International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Successful Grey Mangrove *(Avicennia Marina)* Plantation on Raised Platforms (Dispersal Centers) in Permanently Inundated Zone of Abu Al Abyad and Ras Ghanadah, Abu Dhabi, UAE

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Abstract
The grey mangrove (*Avicennia marina*) thrives across Abu Dhabi's extreme coastal environments, offering vital ecosystem services such as carbon sequestration, shoreline stabilization, and nursery habitats. This study demonstrates a successful mangrove restoration strategy using elevated "Dispersal Centers" (DCs) in permanently inundated intertidal zones of Abu Al Abyad and Ghanadah Islands. A total of 135 DCs supported 2,700 saplings with an average survival rate of 96.34%. Elevated sediment mounds effectively mitigated prolonged submergence, enhancing root aeration and stability. The results highlight DCs as an innovative and scalable approach to restoring mangroves in waterlogged habitats, advancing UAE's national carbon sequestration and coastal resilience initiatives.

Keywords: *Avicennia marina*, Abu Dhabi, Coastal resilience, Carbon sequestration, Dispersal centers, Intertidal zones, Mangrove restoration.

1. Introduction

The highly salt tolerant Grey mangrove (*Avicenia marina*) forests in the Arabian Gulf are known for their remarkable resilience and flourishing in one of the driest mangrove habitats globally, forming the dominant coastal vegetation in Abu Dhabi as well as of the Abu Al Abyad Island, which play a vital role in sequestering of atmospheric carbon dioxide, coastal shoreline protection from erosion, sedimentation and natural calamities, and providing natural nursery grounds for varied aquatic phyla. Mangroves in Abu Dhabi cover 10,384ha along 547 km of coastline, constituting approximately 80% of the total mangrove forest area in UAE [1]. The mangrove coverage in the UAE has actually increased in the last few decades, particularly due to a number of large- scale restoration programs and increased public awareness [2],[3]. thus prompting various government agencies to urge developers to increase the mangrove coverage through large-scale active plantation programs. One of the strongest and successful mangrove restoration

programs is being carried out by the Marine Studies Unit of the Aquaculture and Marine Studies Center (AMSC) at Abu Al Abyad Island situated west of Abu Dhabi and the island of Ghanadah, east of Abu Dhabi, consisting of intertidal nurseries producing more than 1,200,000 plants annually [4]. In 2022, the UAE, as part of the National Carbon Sequestration Project updated its mangrove-planting goal to 100 million trees by 2030 [5]. The Aquaculture and Marine Studies Center (AMSC), Abu Al Abyad, a key partner in this initiative, has so far planted a total of 2,200,000 mangrove seedlings across both Abu Al Abyad and Ras Ghanadah islands. All these plantations have been done in shallow suitable intertidal areas. Unlike the island of Abu Al Abyad, the island of Ras Ghanadah has few intertidal areas suitable for planting, most areas being partially submerged even during low tides. Seedlings and young plants in excessively waterlogged soil have a reduced ability to respire effectively. Planting mangroves directly in waterlogged or highly saturated soil presents several challenges that hinder seedling survival and growth. Successful planting on elevated mounds (Dispersal centers) for mangrove restoration has been reported elsewhere [6],[7]. This approach directly addresses the problem of seedlings being submerged too frequently and for too long, which is beyond their physiological tolerance and a primary reason for failure. By creating these higher mounds, restorationists can plant mangroves in areas that are otherwise too wet, allowing them to establish themselves in zones where their root systems will thrive. The Aquaculture and Marine studies Center, Abu Al Abyad carried out some trials in permanently water inundated areas especially in the island of Ghanadah and this article presents the results achieved and suggests the way forward.

2. Material and methods

2.1. Preparation of Mangrove Dispersal Centers

Dispersal centers (DC) are areas that are created by delimiting and topographically modifying to raise up their level by accumulating sediment and form mounds that are stabilized using green mesh or other materials, thus manipulating the site's elevation to ensure seedlings receive the proper tidal inundation for successful. establishment of seedlings. The exact height and size of mounds were decided based on the site's specific tidal patterns, wave exposure, and soil characteristics. Accordingly, in Ghanadah island, where most of the intertidal area is inundated even during low tide, a total of 131 DC's and in Abu Al Abyad 4 DC's was established.

Site reconnaissance and tidal validation surveys were conducted to ground-truth the inundation regimes of potential areas identified both Island **(Fig 1).**

Figure (1): Location of dispersal centre sites in (a)Abu Al Abyad and (b)Ghanadah Island

Each mound acts as a planting microhabitat capable of sustaining mangrove saplings above the critical inundation threshold. The DC were stabilized using green shade net and outer cover with green iron chain mesh fencing to minimize erosion and maintain sediment integrity **(Fig 2).**

Figure (2): Showing Completed Dispersal Centers formation and stabilization using mesh fencing

Tidal elevation data and inundation frequencies were analyzed using the predicted tide table for Abu Al Abyad and Ghanadah, as published by the National Marine Dredging Company (NMDC, 2024). Based on these data, the optimum dimensions for each dispersal center were determined to be approximately 2 × 2 × 1.5 m (L × W × H), ensuring that the upper surface remains above mean high-water level during neap tides. These physical characteristics allowed DCs to be more stable given their elevated position and maintain salinity conditions that are favourable for the establishment of seedlings. Construction materials consisted of locally available sandy-silt sediments, compacted manually in successive layers to achieve the desired elevation and slope. The spacing between DCs was maintained at 3-5 m to allow tidal water exchange and propagule dispersal between mounds. A total of 135 DCs were established in the Islands. These DCs are intended to function as tidally interactive propagation units, facilitating both direct planting of nursery-raised mangrove saplings and natural propagule settlement in elevated, semi-aerated conditions.

2.2. Sapling plantation activity from 2023 to 2025

Between 2023 and 2025, mangrove dispersal centers (DCs) were progressively established at the Abu Al Abyad and Ghanadah sites to facilitate large-scale plantation activities. Each DC was designed to accommodate approximately 20 saplings. In 2023, a total of 18 DCs were deployed, mainly during February, March, November, and December, representing the initial pilot phase and supporting about 360 saplings. In 2024, the effort expanded to 42 DCs (840 saplings), with peak deployments in February, November, and December, marking the scaling-up of restoration operations. By 2025, a total of 75 DCs (1,500 saplings) were established exclusively at Ghanadah Island, with major deployments in January, February, March, and August **(Table 1)**. This phase reflected full-scale implementation, targeting permanently inundated intertidal areas suitable for sustained mangrove growth. Overall, the number of dispersal centers and corresponding saplings increased steadily each year, highlighting the systematic expansion of mangrove restoration efforts in the region.

3. Results and Discussion

3.1. Post-Establishment Observations of Dispersal Centres

Following initial establishment, a subset of the Mangrove Dispersal Centres (DCs) in Abu Al Abyad and Ghanadah Islands were monitored to assess post-stabilization performance and natural development after the removal of protective fencing. The fencing was removed in 9 nos of DC's approximately 8-12 months after installation, once sediment compaction and sapling establishment were visually confirmed. Upon removal of the mesh fencing, the raised sediment mounds exhibited minimal erosion and retained their overall morphology. The compacted sediments remained stable despite regular tidal inundation, suggesting that the DC design (2 × 2 × 1.5 m) effectively resists hydrodynamic disturbance under local tidal regimes. The surrounding tidal water facilitated natural sediment accretion along the lower flanks of the mounds, further reinforcing the structural stability. No significant displacement or slump failures were recorded in the sites.

Mangrove saplings (*Avicennia marina*) exhibited well-developed pneumatophores and lateral root networks, extending radially across the mound surface and partially into adjacent tidal flats (Figure 30). The dense root matrix functioned as a natural stabilizing framework, binding fine sediments and enhancing substrate cohesion. In several DCs, pneumatophores reached lengths of 10–15 cm, indicating effective oxygen exchange in periodically flooded conditions. The visible anchoring of root systems reduced susceptibility to tidal scouring, confirming that sapling-root interaction plays a key role in mound stabilization once artificial fencing is removed.

All monitored sites at Ghanadah including the Near Palace, 2nd Plantation Site, and Near Bridge demonstrated consistently high survival rates, each reaching close to 100%. The average survival rate of mangrove saplings was about 99.73%. This uniform success suggests favourable environmental conditions and effective adaptation of saplings in the permanently inundated intertidal zones of Ghanadah. Overall, survival performance was markedly higher at Ghanadah compared to Abu Al Abyad, indicating that site conditions and water regime stability play a critical role in mangrove establishment and survival **(Figure 3)**.

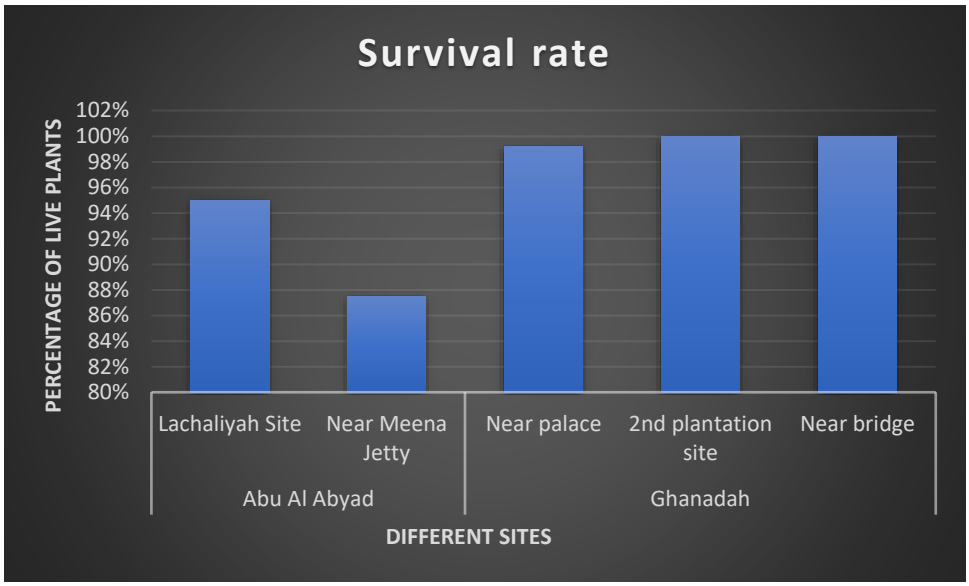

Figure (3): Showing the survival rate (%) different between Abu Al Abyad and Ghanadah Dispersal centers.

Hydrological monitoring revealed that water circulation between mounds remained unimpeded, maintaining adequate tidal flushing for nutrient exchange. The surface elevation of the DCs ensured that sapling root collars were exposed during low tide, promoting aeration and reducing anoxic stress. During high tide, partial submergence allowed sediment deposition and organic matter accumulation, further supporting root zone development. Comparative assessment between Abu Al Abyad and Ghanadah sites indicated that Ghanadah DCs showed higher rates of root proliferation and sediment consolidation, likely due to finer substrate composition and lower wave energy conditions. In contrast, DCs at Abu Al Abyad, though fewer in number, demonstrated greater resilience against periodic wind-driven wave action. Overall, both sites achieved functional stability within the first year of establishment, with vegetation cover and substrate strength progressively improving over time (Figure 4).

Figure (4): Mangrove Dispersal Centre after fencing removal, showing root proliferation, pneumatophore development, and stable sediment mound under tidal conditions.

4. Conclusion

Mangrove restoration in Abu Dhabi is a vital nature-based solution for climate change mitigation, fisheries protection, and coastal ecosystem conservation. Large-scale initiatives are underway to restore extensive mangrove areas, enhancing carbon sequestration and shoreline resilience. Restoration is being implemented through nursery-raised sapling transplantation and direct propagule broadcasting. While natural regeneration through suitable biophysical conditions remains the most effective approach, this study demonstrates a complementary method that enables successful mangrove establishment in permanently inundated intertidal zones, such as Ghanadah Island. The positive results support expanding this approach to additional sites, potentially increasing the spatial extent, resilience, and long-term sustainability of restored mangrove ecosystems, supported by appropriate socioeconomic incentives.

Compliance with ethical standards

Acknowledgments

This study forms part of the Mangrove Restoration Project conducted under the Aquaculture and Marine Studies Center, Abu Dhabi, UAE. The authors gratefully acknowledge the dedicated efforts of the Marine Studies Unit planting team at Abu Al Abyad Island and extend their appreciation to the management team at Ras Ghanadah for their valuable support and cooperation throughout the period.

Disclosure of conflict of interest

The authors declare no conflict of interest.

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Table (1): Dispersal canter's saplings details in Abu Al Abyad and Ghanadah

SN	Location	Abu Al Abyad		Ghanadah			Total	Total No. of Protective fencing removed
		Lachaliyah Site	Near Meena Jetty	Near palace	2nd plantation site	Near bridge		
1	No. of DC	2	2	21	5	105	135	9
2	No. of saplings planted	40	40	420	100	2,100	2,700	-
3	Live saplings	38	35	417	100	2,100	2,690	-

4	**Percentage of live plants (%)**	95%	87.5%	99.2%	100%	100%	96.34%	-

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Figure (2): Showing Completed Dispersal Centers formation and stabilization using mesh
Figure (3): Showing the survival rate (%) different between Abu Al Abyad and Ghanadah Dispersal centers.
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