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Eco-Schools

Mangrove Forest Ecosystem

The Lesson Plan and Nature-based activities
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Photo Source: Raviv Cohen

Mangrove Ecosystem

The Lesson Plan and Nature-based activities

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Acknowledgment to the Earthna Center

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Ecosystem: Mangrove Forest Before-you-begin

Task 1: Before-you-begin

Moving farther away from the open Gulf waters through the coral reefs and the seagrass beds, we land in mangrovial forests that line sheltered shores. This is yet another example of an ecosystem being named after the species that engineers it from scratch, the mangrove, which in its original Spanish "mangle" means swamp.

There are about 70 different species of mangroves in the tropics and sub-tropic climates, with the Indo-West Pacific having the most diverse assemblage (30-35 species), and the Arabian Gulf having the least diverse community of just two native species: *Rhizophora macrunata* and *Avicennia marina.* The last, is the only one that takes root on the shores of Qatar. *Avicennia marina,* the grey or white mangrove, is particularly equipped for life in very saline habitats and sediments that get quickly depleted of oxygen. Using its aerial roots that extend vertically out of the main root, it performs ultrafiltration of seawater, leaving the salt behind. The salt that makes it in is then excreted on the underside of its sclerophyllous (hard) leaves.

The aerial roots are called pneumatophores (lung carriers) because they bring in extra oxygen. In Al Khor and Al Thakira, we find two of the naturally occuring mangrovial forests. The rest, have been partially or fully afforested (planted by humans) in the 1980's, when it was recognized that mangroves could help protect from coastal erosion, flooding, and filter out pollution. These are what we call ecosystem services in ecology. After all these decades, the young planted seedlings have grown into lush forests that can be seen on satellite images.

Like coral reefs, and in more similar ways to seagrass beds because they are both ecosystems pioneered by plants, mangrove forests too act as refugia, feeding grounds and nurseries for a diverse array of aquatic organisms. It all starts when a seed grown on its mother plant gets released, a characteristic we call vivipary, an adaptation to the ever-changing coasts. After that, all the seedling needs is some sand or sediment to bind to and it starts extending its roots out horizontally, creating micro-habitats and niches for other organisms to settle around the root system, on the actual mangrove or amidst the forest area. Some common inhabitants of the forest include purple swimming crabs, hermit crabs, sea snails, barnacles, and a variety of fish. The mudskipper is regarded as one of the most impressive fish species, because it performs a ceremonial dance during mating season to attract females, by jumping up and off the ground with the wondrous agility of a decorated gymnast. Mangrove forests are also transient homes to marine birds visiting during their fall and spring migrations on the East Africa/West Asia Flyway. These include the vibrant flamingo, curlews, sandpipers, gulls, plovers, pied avocets and kingfishers. The tall tippy tops of the trees are nesting sites for herons and ospreys alike, while the Arabian honey bee, constructs elaborate honey combs hanging from the inner branches of the tree.

Photo Source: Shutterstock

Threats: Recreational activities that involve driving over or walking on seedlings and aerial roots, negatively affect the fitness of the mangrove trees as well as the forest's wildlife. coastline development is another threat since these trees are uprooted in the process and thus the habitat is lost to all the resident organisms. Mangrove trees are also nutritionally impacted when seaweeds like *Sargassum boveanum* get wrapped around and cover the photocenters of leaves, rendering them unable to carry out photosynthesis to produce organic molecules essential for their growth.

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Task 2

Eco-schools 6-9 Years

Introduction:

As with all forests, the coastal forests of mangroves buzz with activity and provide shelter to a biodiverse community of organisms. Mangrove species situate themselves along a gradient of salinity, depending on their adaptations to freshwater versus seawater, and in the Gulf we find two of the most salt-tolerant species. Mangrove ecosystem services contribute to human and environmental wellbeing as they sequester carbon, protect against coastal erosion, and provide livelihood and sustenance for the community in the form of timber, fisheries etc.

The lesson plan familiarizes the students with the mangrovial forest ecosystem, its micro-habitats and biodiversity.

The learning processes include exchanging of information on the topic, classroom interaction, and a presentation of the topic through art.

Age Group: Eco-Schools 6-9 years

Eco-Schools Steps: : Environmental Review, Action Plan, Curriculum Linkages, Inform and Involve, Monitoring and Evaluation

Objectives:

Students will be able to:

- Describe the mangrove forest ecosystem, and list threats
- Explain how the mangroves engineer a whole ecosystem
- Illustrate the community of organisms in mangrove forests with an emphasis on those in Qatar
- Develop positive actions for the protection of mangrove forests

Time required/ Duration:

Classroom Session 1: 45 minutes
(20 minutes to explain how the mangrove trees create habitats for a large community of organisms; 20 minutes provided for students to label and color the mangrove inhabitants worksheet, 5 minutes to devise positive actions for ecosystem protection). It is left up to the facilitator's discretion to expand the timings as needed to allow students to better assimilate the information and to properly devise positive actions.

Environmental Review:

Resources Required: "Before-you-begin":
Mangrove forest ecosystem
Key concepts: overview of the mangrove forest ecosystem with a focus on those found in the Arabian Gulf; mangrove species; biodiversity hotspots; nurseries; refugia; ecosystem services; threats.

Online Resources

www.enature.qa
Key concepts: marine species biodiversity in the Arabian Gulf

www.thebluecarboninitiative.org
Key concept: blue planet, blue carbon ecosystems, conservation

Photo Source: Aspa D. Chatziefthimiou

- Brainstorm with the students ideas on why this ecosystem is important, how and which human activities threaten the health of this ecosystem, and what we can do to help protect mangrove forests.

- Resource 1 (Mangrove Inhabitants Worksheet)
- Student stationary, pencils, colored markers, scissors
- Dedicated display board

Action Plan:

Action Plan 1

- Discuss with the students how the physical structure of the mangrove's root system helps create habitats for other organisms, in part because it stabilizes the coast in place.
- Screen Nature Conservancy's short film

https://www.youtube.com/watch?v=aoMrLYJOdA4&t=12s

so that students can visualize how mangroves dissipate wave action protecting the coasts.

- Help the students understand that the position of each organism in the mangrovial forest depends on its food and sheltering requirements. For example, barnacles attach to the tree trunk, because they need a surface to attach to, from where they filter feed on seawater.
- Check out

https://bmrg.org.au/wp-content/uploads/2019/07/MarvellousMangoveAustralia_2_MangrovesAsHabitat.pdf

Action Plan Activity 1

- Provide students with the Mangrove Inhabitants Worksheet (Resource 1). Ask them to color and label the organisms on it.
- Ask the students to draw in some additional organisms that we find in the mangroves of Qatar.
- Ask the students whether the mangrove tree species depicted in the worksheet are the ones we find in Qatar, and if they are not, ask them to draw in the parts of the tree that are missing.

Action Plan 2

- Use The Blue Carbon Initiative

https://www.thebluecarboninitiative.org/

to explain to the students the concepts of the blue planet and blue carbon, and convey to them the importance of coastal areas in carbon sequestration and climate change.
Use Nature Conservancy's "Get involved / How to help"

https://www.nature.org/en-us/get-involved/how-to-help/

to showcase and provide ideas to the students of the possible positive actions they can take individually and as a school to protect mangrove forests.

Action Plan Activity 2

- Ask the students to list one action they can take individually and as a school to help protect mangrove forests and their inhabitants.

3. Curriculum Linkages: Environmental Science, Ecology, Conservation, Art & Craft

4. Inform and Involve
Mangrove Inhabitants Worksheets should be displayed on the Eco-Schools bulletin board as part of inform and involve the school community.

Evaluation:
Conduct a review of the students' worksheets to determine their knowledge on mangrove forest biodiversity in general and for Qatar in particular.

Resource 1

Mangrove Inhabitants Worksheet

https://bmrg.org.au/wp-content/uploads/2019/07/MarvellousMangoveAustralia_2_MangrovesAsHabitat.pdf

Task 2

Eco-schools 10-13 Years

Introduction:

As with all forests, the coastal forests of mangroves buzz with activity and provide shelter to a biodiverse community of organisms. Mangrove species situate themselves along a gradient of salinity, depending on their adaptations to freshwater versus seawater. In the Gulf we find two of the most salt-tolerant species. Mangrove ecosystem services contribute to human and environmental wellbeing as they sequester carbon, protect against coastal erosion, and provide livelihood and sustenance for the community in the form of timber, fisheries etc.

The lesson plan familiarizes the students with the mangrovial forest ecosystem, its biodiversity, and its placement in relation to other ecosystems.

The learning processes include researching information pertaining to the topic, class interaction, cartography, creative writing, and communicating the topic in a "creative clues" game.

Age Group: Eco-Schools 10-13 Years

Eco-Schools Steps: Environmental Review, Action Plan, Curriculum Linkages, Inform and Involve, Monitoring and Evaluation

Objectives:

Students will be able to:

- Describe the mangrove forest ecosystem, and list threats
- Explain the importance of ecosystem services of mangroves, and why they are used in afforestation
- Map mangroves forests, and explain where this ecosystem is located in the Arabian Gulf
- Develop "clues" game for mangrove forest organisms to raise awareness
- Develop positive actions for the protection of mangrove forests

Time required/ Duration:

Classroom Session 1: 45 minutes
(20 minutes for the mapping exercise and to brainstorm with the students on ecosystem engineering and services. 20 minutes provided to students to solve the clues on the Guess the Organism Worksheet and create their own clues for their favorite organisms, 5 minutes to devise positive actions for ecosystem protection). It is left up to the facilitator's discretion to expand the timings as needed to allow students to better assimilate the information and to properly devise positive actions.

Environmental Review:

Resources Required: "Before-you-begin":
Mangrove forest ecosystem
Key concepts: overview of the mangrove forest ecosystem with a focus on those found in the Arabian Gulf; mangrove species; biodiversity hotspots; nurseries; refugia; ecosystem services; threats.


Photo Source: Aspa D. Chatziefthimiou

Online Resources

www.enature.qa
Key concepts: marine species biodiversity in the Arabian Gulf

link.springer.com
Al-Khayat et al 2021. Molluscan Diversity Influenced by Mangrove Habitat in the Khors of Qatar.

papers.ssrn.com
Al-Khayat and Balakrishnan 2014. Avicennia Marina Around Qatar: Tree, Seedling and Pneumatophore Densities in Natural and Planted Mangroves Using Remote Sensing.

- Brainstorm with the students ideas on why this ecosystem is important, how and which human activities threaten the health of this ecosystem, and what we can do to help protect mangrove forests.
- Resource 1 (Map of Qatar - Bathymetric)
- Resource 2 (Map of Qatar - Mangrove Forest Locations)
- Resource 3 (Guess the Organism Worksheet)
- Student notebooks, pencils, colored markers
- Dedicated display board

Action Plan:

Action Plan 1

- Use the available resources as a guide to brainstorm ideas to help students come to an understanding of why we call mangroves ecosystem engineers. What are some other organisms that we find in the Arabian Gulf that are ecosystem engineers? Do they engineer their ecosystem the same way?
- Provide students with the Bathymetric Map of Qatar (Resource 1).
- Show the map of natural and planted mangrove forests in Qatar (Resource 2). Ask the students to mark these location on their map. This will illustrate for the students that we find them in coastal shallow areas.
- Introduce students to the concept of ecosystem services
- Screen Nature Conservancy's short film

https://www.youtube.com/watch?v=aoMrLYJOdA4&t=12s

so that students can visualize how mangroves dissipate wave action protecting the coasts.

- Engage the students in coming up with some additional ecosystem services that mangroves provide. Assist the students to make the connection that mangroves were planted in the first place because of these ecosystem services.

Action Plan Activity 1

- Provide the students with the Guess the Organism Worksheet (Resource 3).
- Facilitate students to solve the clues given for each organism.
- Help students understand the connectivity of the Arabian Gulf ecosystems. Ask the students to name the other ecosystems.
- Facilitate students to create another 5 clues in the same style for their favorite mangrove forest organisms.

Action Plan:

Action Plan 2

- Use The Blue Carbon Initiative

https://www.thebluecarboninitiative.org/

to explain to the students the concepts of the blue planet and blue carbon, and impress in them the importance of coastal areas in carbon sequestration and climate change.

- Use Nature Conservancy's "Get involved / How to help"

https://www.nature.org/en-us/get-involved/how-to-help/

to showcase and provide ideas to the students of the possible positive actions they can take individually and as a school to protect mangrove forests.

Action Plan Activity 2

- Ask the students to list one action they can take individually and as a school to help protect mangrove forests and their inhabitants.

3. Curriculum Linkages: Environmental Science, Ecology, Geography

4. Inform and Involve

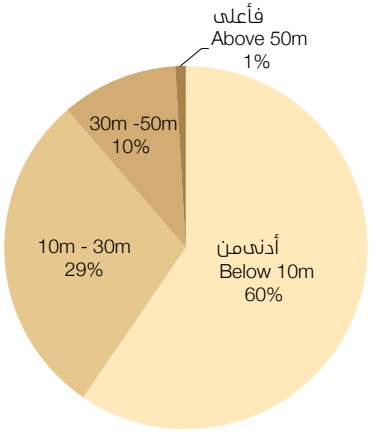
- Completed maps and un-filled Guess the Organism Worksheets should be displayed on the Eco-Schools bulletin board as part of inform and involve others in the school. A very entertaining option can be to create an Eco-Schools-wide competition using these clues.

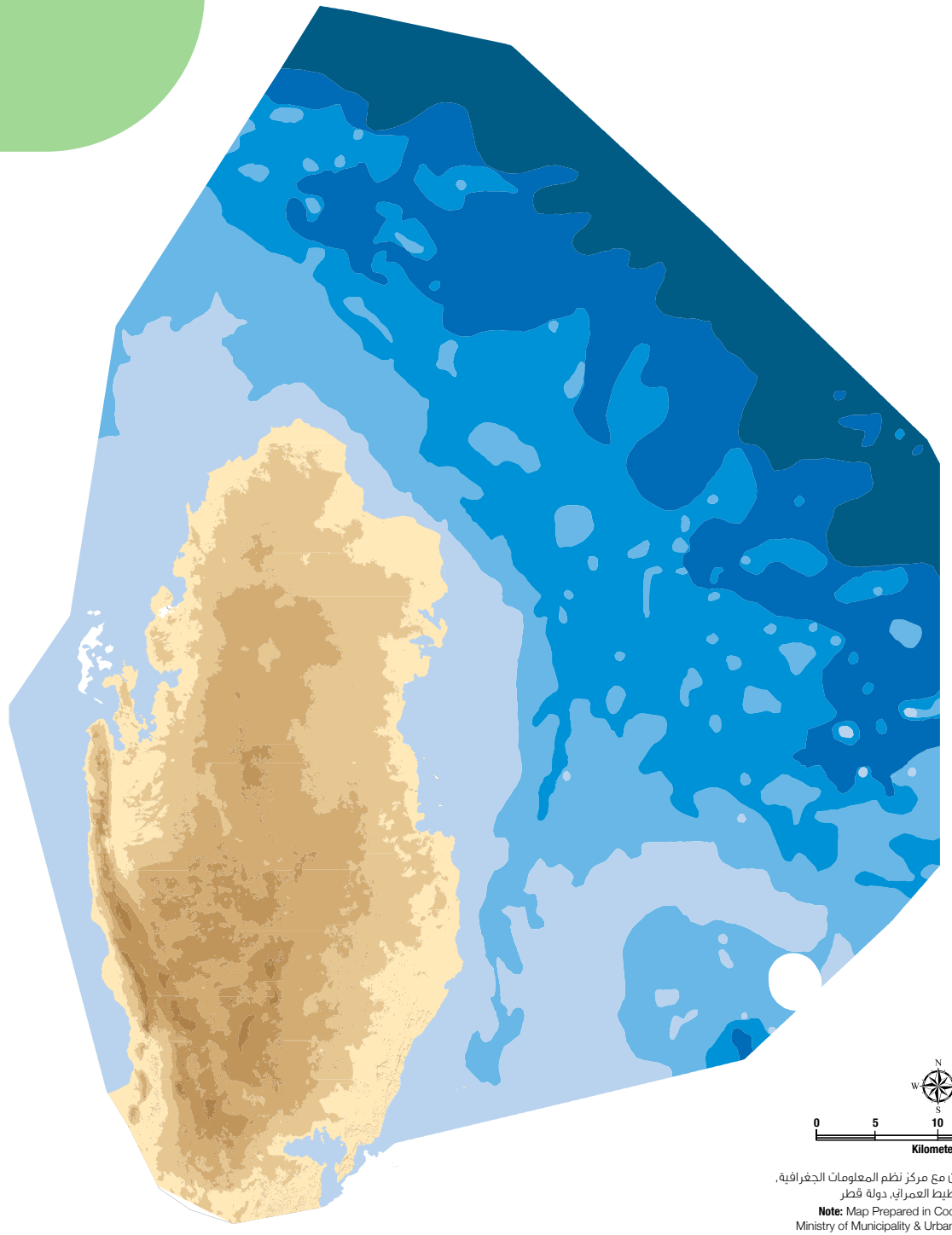
Evaluation:
Review their maps to determine whether students can correctly locate the mangrove forests on them. Display the clues on the board, and solve them with the students. Assess their knowledge based on the actual clues and their responses to the clues.

Resource 1

Map of Qatar - Bathymetric

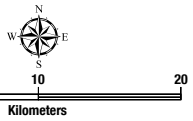
قطر: مساحة الأرض حسب مناطق المرتفعات
Qatar Land Area by Altitudinal Zones





Legend	مفتاح الخريطة
Bathymetry (in Metres)	البيثميتري (بالأمتار)
0 - 10	١٠ - ٠
10 - 20	٢٠ - ١٠
20 - 30	٣٠ - ٢٠
30 -50	٥٠ - ٣٠
50 +	+ ٥٠

Height (in Metres) Above Mean Sea Level	الارتفاع (بالأمتار) فوق متوسط مستوى سطح البحر
0 - 10	١٠ - ٠
10 - 30	٣٠ - ١٠
30 - 50	٥٠ - ٣٠
50 - 70	٧٠ - ٥٠
70 - 90	٩٠ - ٧٠
90 - 100	١٠٠ - ٩٠
100 +	+ ١٠٠



ملاحظة: أعدت الخريطة بالتعاون مع مركز نظم المعلومات الجغرافية، وزارة البلدية والتخطيط العمراني، دولة قطر

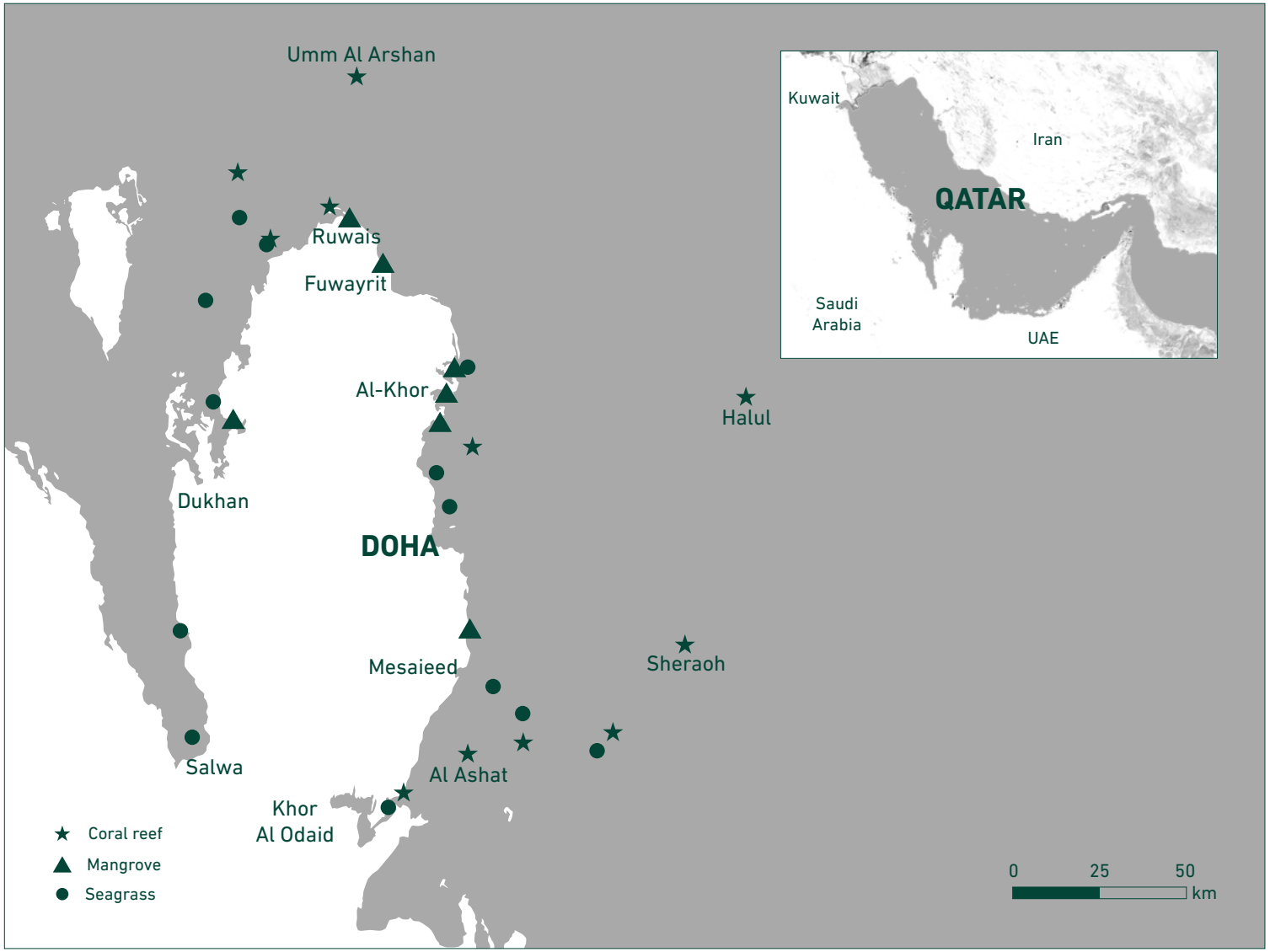
Note: Map Prepared in Coordination with CGIS, Ministry of Municipality & Urban Planning, State of Qatar

Resource 2

Map of Qatar - Mangrove Forest Locations

Location map of coastal marine ecosystems.

Al Khor and Al Thakira mangrove forests▲ are the only naturally occurring ones out of those depicted on the map. In Zekreet, Al Mafjar, Fuwairit and Semaisma, the mangroves have been planted. Other mangrove forests with significant stand, not depicted in the map and naturally occurring can be found all along the north western coast, and all along the entire east coastline. In Al Wakra the naturally occurring mangrove forest was transplanted to the northern area of the coastline as part of the offsetting of the Messaid Port development.



Map source:
Burt et al. 2017. Improving Management of Future Coastal Development in Qatar Through Ecosystem-based Management Approaches.

https://doi.org/10.1016/j.ocecoaman.2017.08.006

Resource 3

Guess the Organism Worksheet

1. I am the _____

- **I eat** insects, small fish and shrimp
- **Fun facts:** I don't have a tongue to catch prey with, so the smart creature I am, I suck in water which I expel to flood my prey and then I engulf it. Yummy! I live in water pools and when it is mating time, I jump up and down in an elaborate dance to attract females.

2. I am the _____

- **I eat** carbon dioxide and I use sunlight energy to make photosynthate sugars
- **Fun facts:** I am an ecosystem engineer, providing shelter and food for many other organisms around me.
  I can survive very salty waters because my leaves can excrete the salt that I bring in.
  I can survive anoxic sediments because my roots have pneumatophore extensions that help bring more oxygen in for me.

3. I am the _____

- **I eat** everything including phytoplankton, seaweed and dead fish, squid and crabs
- **Fun facts:** I am an omnivore and a scavenger. I am not a true crab, and although I live inside a snail's shell to protect my soft under-body, I cannot build that shell. When I get bigger I am constantly on the look out for a larger empty shell to inhabit.

4. I am the _____

- **I eat** everything in the water column including fish, shrimp and microbes
- **Fun facts:** I am a filter-feeder. I siphon seawater and filter it through my bill.
  My lower beak is larger than my upper beak. To swallow, sometimes, I turn my head upside down.
  I get my flamboyant color from the carotenoid pigments of my prey.

5. I am the _____

- **I eat** fish, shrimp, mudskippers, crabs
- **Fun facts:** I like to stand still in wait for prey, sometimes on one leg.
  My beak is long and so are my legs and wingspan.
  I make my nest on the top of tall trees in mangrove forests and elsewhere.

KEY

1. Mudskipper

2. Mangrove tree

3. Hermit crab

4. Flamingo

5. Indian Reef Heron

Task 2

Eco-schools 14-17 Years

Introduction:

As with all forests, the coastal forests of mangroves buzz with activity and provide shelter to a biodiverse community of organisms. Mangrove species situate themselves along a gradient of salinity, depending on their adaptations to freshwater versus seawater, and in the Gulf we find two of the most salt-tolerant species. Mangrove ecosystem services contribute to human and environmental wellbeing as they sequester carbon, protect against coastal erosion, and provide livelihood and sustenance for the community in the form of timber, fisheries, etc.

The lesson plan familiarizes the students with the mangrovial forest ecosystem, its biodiversity, how this ecosystem is engineered, and how succession looks like in satellite imagery.

The learning process includes researching information pertaining to the topic, class interaction, technology, brainstorming, and communicating the topic by producing a time-lapse video.

Age Group: Eco-Schools 14-17 Years

Eco-Schools Steps: Environmental Review, Action Plan, Curriculum Linkages, Inform and Involve, Monitoring and Evaluation

Objectives:

Students will be able to:

- Describe the mangrove forest ecosystem and list threats
- Explain mangrove anatomical structures and adaptations to the extremes of the Arabian Gulf
- Navigate the program Google Earth Pro, and monitor environmental / land use change through satellite images
- Record a time-lapse video to include in a presentation about threats to mangroves and raise awareness
- Develop positive actions for the protection of mangrove forests

Time required/ Duration:

Classroom Session 1: 45 minutes
(20 minutes to discuss with the students the characteristics of mangroves and their forests, including distribution and adaptations, 20 minutes to brainstorm with students ideas on how mangroves are threatened and track these threats using time-lapsed satellite imagery, 5 minutes to devise positive actions for ecosystem protection). It is left up to the facilitator's discretion to expand the timings as needed to allow students to better assimilate the information and to properly devise positive actions.

Environmental Review:


Photo Source: Shutterstock

Resources Required: "Before-you-begin":
Mangrove forest ecosystem
Key concepts: overview of the mangrove forest ecosystem with a focus on those found in the Arabian Gulf; mangrove species; biodiversity hotspots; nurseries; refugia; ecosystem services; threats.

Online Resources

earthobservatory.nasa.gov
Key concepts: mangrove distribution; habitat loss; threats; mapping

www.enature.qa
Key concepts: marine species biodiversity in the Arabian Gulf

www.youtube.com
Key concepts: mangrove ecosystem services; threats

link.springer.com
Al-Khayat et al 2021. Molluscan Diversity Influenced by Mangrove Habitat in the Khors of Qatar.

papers.ssrn.com
Al-Khayat and Balakrishnan 2014. Avicennia Marina Around Qatar: Tree, Seedling and Pneumatophore Densities in Natural and Planted Mangroves Using Remote Sensing.

- Brainstorm with students ideas on why this ecosystem is important, how and which human activities threaten the health of this ecosystem, and what we can do to help protect mangrove forests.
- Recording device for videography, such as a cell phone
- Dedicated display board

Action Plan:

Action Plan 1

- Provide the students with a general overview of the mangrove as a tree, the number of species that exist in the world and in Qatar, and their distribution.
- Visit the Earth Observatory

https://earthobservatory.nasa.gov/images/47427/mapping-mangroves-by-satellite

to show the students the exact distribution of mangroves.
- Help students understand that the extreme conditions of the Arabian Gulf select the hardiest of mangrove species.
- Discuss with the students some of the adaptations that mangrove trees have to life in high salinity, in ever-changing coastlines, and to anoxia.
- Discuss with the students the concepts of the ecosystem engineers and ecosystem services provided by the mangrove forests.
- Screen Nature Conservancy's short film

https://www.youtube.com/watch?v=aoMrLYJOdA4&t=12s

so that students can visualize how mangroves dissipate wave action protecting the coasts.
- Brainstorm with the students ideas of the threats that are faced by mangrove forests and the community of organisms they support the world over.
- Visit the Earth Observatory

https://earthobservatory.nasa.gov/images/147142/mapping-the-roots-of-mangrove-loss

to show students the areas of the globe where mangrove forests are being lost, and the root causes of that loss.

Action Plan Activity 1

- Facilitate the students in monitoring the succession of a mangrove forest in Qatar using the "Time-lapse" or "Historical Imagery" tool on Google Earth Pro. Help them pick one coastal zone, the forest at Lat. 25.680933° Lon. 51.564036°, for example, and have them start from the earliest satellite imagery available to the present time.
- Guide the discussion using the following questions:

  How does the landscape change through time?

  Does the extent of the forest increase or decrease?

  What are some of the factors that lead to the decrease in cover?

  How does that affect ecosystems services and biodiversity?

- Facilitate students to record the time-lapse of different mangrove forests in Qatar, and to create a short presentation with the threats.

Action Plan:

Action Plan 2

- Use The Blue Carbon Initiative

https://www.thebluecarboninitiative.org/

to explain to the students the concepts of the blue planet and blue carbon, and convey to them the importance of coastal areas in the carbon sequestration process as well as in climate change.

- Use Nature Conservancy's "Get involved / How to help"

https://www.nature.org/en-us/get-involved/how-to-help/

to showcase and provide ideas to the students about the possible positive actions they can take individually and as a school to protect mangrove forests.

Action Plan Activity 2

- Ask the students to list one action they can take individually and as a school to help protect mangrove forests and their inhabitants.

3. Curriculum Linkages: Environmental Science, Ecology, Technology, Geography

4. Inform and Involve
Student time-lapse videos and short presentations can be showcased on Ocean Day and on the Eco-Schools bulletin board to inform and involve the whole school community.

Evaluation:
Evaluate the technological abilities of the students. Review their videos to determine how well they synthesized information on the mangrove forest ecosystem and its threats, and their level of creativity.