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CHALLENGES AND CONSERVATION IMPERATIVES FOR MANGROVE WETLANDS IN KUNHIMANGALAM PANCHAYATH, KANNUR, KERALA

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ABSTRACT :

Mangroves are vital coastal ecosystems that provide numerous ecological, economic, and social benefits, including shoreline stabilization, biodiversity conservation, and carbon sequestration. However, these ecosystems are increasingly under threat due to anthropogenic activities and natural stressors. This study focuses on the threats faced by mangroves in Kunhimangalam Panchayath, a region known for its rich mangrove biodiversity in Kerala, India. Through field observations, stakeholder interviews, and secondary data analysis, the research identifies key threats such as land reclamation, pollution, encroachments, aquaculture expansion, ecosystem, and climate change. The study also explores the socio-economic dependencies on mangroves and the policy gaps that hinder effective conservation. Findings highlight the urgent need for community-driven conservation efforts, stricter policy implementation, and sustainable management strategies to mitigate these threats. The study concludes with recommendations for integrated mangrove conservation initiatives involving local authorities, environmental organizations, and the community to ensure the long-term sustainability of these fragile ecosystems.

Keywords: Mangroves, Conservation, Sustainable Management,

Introduction

Mangroves are halophytes occurring in saline marshy places. Mangrove forests dominate the world's tropical and subtropical coastal lines. The word mangrove is a combination of the Portuguese word 'Mangue' and the English word 'Grove' (Vaiga, 2016). In 1968. Macnae introduced a new term to the mangrove, 'Mangal' for mangrove community and 'Mangrove' for individual species. The coastal habitat of mangrove includes the intertidal seaboards, backwater, river mouths, and shelter bays of the west coast of the world (Mandal and Naskar, 2008). There is a large number of inorganic nutrients from the land and decomposed leaves supply valuable organic nutrients. Thus mangrove swamps serve as feeding, breeding, spawning and nursery ground for many marine organisms (Muraleedharan et al., 2009).

Mangroves act as a buffer between the transitional, near-shore lagoon and estuarine environments. Leaves of many mangroves possess halophilic properties with a thick cuticle and large mucilage cells. Buttress roots, knee roots, stilt roots, and vertical pneumatophores are some other adaptations exhibited by mangrove plants to thrive in harmony within the intertidal zone. As the abode of rich biodiversity, their role in the sustainability of seafood species and shoreline stability, and in the context of the predicted scenarios of global warming and sea-level rise, conservation of mangrove vegetation is very important (Deshmukh, 1991). In Kerala especially in Kannur district had very thick mangrove forests, especially along its coastline. About 700 km^2 of mangroves are present along with the coastal environment of Kerala (Ramachandran et al., 1986).

Kannur district has good natural patches than that in the other districts. There was approximately 755 hectare of mangrove forest is present in Kannur. The mangrove ecosystem covers only 0.003% of the world's surface or 0.12% of the earth's land area (Vaiga, 2016). Mangroves are a taxonomically diverse group of salt-tolerant, mainly arboreal, flowering plants that grow primarily in tropical and subtropical regions (Ellison and Stoddart 1991). A 'mangrove' has been defined as a "tree, shrub, palm or ground fern, generally exceeding more than half a meter in height, and which normally grows above mean sea level in the intertidal zones of marine coastal environments, or estuarine margins" (Duke 1992). The term 'mangrove' can refer to either the ecosystem or individual plants (Tomlinson 1986).

Mangroves-forests of tropical trees and shrubs rooted in saltwater sediments between the coast and the sea-are crucial nurseries for coral reef fish, according to a new study John Roach, 2004). Mangroves are specialized ecosystems found in tropical and subtropical intertidal zones. These salt-tolerant plant species, including trees, shrubs, and ferns, have evolved to thrive in saline coastal environments, where they form dense forests along estuaries, lagoons, and shorelines. Globally recognized for their rich biodiversity, mangroves serve as breeding and nursery grounds for numerous marine organisms, support migratory birds, and protect coastal regions from erosion and storm surges. Mangroves are vital coastal ecosystems that bridge land and sea. Known for their unique ecological characteristics, mangrove wetlands are home to diverse flora and fauna, offer protection against coastal erosion, and

play a critical role in carbon sequestration. Kerala, with its vast network of backwaters and estuarine systems, supports several mangrove belts, many of which are under increasing pressure from urbanization and climate change.

Kerala's mangroves, though limited in area, are ecologically significant. Once spread over an estimated 700 km², they have now dwindled to less than 17 km² due to rampant land use changes. The remnants of these ecosystems, particularly in the northern districts like Kannur, are under growing threat due to developmental activities, pollution, and lack of public awareness. In the Indian context, mangrove forests cover approximately 4,992 square kilometers, which constitutes about 3% of the world's mangroves. Despite their relatively small area, Indian mangroves are ecologically diverse and provide critical services to coastal communities. Kerala, with its vast network of backwaters and estuarine systems, was once home to extensive mangrove forests. However, rapid urbanization, land reclamation, and pollution have led to a drastic decline in mangrove cover across the state.

Mangrove wetlands are among the most productive and ecologically significant ecosystems in the world. Despite their importance, they remain one of the most threatened natural habitats due to unregulated urbanization, land conversion, pollution, and climate change. In Kerala, particularly in the northern coastal regions like Kunhimangalam Panchayath in Kannur district, mangroves are rapidly shrinking due to anthropogenic pressures and lack of awareness about their ecological value. This study seeks to address these issues through a focused exploration of the challenges and conservation imperatives associated with mangrove wetlands in the region.

In view of the above, in the present investigation studied the challenges and conservation imperatives for mangrove wetlands in Kunhimangalam Panchayath, Kannur. The results of the present investigation discussed in detail in this manuscript.

Materials and methods

The study followed a descriptive and investigative research design. It aimed to identify the existing species of mangroves, assess the ecological condition of the wetlands, understand the challenges faced by these ecosystems, and explore the perceptions of the local community regarding conservation.

Study Area

The research was conducted in Kunhimangalam Panchayath, located in the Kannur district of Kerala. The region lies along the Kavvayi backwaters and includes several pockets of mangrove wetlands that are ecologically significant yet under increasing anthropogenic pressure. The area was selected due to its rich biodiversity and the visible impact of developmental activities on its mangrove habitats. According to the 2011 Census, it had 18,965 residents, 8,438 of whom were men and 10,527 of them were women, and covered an area of 15.34 square kilometers. 26.29 Acre of Mangroves is present in Kunhimangalam Panchayath.

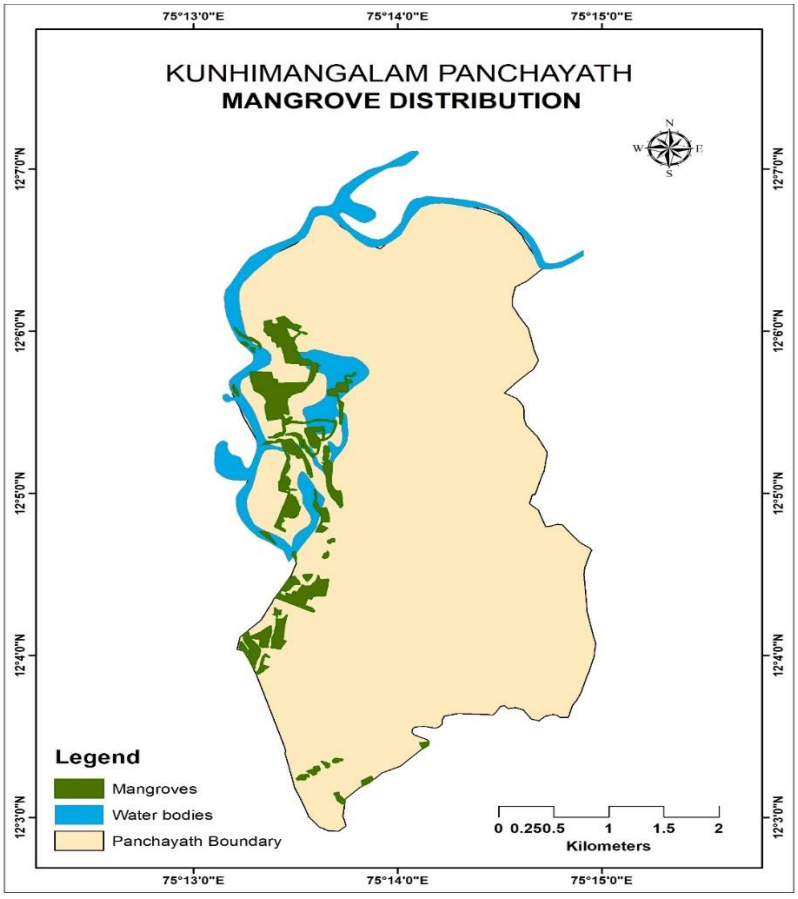

Figure 1 Location map of the study

Kunhimangalam Panchayath, located in the Kannur district of northern Kerala, is one of the largest and most ecologically significant estuarine systems in the state. Known for its rich cultural heritage and traditional livelihoods, Kunhimangalam is also home to diverse mangrove wetlands that thrive along its backwater margins and tidal inlets. These mangrove patches, though fragmented and shrinking due to anthropogenic pressures, support a wide range of flora and fauna and play a critical role in maintaining local ecological balance. The mangroves in Kunhimangalam act as breeding and nursery grounds for fish, crabs, and other aquatic organisms, and provide natural protection against shoreline erosion and tidal surges. Figure 1 shows the location map of the study.

Data Collection and analysis

On-site visits were conducted to visually assess the health, density, and distribution of mangrove patches. Photographic documentation and GPS-based mapping were used. Botanical identification of mangrove species was carried out with the help of local experts and field guides. Interviews were conducted with local residents, fishermen, Panchayath members, and environmental activists to gather insights on past and present conditions of mangroves. Small group discussions were held with community members, especially those dependent on wetland resources, to understand their perceptions and suggestions regarding conservation. Structured questionnaires were distributed among selected households and stakeholders to collect data on knowledge, attitude, and practices related to mangrove wetlands. Content Analysis was applied to qualitative data from interviews. Species documentation was compared with existing floristic records to assess species richness.

Results and Discussion

The results include the identification of mangrove species, ecological observations, local community perceptions, and threats affecting the sustainability of the wetlands. The findings are further discussed in light of existing literature and broader environmental concerns.

Mangrove Species identified in Kunhimangalam Panchayath

Field surveys revealed the presence of several true mangrove and associate species in the wetlands of Kunhimangalam. Among the true mangroves, the most dominant species identified were *Avicennia officinalis*, *Rhizophora mucronata*, and *Bruguiera cylindrica*. These species were typically found in waterlogged zones along the Kavvayi backwaters. Associate species such as *Acanthus ilicifolius* and *Clerodendrum inerme* were also observed along the fringes. The relatively high occurrence of *Avicennia officinalis* indicates moderate salinity tolerance in the region. However, the absence or limited presence of other key species such as *Sonneratia alba* and *Excoecaria agallocha* suggests ecosystem fragmentation and declining biodiversity, likely due to human interference and shrinking habitat zones.

Avicennia marina (Gray mangrove)

Avicennia marina, commonly known as the Grey Mangrove, is a highly salt-tolerant mangrove species belonging to the family Acanthaceae(Figure 2). It is widely distributed along coastal and estuarine regions and is found in scattered patches in Kunhimangalam Panchayath, especially near brackish waters. This species is identifiable by its grey bark, silvery-green leathery leaves, and pencil-like pneumatophores that help in gas exchange in waterlogged, oxygen-poor soils. The tree can grow up to 10 meters in height and is known for its ability to thrive in extreme saline conditions. Ecologically, *Avicennia marina* plays a vital role in coastal protection, soil stabilization, and as a nursery habitat for fish and crustaceans. It also contributes significantly to carbon sequestration. The plant reproduces through viviparous seeds, which germinate while still attached to the parent tree, enhancing survival in tidal zones.

Despite its resilience, *Avicennia marina* is threatened by habitat destruction, pollution, and unregulated land use, highlighting the need for targeted conservation in regions like Kunhimangalam. Leaves, fruits, and bark used in the treatment of skin diseases and digestive disorders. The wood of the plant is used for the treatment of snakebites and the aqueous extract of the seed against sores.

Figure 2 *Avicennia marina* (Gray mangrove)

Avicennia officinalis (White mangrove)

Avicennia officinalis, commonly known as the White Mangrove, is a true mangrove species belonging to the family Acanthaceae (Figure 3). It is widely distributed in tropical coastal wetlands, including the estuarine zones of Kunhimangalam Panchayath, where it is often found along muddy banks and brackish water channels. This species typically grows as a small to medium-sized tree, reaching heights of 5 to 10 meters. It has broad, green, leathery leaves, smooth grey bark, and pneumatophores (aerial roots) that emerge from the soil to support respiration in anaerobic conditions. The leaves may appear slightly yellowish or pale green, often with salt crystals due to the plant's salt-excreting ability. *Avicennia officinalis* produces small, orange-yellow flowers and smooth green fruits. It is known for its high salt tolerance, fast growth, and ability to stabilize coastal soils. Ecologically, it provides critical habitat for aquatic species and acts as a buffer against erosion and tidal surges. In Kunhimangalam, the species faces threats from pollution, land conversion, and waste dumping, necessitating conservation efforts to protect its ecological role and ensure its regeneration.

Figure 3 *Avicennia officinalis* (White mangrove)

Excoecaria agallocha (Blinding tree)

Excoecaria agallocha, commonly known as the Blinding Tree or Milky Mangrove, is a mangrove species belonging to the Euphorbiaceae family (Figure 4). It is found in intertidal zones and along estuarine banks, including the mangrove patches of Kunhimangalam Panchayath. This small to medium-sized tree can grow up to 10–12 meters and is known for its milky, toxic latex, which can cause skin irritation and temporary blindness if it comes into contact with the eyes hence the name "blinding tree." It has simple, oval-shaped leaves with a glossy green appearance and produces small, yellowish flowers and capsule-like fruits.

Figure 4 *Excoecaria agallocha* (Blinding tree)

Excoecaria agallocha is moderately salt-tolerant and typically grows in the landward fringes of mangrove forests. It contributes to biodiversity, provides habitat for birds and insects, and plays a role in shoreline stabilization. Despite its toxicity, the tree has traditional medicinal uses and ecological importance. However, in Kunhimangalam, its population is under pressure due to habitat fragmentation, pollution, and encroachment, emphasizing the need for protective measures.

Rhizohora apiculata (Tall stilt mangrove)

Rhizophora apiculata is a prominent true mangrove species belonging to the Rhizophoraceae family (Figure 5). Commonly found in tropical estuaries and tidal creeks, it is present in select locations within Kunhimangalam Panchayath, typically along the seaward edges of mangrove forests. This species grows as a medium to tall tree, reaching up to 20–25 meters. It is easily recognized by its distinct stilt roots that provide strong support in soft, muddy soils. The leaves are dark green, leathery, and oval-shaped, while the buds and fruits are reddish-brown, with elongated, viviparous propagules (seedlings

that germinate while still attached to the parent tree). *Rhizophora apiculata* plays a key role in coastal stabilization, reducing wave energy and preventing erosion. Its dense root system provides a rich habitat for aquatic organisms and contributes significantly to carbon sequestration. In Kunhimangalam, the species faces pressures from coastal development, pollution, and restricted natural regeneration, making it a priority for conservation and restoration efforts.

Figure 5 *Rhizophora apiculate* (Tall stilt mangrove)

Rhizophora mucronata (Asiatic mangrove)

Rhizophora mucronata, commonly known as the Asiatic Mangrove, is a dominant true mangrove species in tropical coastal and estuarine environments (Figure 6). It belongs to the Rhizophoraceae family and is commonly found along the tidal creeks and backwaters of Kunhimangalam Panchayath. This species can grow up to 20–25 meters in height and is characterized by its arched stilt roots, which provide strong anchorage in soft, muddy substrates. The leaves are broad, dark green, and glossy, ending in a distinctive pointed tip. It produces small yellowish flowers and long viviparous propagules, which float and disperse with the tides before establishing in suitable mudflats. *Rhizophora mucronata* plays a vital ecological role by stabilizing shorelines, reducing tidal impacts, and supporting rich biodiversity, including fish, crabs, and mollusks. It is also highly efficient in carbon storage, making it important in climate change mitigation. Although relatively resilient, the species in Kunhimangalam is affected by land reclamation, restricted freshwater flow, and pollution, emphasizing the need for active protection and replantation initiatives.

Figure 6 *Rhizophora mucronata* (Asiatic mangrove)

Bruguiera cylindrica (Small leaved orange mangrove)

Bruguiera cylindrica, commonly known as the Small-leaved Orange Mangrove, is a true mangrove species belonging to the Rhizophoraceae family (Figure 7). It is typically found in intertidal zones and muddy backwaters, and occurs in small patches within Kunhimangalam Panchayath. This species is a small to medium-sized tree or shrub, usually growing up to 6–10 meters. It is recognized by its small, glossy leaves, knee-shaped pneumatophores, and distinctive orange-red flowers. The fruit is a single-seeded, spindle-shaped propagule, which germinates while attached to the parent plant (vivipary).

Figure 7 *Bruguiera cylindrica* (Small leaved orange mangrove)

Bruguiera cylindrica plays an important ecological role in sediment stabilization, nutrient cycling, and providing habitat for juvenile aquatic species. It often grows in the inner zones of mangrove forests, contributing to biodiversity and wetland resilience. In Kunhimangalam, the species faces pressure from reduced tidal flow, pollution, and land-use changes, making it essential to include it in local conservation and reforestation efforts.

Kandelia candel

Kandelia candel is a true mangrove species from the Rhizophoraceae family, typically found in intertidal and estuarine environments (Figure 8). Though less common, it has been observed in select sheltered coastal zones of Kunhimangalam Panchayath. This species is a small to medium-sized tree, usually growing up to 5–10 meters. It is characterized by opposite, shiny green leaves, smooth grey bark, and arching stilt roots that provide firm support in soft, muddy soils. It bears small reddish flowers and produces viviparous propagules, which are slender and cigar-shaped. *Kandelia candel* contributes to shoreline stabilization, wave attenuation, and biodiversity support, acting as a nursery for various fish and invertebrates. It is also effective in carbon sequestration and improves soil structure through sediment trapping. Although hardy, its distribution in areas like Kunhimangalam is limited, and its habitats are threatened by development, waste dumping, and changes in salinity levels, highlighting the need for protection and sustainable management.

Figure 8 Kandelia candel

Aegiceras corniculatum (Black Mangrove)

Aegiceras corniculatum, commonly known as the Black Mangrove, is a shrub or small tree belonging to the Primulaceae family (Figure 9). It grows in brackish estuarine zones, often along creek edges and muddy banks, and is occasionally found in parts of Kunhimangalam Panchayath. This species typically grows up to 3–6 meters in height and has dark green, leathery leaves with rounded tips. Its name “black mangrove” refers to the dark bark and sometimes the blackish appearance of its roots. It produces fragrant white flowers and distinct curved, horn-like fruits, which float and disperse with the tides.

Figure 9 *Aegiceras corniculatum* (Black Mangrove)

Aegiceras corniculatum is valued for its role in erosion control, salt tolerance, and as a habitat for juvenile fish and invertebrates. It also contributes to nutrient cycling and coastal ecosystem balance. Although moderately resilient, its survival in Kunhimangalam is impacted by encroachment, waste pollution, and altered water flow, emphasizing the importance of targeted conservation.

Acanthus ilicifolius (Holy Mangrove)

Acanthus ilicifolius, commonly known as the Holy Mangrove, is a spiny, shrubby mangrove associate belonging to the Acanthaceae family (Figure 10). It is typically found along mudflats, creek edges, and the landward fringe of mangrove forests, including parts of Kunhimangalam Panchayath. This low-growing shrub reaches 1–2 meters in height and is characterized by its dark green, glossy, spiny-edged leaves that resemble those of holly hence the name. It produces large, showy purple to bluish-violet flowers arranged in spikes, which are pollinated by bees and butterflies. The plant bears small, capsule-like fruits containing 2–4 seeds. *Acanthus ilicifolius* plays a crucial role in preventing soil erosion, retaining moisture, and serving as a pioneer species in mangrove regeneration. It also supports pollinator biodiversity and has documented medicinal properties, used in traditional remedies for ailments like asthma and rheumatism. Though hardy, it is vulnerable to habitat disturbance and overgrowth by invasive species, making it important to include in conservation and ecological restoration programs in areas like Kunhimangalam.

Figure 10 *Acanthus ilicifolius* (Holy Mangrove)

Challenges Faced by the Mangrove Ecosystem in Kunhimangalam

Mangrove ecosystems in Kunhimangalam Panchayath, like many coastal regions, face a range of ecological, social, and developmental challenges. These issues threaten the sustainability of mangrove habitats and their ability to provide essential ecosystem services. Mangrove deforestation in Kunhimangalam Panchayath has emerged as a serious ecological concern in recent years. Despite their critical role in protecting coastal ecosystems and livelihoods, mangrove wetlands are being degraded and cleared to accommodate various human activities. Mangrove-rich marshlands and creeks are frequently reclaimed using soil and debris to develop land for housing, agriculture, and commercial use. This activity alters natural drainage patterns, blocks tidal flow, and leads to permanent loss of mangrove ecosystems. In many cases, native mangrove species are unable to regenerate in the compacted, altered soil conditions. As Kunhimangalam gains attention for its scenic beauty and backwater stretches, tourism infrastructure including resorts, boat jetties, and private homestays has begun to encroach into ecologically sensitive zones.

Mangroves are cleared to make way for construction along waterfronts, often violating CRZ (Coastal Regulation Zone) norms. This results in loss of biodiversity, disturbed wildlife habitats, and weakened natural barriers against coastal erosion and storms. Urban expansion and the construction of roads, bridges, and drainage systems often cut across mangrove belts. In Kunhimangalam, some small-scale infrastructure projects have intruded into wetland

margins, fragmenting habitats and impeding water circulation necessary for mangrove survival. The cumulative effect of such developments leads to habitat degradation and species displacement.

Habitat Destruction and Land Reclamation

Rapid urbanization and land conversion for agriculture, aquaculture, and construction have resulted in the large-scale clearance of mangrove forests (Figure 11 and 12). In Kunhimangalam, parts of the wetland have been reclaimed for settlements and tourism infrastructure, reducing the extent of natural mangrove cover.

Figure 11 Land Reclamation

Figure 12 Encroachment as Tourism development

Figure 13 Mangrove Deforestation for Shrimp Farming

The expansion of brackish water shrimp aquaculture has led to the widespread clearing of mangrove forests in low-lying estuarine areas (Figure 13). Traditional paddy fields and mangrove belts are being converted into shrimp ponds, disrupting the natural hydrology and soil balance. This shift not only destroys native flora but also introduces high levels of chemical effluents, antibiotics, and saline discharge into the surrounding environment, further deteriorating wetland health. Bijith et al., 2022 also pointed out that shrimp farming is a great threat to the Mangrove ecosystem.

Unregulated dumping of solid waste, domestic sewage, and industrial effluents into backwaters and creeks has led to the degradation of water quality. Mangroves, being filter ecosystems, are particularly sensitive to toxic pollutants, which can damage root systems and reduce biodiversity. Local communities often depend on mangrove resources such as firewood, timber, fish, and shellfish. However, unsustainable harvesting practices have led to the depletion of these resources and weakened the regenerative capacity of mangrove species. The invasion of exotic or fast-spreading plant species in mangrove areas such as *Prosopis juliflora* or *Ipomoea* can choke native flora, alter soil chemistry, and hinder the natural growth of mangrove seedlings. Rising sea levels, increased salinity, and irregular tidal patterns due to climate change are putting additional stress on mangrove ecosystems. Saltwater intrusion can shift species composition and lead to dieback in less tolerant species.

Many residents are unaware of the ecological importance of mangroves and their role in disaster mitigation and biodiversity conservation. This lack of awareness often leads to indifference toward conservation efforts and enables destructive practices. Although there are environmental laws in place to protect coastal ecosystems, poor enforcement and lack of monitoring mechanisms often result in violations going unchecked. In Kunhimangalam, encroachments and unauthorized construction continue to impact mangrove zones. Increasing tidal variation and salinity changes, likely influenced by broader climate trends, have also begun to impact mangrove health and regeneration.

The Role of Wildlife Trust of India (WTI) in the Mangrove Restoration

The Wildlife Trust of India (WTI) is a leading nature conservation organization committed to protecting India's wildlife and natural habitats. Established in 1998, WTI works across the country to address critical issues concerning endangered species, human-wildlife conflict, habitat restoration, and wildlife crime prevention. Mangrove ecosystems in Kerala, especially in regions like Kunhimangalam Panchayath in Kannur, have witnessed increasing degradation due to human activities. Recognizing the urgent need for conservation, organizations like the Wildlife Trust of India (WTI) have partnered with local communities and government bodies to implement impactful restoration efforts most notably through the Kannur Kandal Project. The Wildlife Trust of India (WTI) is a nationally recognized non-profit organization dedicated to wildlife and ecosystem conservation. In Kerala, WTI has taken a proactive role in protecting coastal biodiversity, with a strong focus on mangrove restoration, community-based conservation, and biodiversity monitoring.

Kannur Kandal Project: A Model for Community-Led Restoration

The Kannur Kandal Project is a significant mangrove conservation and restoration initiative based in Kannur district, Kerala. Spearheaded by the Wildlife Trust of India (WTI) in collaboration with local communities and panchayaths, the project aims to protect and rejuvenate the region's rapidly declining mangrove ecosystems. The project involves planting native mangrove species, raising community awareness, and promoting sustainable livelihoods that align with conservation goals. The Kannur Kandal Project, spearheaded with the support of WTI and local stakeholders, is a pioneering mangrove restoration initiative aimed at reviving degraded wetlands across Kannur District, including areas like Kunhimangalam.

The Role of Local communities in the Mangrove Restoration

Local communities play a pivotal role in the success of mangrove restoration efforts, particularly in regions like Kunhimangalam Panchayath, where the connection between people and nature is deeply rooted in daily life and livelihood. The engagement of local residents has proven to be not just beneficial but essential in ensuring the long-term sustainability of conservation initiatives. Local communities in Kunhimangalam Panchayath have played a vital role in mangrove conservation, with active involvement from organizations like SEEK (Society for Environmental Education, Kerala) and the Kandal Samrakshana Samithi. These grassroots groups have been instrumental in mobilizing public participation, spreading awareness, and carrying out practical restoration work. SEEK has contributed significantly through awareness campaigns, eco-education programs, and school-level initiatives that educate the public on the ecological value of mangroves. Their efforts have helped build a culture of conservation, especially among students and youth. The Kandal Samrakshana Samithi, a local conservation collective, has been directly involved in mangrove planting, site protection, and monitoring. Comprising local volunteers including fisherfolk, farmers, and women's groups the Samithi has led efforts to regenerate degraded mangrove areas, often working in partnership with NGOs and institutions like WTI, Panchayaths, Forest Department and Colleges. Together, these groups exemplify how community-based action can successfully restore and protect fragile ecosystems. Their work continues to inspire sustainable stewardship of mangroves in Kunhimangalam and beyond.

Discussion

The mangrove ecosystems in Kunhimangalam Panchayath represent a vital ecological asset for the region, supporting biodiversity, protecting shorelines, and sustaining the livelihoods of local communities. However, the study findings indicate that these ecosystems are under considerable stress due to multiple anthropogenic pressures. One of the most pressing threats to mangroves in the region is land conversion, particularly for aquaculture and shrimp farming. These practices alter the salinity and hydrology of wetlands, making them unsuitable for native mangrove growth. Additionally, reclamation of land for housing and construction, especially along backwater stretches, has led to habitat loss and fragmentation. Tourism-related encroachment, the spread of homestays, and lack of proper waste disposal have further exacerbated degradation. Pollution mainly in the form of plastic waste and untreated

sewage was also observed in several mangrove belts, impacting both plant health and aquatic fauna. Despite these challenges, the study found that conservation awareness is increasing at the community level.

Local organizations such as SEEK, Kandal Samrakshana Samithi, and academic collaborators, working with support from Wildlife Trust of India (WTI), have played a key role in promoting restoration and eco-awareness. Through plantation programs, eco-camps, school outreach, and public engagement, these groups have helped revive community interest in preserving mangroves. The restoration efforts carried out under initiatives like the Kannur Kandal Project have had a measurable impact. In several degraded patches, replantation using native species like *Rhizophora mucronata*, *Avicennia marina*, and *Bruguiera cylindrica* has resulted in healthy sapling growth. Field data and observations indicate that restored areas are showing early signs of ecological recovery such as returning fish populations, stabilized soil, and reduced shoreline erosion.

However, challenges remain in ensuring the long-term survival of these plantations, especially due to grazing, flooding, and inconsistent monitoring. Looking forward, the future of the mangrove ecosystem in Kunhimangalam will depend on a multi-stakeholder approach. Stronger policy enforcement, integration of mangrove protection in local development planning, and sustained funding for community-based restoration are critical. Ecosystem-based adaptation strategies that blend traditional ecological knowledge with modern conservation science can enhance resilience against climate change impacts such as rising sea levels and storm surges.

In summary, the study highlights that while the mangrove ecosystem in Kunhimangalam is under serious threat, there is also hope and momentum for recovery. Through continued restoration, awareness-building, and policy support, these fragile wetlands can be conserved not only for their ecological value but also for the well-being of future generations.

Conclusion

The study highlights the vital ecological and socio-economic role played by mangrove ecosystems in the region. These unique coastal wetlands not only support biodiversity and fisheries but also offer natural protection against coastal erosion, flooding, and the impacts of climate change. However, the findings underscore that these ecosystems are increasingly under threat due to unsustainable human activities such as land reclamation, shrimp farming, tourism encroachment, and pollution. Despite these pressing challenges, the study also brings to light the growing awareness and commitment within the local community toward mangrove conservation. Initiatives by grassroots organizations like SEEK and Kandal Samrakshana Samithi, Panchayaths and institutional collaborations, have shown that community-based restoration is both possible and effective. The restoration of degraded patches, increased participation of students and youth, and the revival of native species are all positive indicators of ecological recovery. To secure the future of mangroves in Kunhimangalam, a more integrated and sustained approach is essential. This includes strengthening local policy enforcement, ensuring scientific planning in restoration activities, empowering community participation, and incorporating mangrove protection into local governance and education systems. The study concludes that with continued effort and collaborative action, the mangrove wetlands of Kunhimangalam can be conserved and restored, offering both environmental resilience and socio-economic benefits for generations to come.

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