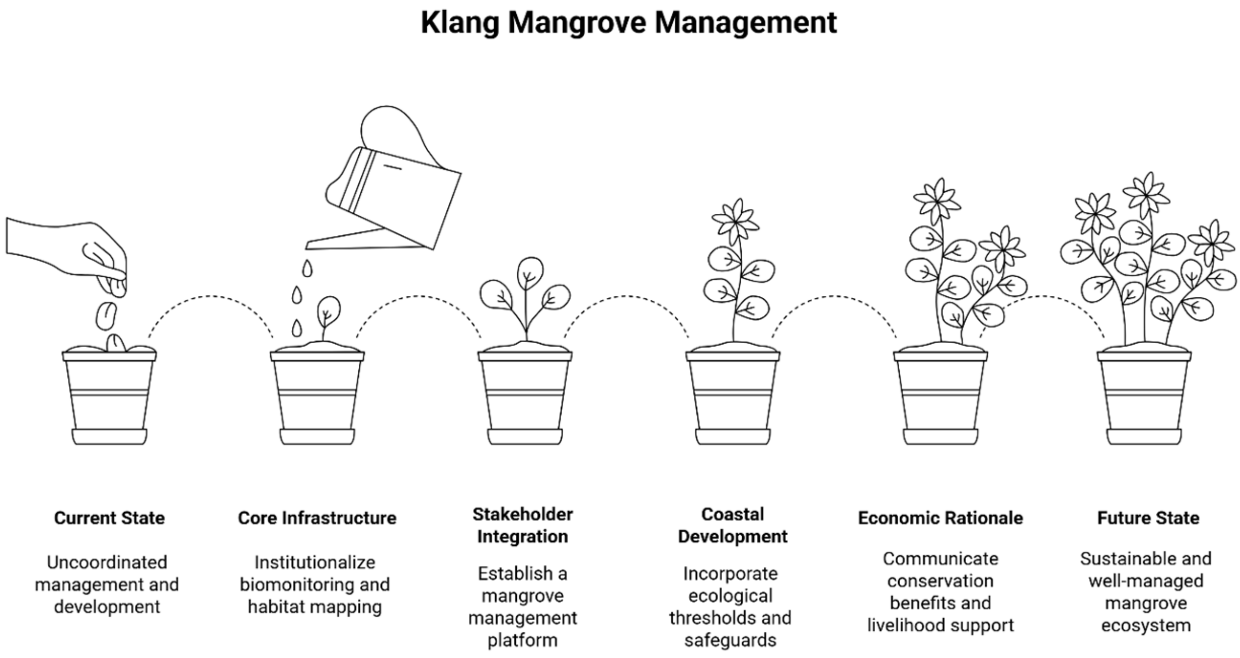


Figure 11: Conceptual pathway for sustainable management of the Klang mangrove ecosystem.

Secondly, governance needs to take into consideration the fact that Klang mangroves represent a socio-ecological interface. The participation of all stakeholders is not just a buzzword but an operational necessity where those with significant power need to be brought on board along with the local communities and resource users [12]. In this regard, what can be recommended is that a Klang mangroves management platform is formed which comprises all relevant agencies and stakeholders from the private sector with clear indicators for monitoring and information exchange. Thirdly, coastal development planning needs to account for ecological thresholds and protection zones based on experiences in other regions within Malaysia that experienced development pressure correlated with reductions in mangrove cover [15]. This is important because it means that environmental impact assessments will have to account not just for canopy cover reduction, but also for functional degradation indicators like sediment characteristics and macrofaunal condition. Similarly, development plans need to consider bank stability in boating and shore construction activities, as mechanical disruption can cause habitat and macrofaunal loss even if the forest is still standing.

Finally, managers in Klang need to explain the economic case for conservation and restoration with the understanding that there is variability of impacts. Studies into regional valuation have shown that mangrove services are valuable but highly variable due to biophysical and socio-economic factors [11]. In terms of livelihoods, experiences in Southeast Asia suggest that greater expansion of aquaculture practices and resource access will create inequalities and make poor households more vulnerable [13]. This indicates that considerations such as livelihood-sensitive measures should be made by recommending livelihood activities through alternative sources of income associated with mangrove conservation, participation in monitoring practices, and distribution of benefits that arise from mangroves being conserved, in accordance with sustainable community-based management guidance around the world [14]. As such, the most compelling conclusion to draw from this narrative is that good management of the Klang mangroves can only happen with decision-making rooted in biology through muddy walks and molluscs gathering.

Conclusion

This case study shows the importance of using direct observations and physical samples in the study of mangrove ecosystems and fauna inhabiting them. Through detailed descriptions of the Klang mangrove coastal zone, populations of molluscs, sampling sites, procedures employed, and anthropogenic activities occurring in the vicinity of the study site, this research reveals the significance of on-site observations for studying the characteristics of small-scale ecological factors. The presence of molluscs on muddy substrates, mangrove stems, roots, and wood litter shows the importance of the habitat and its complexity for the development of different species of intertidal animals. The combination of biological characteristics and environmental factors creates a realistic foundation for further spatial analysis and confirms the need for primary ecological studies of rapidly changing coastal zones. In conclusion, one can say that coastal management requires not only the use of satellite imagery and policy-making but also an in-depth understanding of the ecological system based on on-site observations and sample collection. The Klang mangrove ecosystem, shaped by both natural tidal dynamics and intensive human use, illustrates the need for management strategies that are informed by biological realities on the ground. By documenting mollusc occurrence alongside anthropogenic pressures, this study contributes a practical ecological perspective that can support informed decision-making, sustainable resource use, and long-term conservation of mangrove coastal systems.

Declaration on the Use of Artificial Intelligence

The authors declare that generative artificial intelligence tools were used in a supportive capacity during the preparation of this manuscript. These tools assisted with language refinement, structural organization, and stylistic clarity of the text. All ideas, interpretations, arguments, and conclusions presented in this paper are the authors' own and are grounded in personal experience and scholarly judgment. The authors retain full responsibility for the content, accuracy, originality, and integrity of the manuscript..

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