



EXECUTIVE SUMMARY

The mangroves in the emirate of Ras Al Khaimah are under threat due to the encroachment of development, which directly claims land from the mangroves and releases waste into their waterways. This paper highlights the importance of preserving the mangrove wetlands as a vital ecosystem with a multitude of services. It also presents the findings of a study of visitors and residents in Ras Al Khaimah aimed at assessing public environmental awareness and obtaining insights into how people believe the potential conflicts between the economic development of Ras Al Khaimah and the preservation of the mangroves can be resolved. Finally, it proposes recommendations for alternative policies and collaborations to ensure the preservation of the mangrove ecosystem.

Assessing Policy Alternatives and Public Support for Protecting the Ras Al Khaimah Mangroves

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Introduction

Historically, the environmental protection movement has diverged from urban development and planning discussions around the world. In the United States, for example, the Housing and Urban Development Authority acts in isolation from the Environmental Protection Agency (Engel et al., 1996). As a result, there is little alignment of agendas and the protection of natural environments is frequently placed at odds with economic and urban development.

Development in the Arabian Gulf, especially that of the coastal areas of the United Arab Emirates (UAE), follows this trend. There is a concern that this would have a detrimental impact on the highly productive and significant coastal ecosystems of the emirates. These ecosystems include the country's mangrove swamps, sabkha, mudflats, seagrasses, and coral reefs (Burt, 2014). The adverse conditions impacting these ecosystems in the UAE are different from those in other contexts. Unlike in many developing countries, there is no direct use of the flora and fauna of the mangrove ecosystems that would lead to their collapse. The threat to the UAE's mangroves stems mainly from the coastal encroachment of development, which directly claims land from the mangrove areas across the country as well as releases waste into their waterways (Paleologos et al 2019).

The common notion that economic development should be decoupled from environmental discussions because they are negatively impacting the welfare of the other is an assumption of developers and the public policy sphere in the UAE. This paper argues that socio-economic development and environmental protection can be decoupled and recoupled positively. For example, socio-economic development not only can be achieved without harming the environment, but it can also leverage efforts to further protect it, such as with eco-tourism. Using the UAE emirate of Ras Al Khaimah's mangroves as a case study, this paper also highlights the importance of preserving the mangrove wetlands as a vital ecosystem with a multitude of services. It draws support from the results of an environmental use survey of visitors and residents of Ras Al Khaimah. The survey assessed public environmental awareness and obtained insights into how people believe the potential conflicts between the economic development of Ras Al Khaimah and the preservation of the mangroves can be resolved.

The paper starts by giving an overview of the unique characteristics of mangrove wetlands before describing their key ecosystem services. Results from the environmental value survey are then presented and analyzed, emphasizing the strong support among residents to preserve the mangroves. The paper ends by offering several policy recommendations

to protect this ecosystem and others like it and enhance its capacity to serve current and future generations of Ras Al Khaimah residents.

The UAE's Mangrove Ecosystems

The highly arid coasts of the Arabian Gulf are home to very few species of flora and fauna. Only the hardiest forms of life can survive in this hot and dry region. Years can pass by with only a few drops of rain and temperatures can soar to over 50°C in the summer. Despite these harsh conditions, mangroves eked a living in intertidal waters in the Arabian Gulf, particularly in its southern coasts in what is today the UAE. These mangrove bushes are remnants of much larger and denser forests that spread over the Arabian Gulf during a wetter period some 7,000 years ago. The later onset of aridification, accompanied by high seawater salinity levels and rapid sea-level rise, adversely impacted mangrove ecosystems and has led to their persistent decline up to present times (Berger et al., 2013).

Although mangrove wetlands are deteriorating worldwide, mangroves in the UAE have seen an increase from an earlier estimate of 4,000 ha (Böer & Aspinall, 2005) to over 13,600 ha in 2014. Moore et al (2014), however, attribute some of this increase to improvement in the accuracy of measuring mangrove areas. Most of the mangrove wetlands in the UAE are in Abu Dhabi due to concerted and strategic efforts by the emirate to expand its mangrove wetlands. They are understood to be acting as a "green lung" for the city, protecting the shoreline from erosion, providing habitat for wildlife, and granting recreation grounds for residents.

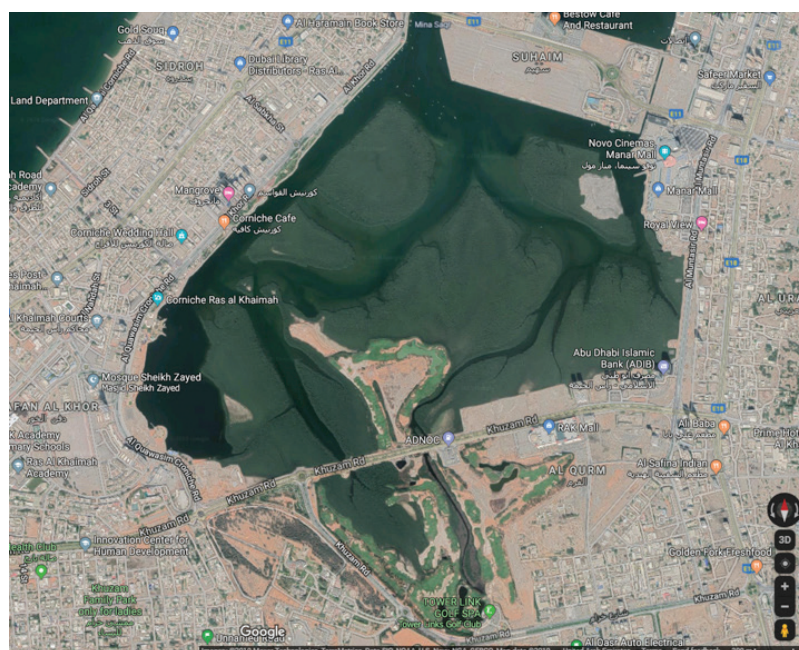
In Ras Al Khaimah, the mangroves are concentrated in Ras Al Khaimah Khor, an area well protected from high wave

action. In their location at the center of the city (see *Figure 1*), they offer a magnificent scene of lush green against a background of mountains and city buildings. The mangroves lend Ras Al Khaimah a unique blend of urban and natural, offering residents an opportunity to enjoy a natural environment away from city life.

In earlier times the people of Ras Al Khaimah relied on the many ecosystem services of the mangroves. Archeological evidence shows that residents of the region were highly dependent on the mangroves for food and fiber (Beech & Hogarth, 2002). Mangrove wood was valued as timber for home and shipbuilding due to its rot-resistant capabilities and mangrove leaves were used as fodder for livestock. The mangroves also played a crucial role in sustaining fish stocks – including some of the highly prized ones – in the emirate and greater Arabian Gulf region (Aspinall, 2001).

The great wealth and national transformation that occurred after the discovery of oil have tremendously changed life in Ras Al Khaimah. People have relied less on mangrove trees and most people have lost their connection to them with little awareness of the mangroves' essential ecosystem services and the threats they are facing. As in other parts of the UAE, the mangroves in Ras Al Khaimah are under pressure from encroaching development, uncontrolled sewage release, and dredging (Howari et al., 2009), all of which are due to the prioritization of economic development and its decoupling from holistic sustainable development and environmental protection of natural resources and critical ecosystems.

Figure 1: Satellite image of the mangrove wetlands of Ras Al Khaimah (obtained from Google Maps, 2017).



Overview of Mangrove Ecosystems and Services

In tropical and subtropical intertidal zones, high temperatures and water salinity, poor soil oxygen levels, and unstable conditions make it impossible for most plants to survive. Mangroves are salt-tolerant evergreen trees or shrubs that dominate these intertidal areas (Duke, 2011) due to their ability to thrive in such conditions. They have evolved from interior inland species and their unique appearance, such as their easily recognizable root systems, and role in the ecosystem is the result of the adaptations they developed to survive in harsh environments.

Mangroves prefer tropical coasts where temperatures are warm throughout the year, with the Arabian Gulf being their most northerly extent. The most ideal habitats for mangroves are intertidal areas that frequently receive freshwater resources from rivers or rainfall, as very high salinity levels can stunt growth. They prefer sheltered lagoons and swamps away from strong wave action, which prevents the settling of its seedlings, and adapt to gradual sea-level rise by slowly moving landward or by moving upward through building peat.

Only one species of mangrove – *Avicennia marina* (grey mangrove) – survives in this very hot and arid region with the highest water salinity levels in the world (Vaughan et al., 2018). Their unique ability to survive in this habitat makes them an ecosystem engineer since they create habitats, supporting numerous different marine and terrestrial species by providing shelter and foraging. Furthermore, different biological, chemical, and physical processes connect mangroves to adjacent ecosystems, including coral reefs and seagrass meadows.

Mangrove Ecosystem Services

Ecosystem services describe the benefits an ecosystem offers at the social, economic, and environmental levels. They range from the provision of food, fiber, and water; the regulation of climate, flooding, and air quality; physical and mental services; and the cultural and spiritual values people attach to the ecosystem (Millennium Ecosystem Assessment, 2005). Building on the previously highlighted benefits and impacts mangrove systems have on their environments, this section provides an overview of the relevant ecosystem services that the Ras Al Khaimah mangroves provide.

Fish and Bird Habitat

The heavily developed root maze of mangrove trees provides a safe refuge from predators for fish roe and juveniles. This nursing habitat is crucial for maintaining fish populations, including commercially valuable stocks (Blum & Herr, 2017). With their thick canopy, mangrove trees provide ideal nesting and roosting ground for many bird species (Florida Museum, 2019) and the mangroves in the UAE provide an ideal winter habitat for migratory birds looking for food and warmth (Kshemkalyani, 2012).

Protection of Offshore Reef Systems and Shoreline Stabilization

Mangrove wetlands fill in a crucial transitional zone between inland ecosystems and the offshore reef systems. They act as a filter, holding off silt sediments and pollutants and passing on clear and clean water for coral habitats (WWF, 2020). Their roots act to stabilize the shoreline against erosion.

Regulation of Air Quality

Trees, particularly in large contiguous areas, play a key role in improving air quality in urban areas by increasing oxygen levels, trapping air pollutants including dust and car emission particulates, and absorbing air gaseous pollutants that are harmful to public health and the environment (Davies et al., 2017). With its dense canopy and relatively wide extent, the mangroves in Ras Al Khaimah Khor are very likely contributing significantly to improving air quality in Ras Al Khaimah. Furthermore, its central location acts to influence airflow patterns, potentially mitigating the impact of sandstorms.

Impact on Urban Microclimate

Built areas of concrete buildings and pavements absorb significant amounts of heat during the day in comparison to vegetated covers and water. When this heat is released it creates additional warming in urban areas – a phenomenon known as an urban heat island (UHI). This phenomenon is exacerbated by the decline of tree cover in urban areas, which reduces their shading effect (EPA, 2008). Mangrove wetlands in urban areas, such as the mangroves in Ras Al Khaimah, offer relief from UHI and help moderate the city's microclimate. Consequently, a decline of the mangroves in Ras Al Khaimah is expected to result in higher temperatures in the city, which can push temperatures to extreme levels in the summer, presenting a serious health hazard.

Sequestration and Storage of Carbon

Mangrove ecosystems play an important role in sequestering carbon dioxide due to their high carbon density. Carbon is not only stored in the leaves, branches, trunks, and roots of the plants, but also in the substrate and accumulated peat (Donato et al., 2011).

Wave Surge Protection

Mangrove forests act as a buffer against high waves generated by strong winds and tsunamis. A study by the International Union for Conservation of Nature (IUCN) has shown that mangrove forests protected several communities during the massive 2004 tsunami. To underscore this benefit, reported casualties from two neighboring impacted coastal villages differed markedly: the village with dense mangrove forest lost two people, while the other with degraded mangrove forest lost 6,000 people (BBC, 2008).

Enhancement of Mental and Physical Wellbeing

Mangrove wetlands in urban settings such as the mangroves in Ras Al Khaimah are a sanctuary to residents looking for relief from the stress of busy schedules, routine daily activities, and heavy traffic. Their natural beauty bestows a sense of serenity that nurtures the soul and enhances mental welling (Bratman et al. 2019). The corniche area bordering the mangroves in Ras Al Khaimah is very popular with residents seeking to exercise or relax with their families in a shared public space.

Assessing Public Attitudes Towards Mangroves in Ras Al Khaimah

Supportive public attitude towards environmental awareness is instrumental in developing and encouraging positive environmentally sensitive behavior among people, and the public policy sphere, to achieve holistic sustainable development. It provides the opportunity to recouple socio-economic development and environmental protection positively and profitably through acquiring the knowledge, skills, and values needed to protect, conserve, and improve the environment for future generations.

An environmental values survey, designed to get insight into how the public in Ras Al Khaimah perceive and value the mangroves, was conducted from April to August 2017. Results from the study have been used to determine the factors that influence perceptions and to inform the development of a range of policy options for the preservation of this key ecosystem. Below is an overview of the study results. A more detailed analysis of the results will be presented in a research publication.

A total of 427 members of the public were interviewed by a group of American University of Ras Al Khaimah students at several locations around the emirate, including malls, coffee shops, and the Al Qawasim Corniche bordering

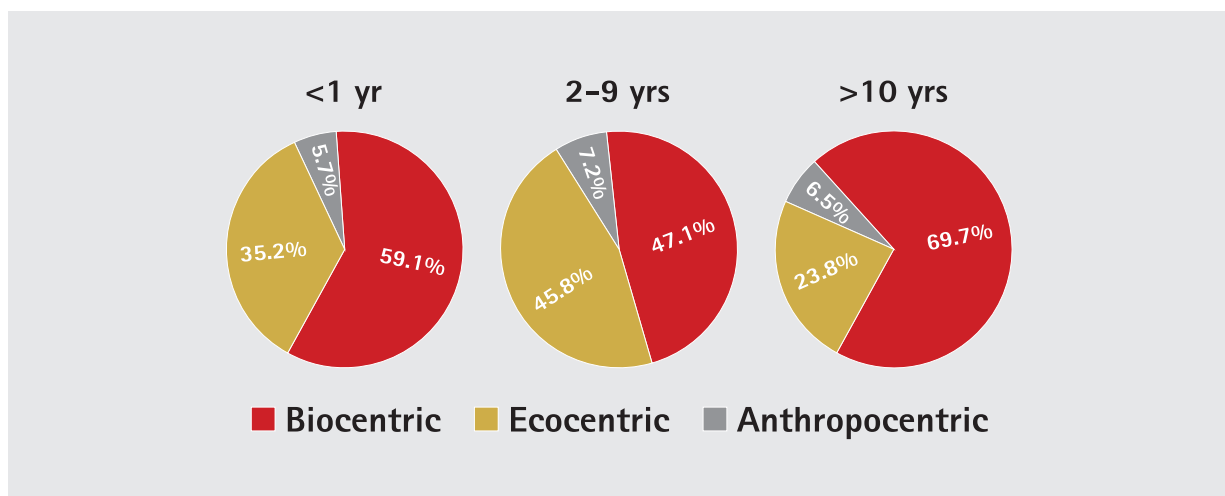
the mangrove wetlands.¹ The survey results were analyzed to assess the links between socio-economic and demographic characteristics (age, gender, education level, income, residence) of respondents and the respondents' environmental attitudes regarding how the mangroves should be managed.

People's environmental values can be categorized into three main categories. The anthropocentric attitude places greater emphasis on the benefits nature provides people, rather than on the nature per se; it favors development over environmental protection. On the other end, the biocentric attitude objects to interfering with the natural environment, even at the cost of forfeiting economic opportunities. Lying between these two ends, the ecocentric attitude favors a tradeoff between economic development and environmental protection (van Uhm, D.P., 2017).

The results from the environmental values survey indicate that most respondents have a biocentric attitude. They favor the protection of the mangroves even at the expense of development. Only a very small minority have an anthropocentric attitude that places a higher priority on economic development regardless of its negative impact on the mangroves. A relatively sizable number of people favor the management of the ecosystem that accommodates both economic development and protection of the ecosystem. The results show that these attitudes are significantly shaped by how long the person has resided in Ras al Khaimah. Attitudes are also affected, albeit to a lesser extent, by the person's age and education. Interestingly, results show that gender and income do not influence a person's environmental attitude.

Figure 2 shows the distribution of the respondents' environmental views categorized by how long the respondent resided in Ras Al Khaimah. Those who lived

Figure 2: Environmental attitudes of survey respondents categorized, by length of residency in Ras Al Khaimah



¹ The locations of data collection are a limitation of this study, as people enjoying their time at the Al Qawasim Corniche bordering the mangrove wetland may be biased, providing useful data but limiting its representative capabilities.

in Ras Al Khaimah for more than 10 years are more inclined to have a biocentric attitude, followed by those who lived in the emirate for less than one year (including visitors). Those with shorter residency are less inclined to be biocentric. This polarized distribution may indicate that affinity towards mangroves is shaped by the stronger bond longer-term residents have towards local natural assets and the appreciation newcomers or visitors have to these same assets.

Figure 3 shows how environmental attitude varies according to the age of respondents. The results indicate that the biocentric attitude is associated with the age of respondents: older generations have a more favorable attitude towards the mangrove. Although the association is not very strong, it could indicate that older generations are more appreciative of natural assets and favor their protection even at the expense of economic development.

Figure 4 shows the distribution of environmental attitudes according to the level of education. Education seems to play a part in shaping an individual attitude towards protecting the mangroves. The high prevalence of the biocentric attitude among those with postgraduate degrees could indicate that highly educated individuals are more aware of the benefits of maintaining mangroves and other natural assets in general.

The overall results indicate overwhelming public support for preserving the Ras Al Khaimah mangroves. They also highlight entry points, such as education and heritage awareness, that could help shape the needed environmental values of residents for holistic sustainable development. Furthermore, the considerable support for managing the mangrove wetlands in conjunction with development lends support to potential institutional policies and procedures that would aim for dual environmental protection and socio-economic development, as discussed in the next section.

Figure 3: Environmental attitudes of survey respondents categorized, by age

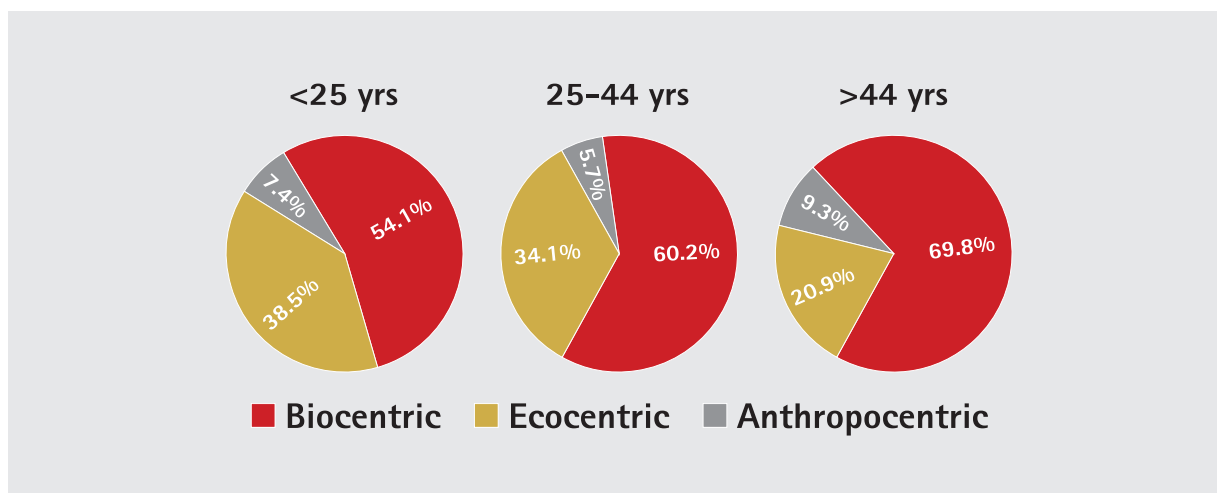
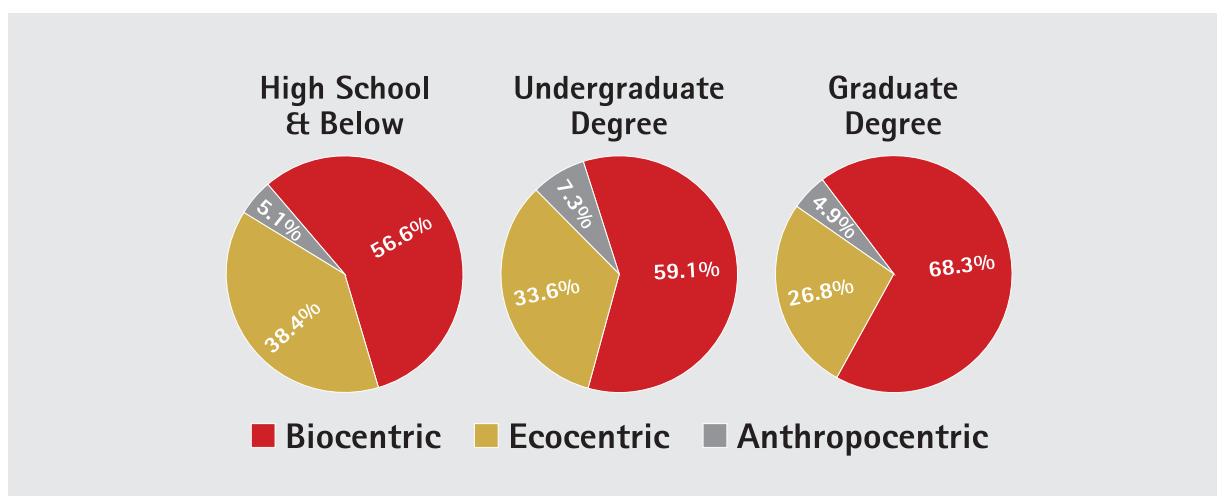


Figure 4: Environmental attitudes of survey respondents categorized, by level of education



Policy Recommendations

As indicated earlier, the mangroves are situated in the middle of one of the most populated and central areas in Ras Al Khaimah city. This presents both an opportunity and a challenge. The mangrove wetlands has a premium location with immense economic value, which places it under threat from further encroachment from commercial and residential development. It borders several commercial and recreational facilities including a golf park, two major malls, several hotels and restaurants, and a popular corniche area.

Below we present several policy options that address threats to the survival of the mangroves in Ras Al Khaimah. This includes an exploration of opportunities to enhance their ecosystem services in order to contribute to the socio-economic development of Ras Al Khaimah and other similar contexts.

Integrating Preservation of the Mangroves with Ras Al Khaimah Economic and Urban Development

Macintosh and Ashton (2002) suggest adopting an integrated coastal area management approach that considers sustainable use of coastal natural resources, including mangroves. A more detailed study is required to assess options for preserving mangroves, including co-existence with development and the design of eco-friendly buildings, infrastructure, and landscapes. Potential solutions could approach this issue as a symbiosis between human development and mangrove ecosystems, where these ecosystems provide a range of key ecosystem services. In return, the living urban environment is designed to be eco-friendly to mangrove ecosystems, protecting and enhancing their health and growth.

Development of Eco-Tourism

Development of Ras Al Khaimah and the protection of the mangroves need not be mutually exclusive. With proper environmental regulations and urban planning, the mangrove wetlands can be conserved – and even expanded – while maintaining healthy growth in the surrounding areas. One of these approaches is the encouragement and regulation of eco-tourism, where residents and visitors can enjoy this natural habitat without negatively impacting the area. In fact, revenues from these activities can be utilized to support a dedicated program to better understand and protect the mangrove ecosystem.

Raising Awareness of the Mangroves in Ras Al Khaimah

As indicated by the survey results, and judging by the large number of people who frequent the Al Qwasim Corniche area, many residents enjoy the mangrove's scenery and highly appreciate its value. However, the

study also indicated that a significant number of people are not aware of the value of this ecosystem and some have negative opinions of it, stemming from the belief that it releases foul odor.

It is therefore important to develop an awareness-raising campaign to promote the importance of conserving this natural resource and to encourage public participation in protecting it from pollution, mismanagement, and abuse. Awareness efforts can range from issuing special stamps commemorating the mangroves, hosting information sessions to students in schools and universities, publishing policy papers, giving presentations, and installing information posts in close proximity to the mangrove wetlands (Saenger et al., 2002). Given its role in safeguarding the environment in Ras Al Khaimah, the Environment Protection and Development Authority (EPDA) is ideally suited to champion this awareness initiative.

Adapting to the Impact of Impending Climatic Changes

If desiccation in the region continues, the mangroves can be expected to decline because less freshwater will be available and seawater salinity will increase. Without human intervention, it is projected that the mangrove wetlands in Ras Al Khaimah, and in the UAE in general, may not survive a drier and hotter future climate. One method to tackle this issue could be to divert excess treated wastewater to the wetland areas to help moderate high water salinity. One of the factors that contributed to the success of mangrove plantation in Abu Dhabi is the diversion of treated wastewater to mangrove areas (Berger et al., 2013).

Rising sea levels as a result of global warming are expected to inundate mangrove wetlands (Macintosh & Ashton, 2002). Naturally, mangrove trees adapt to the rising sea levels by moving inland. It is important therefore to limit coastal development – including sea walls – within proximity of mangrove wetlands to give mangrove trees space to move inland in response to rising sea levels.

Importance of Preserving the Current State of the Mangroves

One of the key ecological principles is that the size of a habitat area determines its ecological capacity to support species: the larger the area the more species it can support. However, this relationship – known as the species-area relationship (SAR) – is not linear. A 50% reduction in the original size of a natural habitat leads to a 10% reduction in the number of species it can support. SAR indicates that area reduction in a small habitat area results in a higher decline in the number of species than the same area reduction in a larger habitat area (Davies et al. 2017).

With its relatively large area, the mangroves wetlands in Ras Al Khaimah is a habitat to many plants and animals, which may decline significantly or disappear altogether if

large areas of the mangroves are disturbed or converted into developed areas. It is not clear how sensitive the mangroves are to reductions in its area. This highlights the need to carry out research to find out how resilient the mangrove ecosystem is.

Designating the Mangrove Wetlands in Ras Al Khaimah as a National Park

One approach to protecting the mangrove wetlands in Ras Al Khaimah is to designate it as a national park with regulated visits and legislated protection from pollution and abuse. A great example is the Abu Dhabi Mangrove National Park, which has been successful in protecting and expanding the mangrove ecosystem in Abu Dhabi while offering visitors and residents an opportunity to enjoy nature and participate in recreational activities that are not harmful to the wellbeing of the mangroves.

In Ras Al Khaimah, the EPDA can collaborate with the Tourism Development Authority to establish a Mangrove National Park. Ras Al Khaimah tourism has already been successful in leveraging the natural environment to develop eco-friendly sustainable tourist facilities, one example being the Jebel Jais Zip Line.

In addition, Ras Al Khaimah city could consider accrediting itself under one of the international eco-urban accreditation schemes such as "Wetland City," "Garden City," "Sponge City," or "City and Biodiversity."

Designating Grey Mangrove as a Protected Species

Given the fundamental role of *Avicennia marina* (grey mangrove) in the ecosystem of Ras Al Khaimah's mangrove wetlands – and in all mangrove wetlands in the Arabian Gulf – it is highly advised to provide protection to grey mangrove and support research into the potential threats to the species, such as human actions, pests, and environmental changes. It is also highly recommended that the species is given special protection in Ras Al Khaimah regulations, given that it sometimes comes under threat from illegal harvesting.

Future Research

Considering the lack of detailed information on the Ras Al Khaimah mangroves, it is quite important to commission an assessment of the mangrove wetlands to determine the quality of its environment, determine causes of degradation, and explore remedial measures. It is also important to support research that assesses the mangrove's ecosystem services, including its impacts on the microclimate of Ras Al Khaimah, carbon sequestration, and support of commercial fish stocks. New advances in remote sensing technology, including the development of mini satellites, offer opportunities to develop low-cost and highly effective monitoring programs in mangrove areas (Moore, 2013).

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Acknowledgments

The author thanks the Sheikh Saud bin Saqr Al Qasimi Foundation for Policy Research for their generous support of this research. The author would also like to acknowledge the contribution of Dr. Sahar Idwan, Dr. Abdul Halim Jallad, Madiha Ammari, Aktham Al Chaar, and Mahmoud.

References

- Aspinall, S. (2001). Environmental Development and Protection in the UAE. In I. Abed, & P. Hellyer (Eds.), *United Arab Emirates: A new perspective* (pp. 277–304). London: Trident Press.
- Kinver, M. (2008, May 6). Mangrove loss 'put Burma at risk', *BBC News, Science and Environment*. <http://news.bbc.co.uk/2/mobile/science/nature/7385315.stm>.
- Beech, M., & Hogarth, P. (2002). An archaeological perspective on the development and exploitation of mangroves in the United Arab Emirates. In: S. Javed & A. De Soyza (ed.), *Proceedings of the 2nd International Symposium and Workshop on Arid Zone Environments: Research and management options for mangrove and salt marsh ecosystems* (pp. 196–198). Abu Dhabi: ERWDA.
- Berger, J. F., Charpentier, V., Crassard, R., Martin, C., Davtian, G., & López-Sáez, J. A. (2013). The dynamics of mangrove ecosystems, changes in sea level and the strategies of Neolithic settlements along the coast of Oman (6000–3000 cal. BC). *Journal of Archaeological Science*, 40(7), 3087–3104.
- Blum, J. & Herr, D. (2017). *Mangroves: nurseries for the world's seafood supply*. IUCN. <https://www.iucn.org/news/forests/201708/mangroves-nurseries-world%E2%80%99s-seafood-supply>.
- Böer, B. & Aspinall, S. (2005). Life in the Mangroves in P. Hellyer, & S. Aspinall (Eds.), *The Emirates: A Natural History* (pp. 133–137). London: Trident Press.
- Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., de Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J., Hartig, T., Kahn Jr., P., Kuo, M., Lawler, J., Levin, P., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R., Ouyang, Z., Roe, J., ... Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances*, 5(7). <https://doi.org/10.1126/sciadv.aax0903>.
- Burt, J. A. (2014). The environmental costs of coastal urbanization in the Arabian Gulf. *City*, 18(6), 760–770. <http://doi.org/10.1080/13604813.2014.962889>
- Davies, P., Corkery, L., & Nipperess, D. (2017). *Urban Ecology: Theory, policy and practice in New South Wales, Australia*. National Green Infrastructure Network. <https://www.environment.nsw.gov.au/resources/grants/urban-ecology-theory-policy-practice-nsw-desktop-review.pdf>
- Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M., & Kanninen, M. (2011). Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience*, 4(5), 293–297. <https://doi.org/10.1038/ngeo1123>.
- Duke N.C. (2011) Mangroves. In Hopley D. (eds) *Encyclopedia of Modern Coral Reefs*. Encyclopedia of Earth Sciences Series. Springer, Dordrecht. http://dx.doi.org/10.1007/978-90-481-2639-2_108.
- Engel, D., Stromberg, E., & Turner, M. (1996). Toward a National Urban Environmental Policy. *Cityscape*, 2(3), 1–16. www.jstor.org/stable/20868419
- EPA (2008). *Reducing Urban Heat Islands: Compendium of Strategies: Urban Heat Island Basics*. U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2017-05/documents/reducing_urban_heat_islands_ch_1.pdf
- Feller, C. (2018, April). *Mangroves*. Smithsonian. <https://ocean.si.edu/ocean-life/plants-algae/mangroves>.
- Florida Museum. (2019). Importance of Mangroves, South Florida Aquatic Environments. <https://www.floridamuseum.ufl.edu/southflorida/habitats/mangroves/importance-mangroves/>
- Howari, F. M., Jordan, B. R., Bouhouche, N., & Wyllie-Echeverria, S. (2009). Field and remote-sensing assessment of mangrove forests and seagrass beds in the northwestern part of the United Arab Emirates. *Journal of Coastal Research*, 25(1), 48–56. <http://doi.org/10.2112/07-0867.1>
- Kshemkalyani, A. (2012). *Sustainability Tribe*, Guide to Birds of UAE. <http://www.sustainabilitytribe.com/guide-to-birds-of-uae/>.
- Macintosh, D. J. & Ashton, E. C. (2002). *A Review of Mangrove Biodiversity Conservation and Management*. Centre for Tropical Ecosystems Research. Centre for Tropical Ecosystems Research (cenTER Aarhus). http://www.mangrove.au.dk/MCB_Files/Desk_Study/2002_Review_WB_MCB_Final.pdf
- Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. <https://www.millenniumassessment.org/documents/document.356.aspx.pdf>
- Moore, G.E., Grizzle, R.E. & K.M. Ward. (2013). *Mangrove resources of the United Arab Emirates: Mapping and site survey 2011–2013*. Final

- Report to the United Arab Emirates Ministry of Environment and Water. <https://www.moccae.gov.ae/en/reports-listing/10/5/2018/2018-mangrove-resources-of-the-united-arab-emirates-mapping-and-site.aspx>
- Moore, G., Grizzle, R., Ward, K., & Alshih, R. (2015). Distribution, Pore-Water Chemistry, and Stand Characteristics of the Mangroves of the United Arab Emirates. *Journal of Coastal Research*, 31(4), 957-963. <http://dx.doi.org/10.2112/JCOASTRES-D-14-00142.1>.
- Ong, J.E. & Gong, W.K. (2013) *Structure, Function and Management of Mangrove Ecosystems*. ISME Mangrove Educational Book Series No. 2. International Society for Mangrove Ecosystems (ISME), Okinawa, Japan, and International Tropical Timber Organization (ITTO), Yokohama, Japan.
- Paleologos, E. K., Welling, B. A., Amrousi, M. E. & Masalmeh, H. A. (2019). Coastal development and mangroves in Abu Dhabi, UAE. *IOP Conference Series: Earth and Environmental Science*, Volume 344, The 5th International Conference on Water Resource and Environment (WRE 2019) 16–19 July 2019, Macao, China
- Saenger, P., Blasco, F., Yousseff, A.M.M., Loughland, R.A. & Wrydani, S. (2002). The mangrove vegetation of the United Arab Emirates, with particular emphasis on those of the Abu-Dhabi Emirate. Proceedings of the 2nd International Symposium and Workshop on Arid Zone Environments: Research and management options for mangrove and saltmarsh ecosystems, pp. 36-49.
- van Uhm, D.P. (2017). A green criminological perspective on environmental crime: the anthropocentric, ecocentric and biocentric impact of defaunation. *Revue internationale de droit penal*, 87(1), 323-340.
- Vaughan, G. O., Al-Mansoori, N. & Burt, J. A. (2019). The Arabian Gulf. In C. Sheppard (Ed.), *World Seas: An Environmental Evaluation* (2nd ed., pp.1-23). Academic Press. <http://doi.org/10.1016/B978-0-08-100853-9.00001-4>.
- WWF (2020). *Mangrove importance*, WWF. https://wwf.panda.org/our_work/oceans/coasts/mangroves/mangrove_importance/

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- To inform policymaking by conducting and commissioning high quality research;
- to enrich the local public sector, especially education, by providing educators and civil servants in Ras Al Khaimah with tools to make a positive impact on their own society; and
- to build a spirit of community, collaboration, and shared vision through purposeful engagement that fosters relationships among individuals and organizations.

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