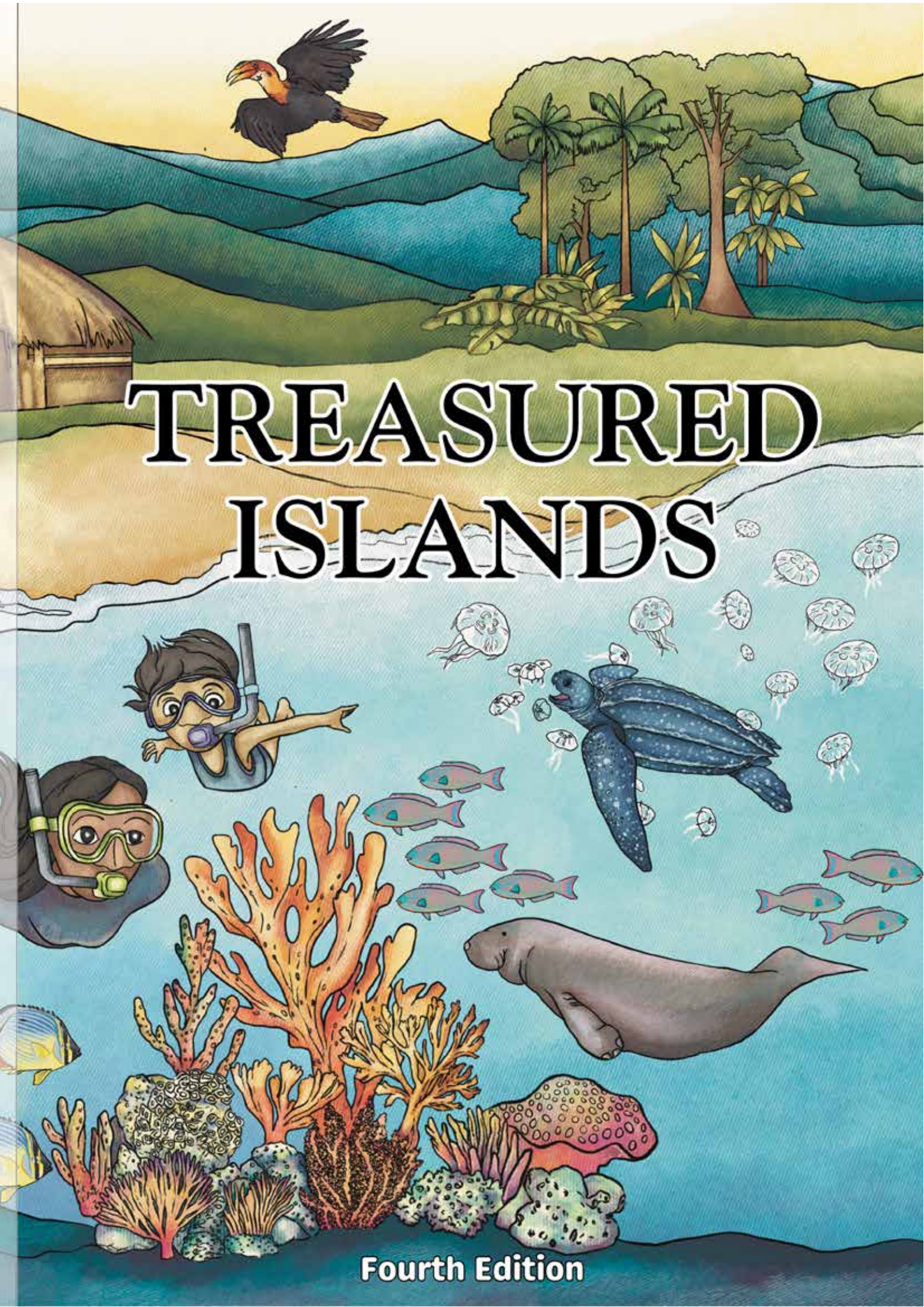

TREASURED ISLANDS

Fourth Edition

Treasured Islands

A Handbook for Teachers
of the Andaman and Nicobar Islands

Classes 6, 7 and 8

Credits

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Treasured Islands

A Handbook for Teachers of the Andaman and Nicobar Islands

Classes 6, 7 and 8

Collaborating institutions

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Kalpavriksh (www.kalpavriksh.org)
Dakshin Foundation (www.dakshin.org)
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The idea for a third and fourth edition was born from the need for an updated Environmental Education resource for teachers in the Islands. While it is nearly impossible to enumerate the contributions of every single individual, we appreciate the time and effort of all those who contributed to these editions.

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CONTENTS

Thank you for your interest in Treasured Islands!

Our knowledge about the Andaman and Nicobar Islands has been growing in leaps and bounds. Sharing this knowledge with young people is the secret ingredient for a long and healthy life for our islands and all the living things sharing this space.

Target users

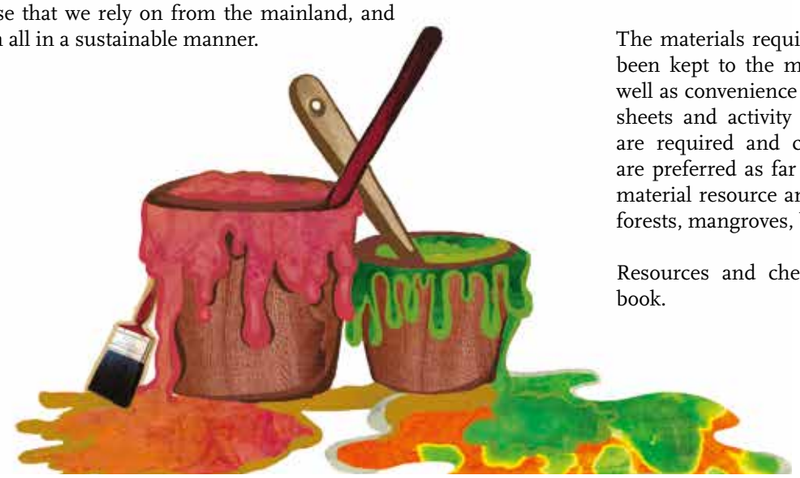
The handbook has been created keeping in mind teachers and students in the Andaman and Nicobar Islands in classes 6, 7, and 8. However, individuals or groups interested or involved in basic environmental education are invited to use this book as they see fit.

How to use this book

This handbook is primarily designed to facilitate the teaching of environmental education in the Andaman and Nicobar Islands. The first edition aimed to help teachers build environmental awareness amongst students. The fourth edition, while continuing to uphold the need for awareness, aims to bridge the deficit in availability of island-specific environmental education content. The book has been written in such a way that it can be used along with the school curriculum as a textbook specifically for environmental education. It can also be used with other subjects to add an environmental perspective.

Contents of the book

The book is divided into chapters, following an introduction. The introduction provides an overview of the islands—their geography and history. The next five chapters describe the various ecosystems of our islands. Chapter six, 'Our Biodiversity', describes island flora and fauna and why we need to protect it. Chapter seven is an exploration of 'Humans of the Islands', describing the journeys of the various social groups in our islands. Finally, 'Resources and Sustainability' informs us about the resources available on the islands, those that we rely on from the mainland, and how to use them all in a sustainable manner.



Chapter content

While the content is not divided according to the grade level, the activities are arranged to progressively deepen understanding of complex concepts. You are the best judge of your group's comprehension and engagement level.

Activities

The content of the chapter is the basis for the activities. The level, goals, student learning outcomes, materials required, time required, and ideal group sizes are mentioned at the outset. In every grade and topic, activities seek to mix indoor and outdoor experiences, individual and group work, and short and more intensive activities. Many indoor activities can also be conducted outside the classroom.

While each activity is carefully crafted so that students don't miss out on learning key concepts, field visits are still vital for effective environmental education. Learning in the field is experiential and even finds mention in the most recent policy governing education. Modifications are best made to suit individual requirements. If older or younger participants are expected, variations can be made to the explanation and challenge level of the task itself.

If field visits are not possible for the whole class, field visits can be organised for interested students or members of the Eco Club. Advice is provided for conducting safe and efficient field trips.

Eco Club

An Eco Club of students particularly interested in the natural world can be constituted. These students can be part of the planning of field trips and even curating talks and workshops by diverse local experts. Activities under the Eco Club can give students access to planning skills and professional social networks.

Materials

The materials required for conducting the activities have been kept to the minimum to pay attention to costs as well as convenience in preparation for the class. Resource sheets and activity sheets are provided where printouts are required and can be photocopied. Local resources are preferred as far as possible. Locations are as much a material resource and should be taken advantage of—the forests, mangroves, beaches, coral reefs, and the ocean.

Resources and checklists are provided throughout the book.

Going beyond the classroom

Environmental education cannot be done in isolation. Use the activities to involve students' families and the community in general in the environmental education programme. Some of the activities in this book need advice and information from parents. Often, you will find that families will happily help out, especially if their experience and wisdom are needed.

Where to go from here?

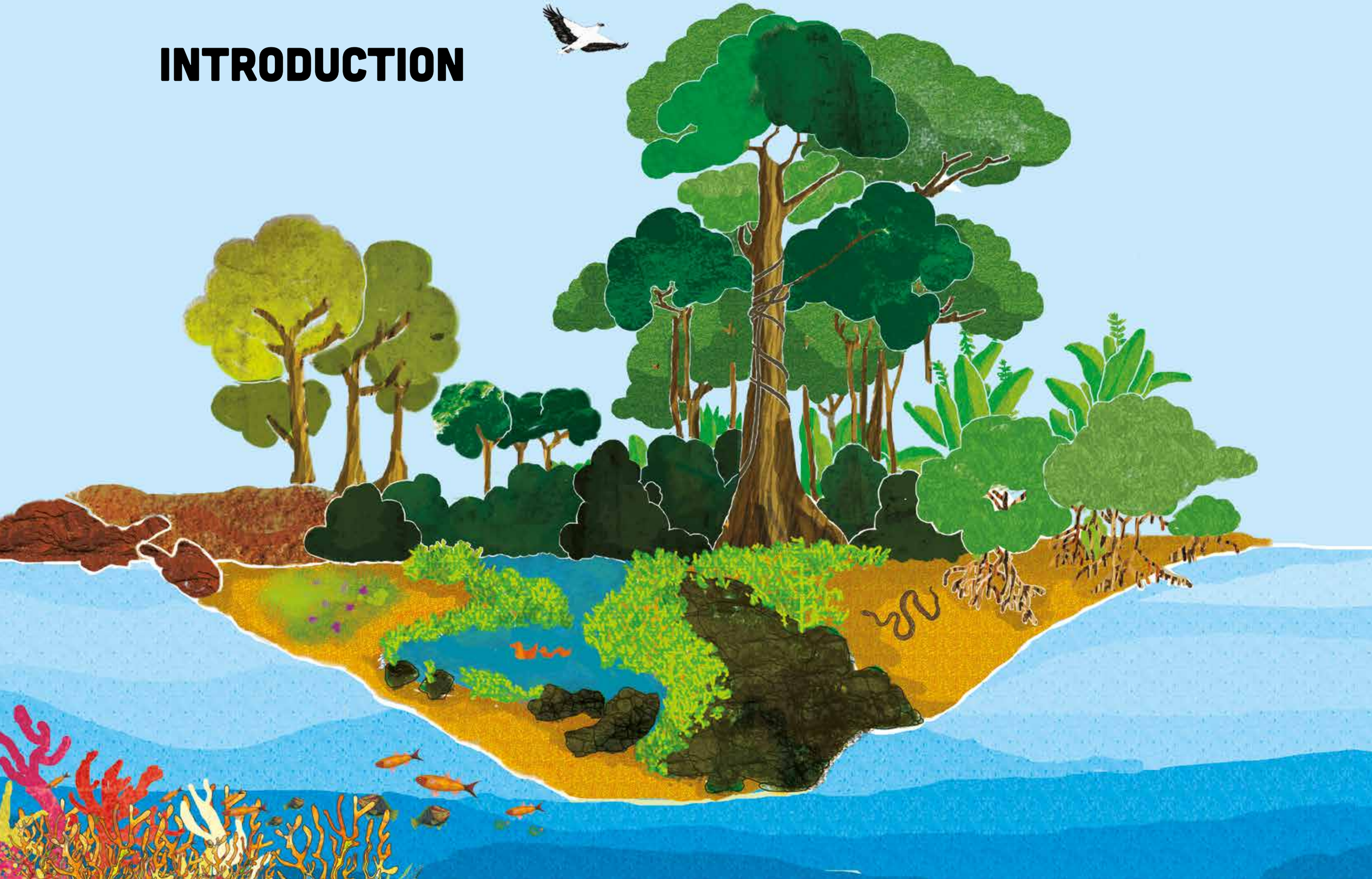
After you have read this book and run some of the activities with the students, ask yourself and the students, "Do we understand a little bit more about nature than we did before? Do we love our unique islands enough to do all we can to protect them from any harm?" If you answered YES, then you have used the book and the message it contains in the best way possible! Carry on; spread the message within your community and throughout the islands!

Planning field trips

- Check the tide time table. For an opportunity for safe and thorough exploration, it is best to go when the tide is low but also when the sun is not too high in the sky.
- Visit the area beforehand and familiarise yourself with the place that you plan to take the students to, including the route to take, rest points and most commonly found organisms.
- Wear cotton clothes that will keep you cool and dry quickly. Wear sandals, preferably with straps. No slippers or shower shoes.
- Keep the group together. In case the group needs to be split up, ensure that each instructor has a first aid kit.
- Apply insect repellent and sunscreen before you enter the intertidal area.
- Restrict wading in water. No one should wade in water that goes higher than mid-calf.
- Students should not touch organisms without a knowledgeable resource person's permission. No one should be permitted to take any items—alive or not—away from the shore. Organisms should be replaced in the same spot if picked up.
- Leave no trace. Always carry a garbage bag along and take back your litter and, if possible, any other litter that is visible.

Group students and instructors in a 10:1 ratio so that differently-abled students are also able to experience engagement and gain from the visit.

INTRODUCTION



Location

The Andaman and Nicobar Islands Union Territory is one of India's two island groups and an invaluable natural treasure. This archipelago comprises 572 islands, islets, and rocks in the Bay of Bengal. The islands are situated on the eastern boundaries of the Bay of Bengal, in close proximity to Myanmar, Thailand, and Indonesia.

Sri Vijaya Puram (previously known as Port Blair) is the capital, with a population of ~ 150,000. This is more than one-third of the islands' total population, estimated in 2019, at over 400,000 people. Sri Vijaya Puram lies on the east coast of South Andaman Island and is approximately 1,300 km east of Chennai and south of Kolkata. Apart from the six indigenous communities, the rest of the population is made up of settlers from various parts of mainland India and Myanmar.

Formation and structure

The Andaman and Nicobar Islands are an extension of the Arakan Yoma that stretches from Myanmar to Sumatra. The exposed tops of these mountains above the sea are what we know as the Andaman and Nicobar Islands.

Many million years ago, the Indian Tectonic Plate broke away from the African landmass and started inching northwards. About 50 million years ago, it collided with the Eurasian and the Sunda Plates. The collision with the Eurasian plate resulted in the upliftment and formation of the Himalayas, while collisions with the Sunda Plate resulted in the formation of the Andaman-Nicobar Basin. Over this basin lies the Andaman Sea, bordered by a string of seismically active landmasses and tectonic plates. The soil here is generally poor and acidic, consisting of limestone and sandstone.

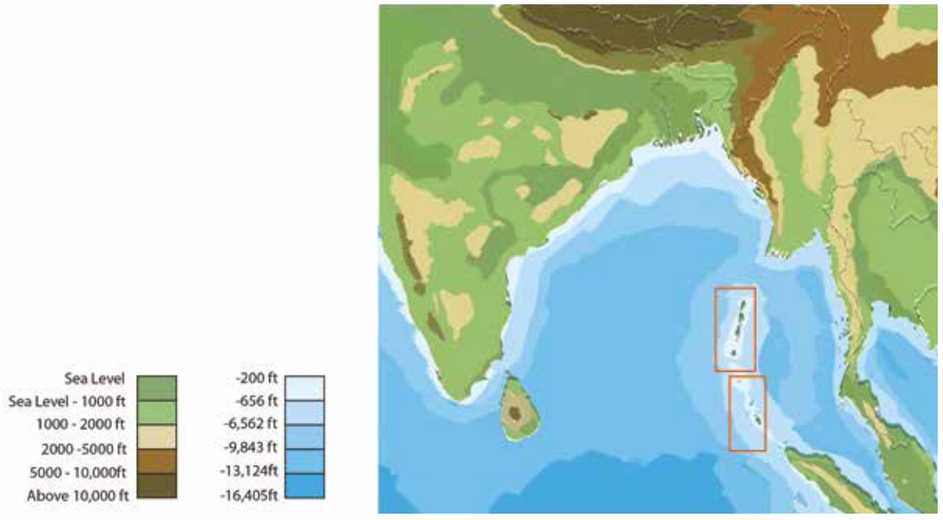
The limestone caves and mud volcanoes on Baratang Island are places of geologic importance. Nests of the highly endangered edible-nest swiftlets are found in these limestone caves. The mud volcanoes in Baratang and Diglipur are the only ones of their kind in India. These are not true volcanoes but conical bumps formed when the earth expels a semi-liquid mixture of certain clayey minerals, heated water, and gases. This mixture comes out through narrow openings on the Earth's surface.

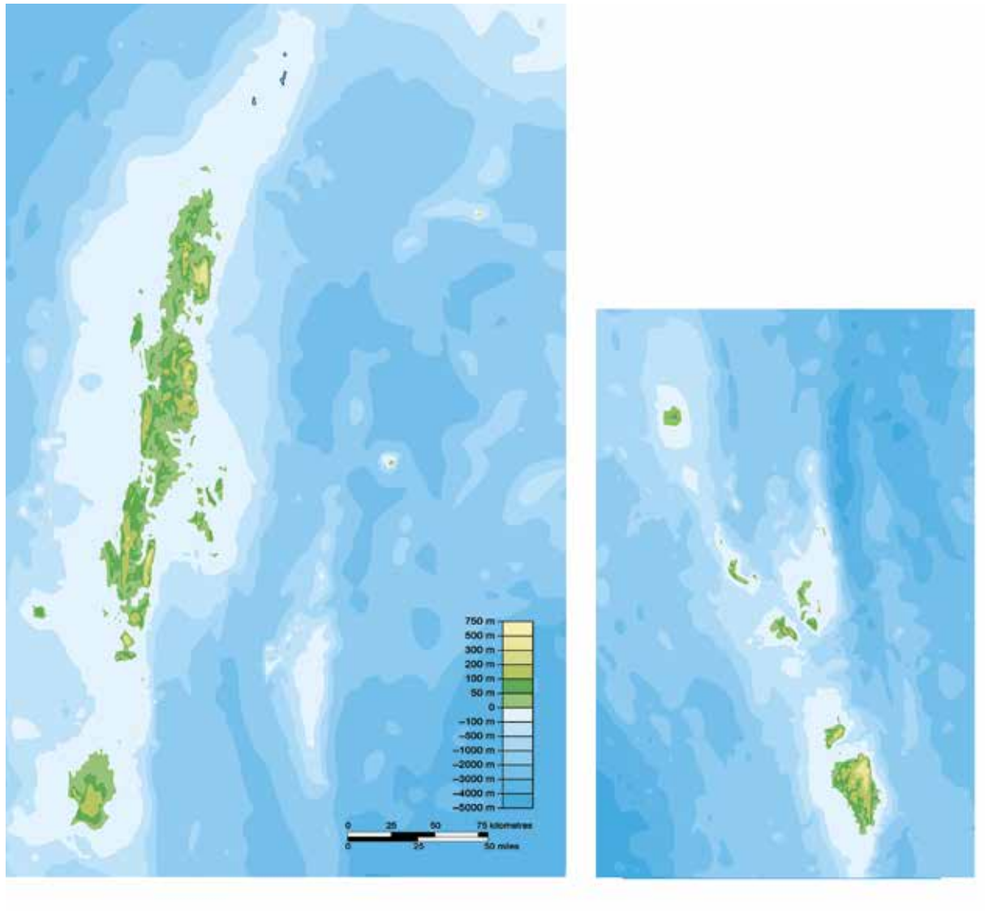
Physical features and resources

The Andaman and Nicobar Islands extend approximately 740 km North to South, defining the eastern and southernmost locations of India. The Andaman group of islands are separated from the Nicobar Islands by a 160 km wide strip of water called the 'Ten Degree Channel'. The northernmost point of North Andaman group, Landfall Island, is separated by about 20 km from the Little Coco Island, the southernmost island of Myanmar.

These undulating landmasses, interspersed with water, are uneven and comprise hills and ridges. The islands are narrow, with an average width of only 20 km. The highest point of the Andaman Islands is Saddle Peak (732 m), and that of the Nicobar Islands is Mount Thuillier (642 m).

Being in close proximity to the equator, these islands experience a tropical climate. They receive substantial rainfall, between 3000 to 3500 mm annually, from both the northeast and southwest monsoons. It rains for seven months of the year here! Great Nicobar has three major rivers flowing through it—Galathea, Alexandra and Dagmar, all with their sources in Mt. Thuillier. The Andaman Islands have one major river—River Kalpong. The islands' first-ever hydropower project has been constructed over this river. Several other perennial streams and creeks are also found in the archipelago.





Why are our islands interesting?

Formed by tectonic activities and isolated for more than 50 million years, the islands' ecosystems are inhabited by some rare and unique flora and fauna. Being surrounded by the sea and with no direct link to other landmasses has resulted in the evolution of several plants and animals which are now unique to the Andaman and Nicobar Islands.

There are two volcanoes here—Narcondam, which is extinct, and Barren, which last erupted in 2022, sending out ash plumes as high as 6100 m.

The striking tropical evergreen forests that cover roughly 80% of the islands stand out like an emerald necklace against its turquoise blue waters.

Ecosystems on the islands

Each of these relatively small and isolated islands has a tremendous diversity of ecosystems. A cross-section of a typical island would illustrate the proximity and interconnectedness of its varied habitats. The unmistakable lowland evergreen forest gives way to the classic littoral system as one approaches the coast. The mangroves that fringe the islands colonise those areas influenced by the tide. The sandy, silty, and rocky coastline quickly gives way to coral reefs and then the great expanse of the ocean. The wonder is that one can find all these different ecosystems, from 'ridge to reef', within a very short distance of each other (sometimes within a few hundred meters).

Many of these plants and animals that inhabitat the Andaman and Nicobar Islands are found nowhere else on earth—we call them endemic species.

The Narcondam hornbill, for instance, is found only on the isolated island of Narcondam. A few other endemic species of plants and animals found here are the Andaman red wood (*padauk*), Andaman vanilla, Andaman day gecko or emerald gecko, Andaman pit viper, Andaman teal, Nicobar green pit viper, and Nicobar treeshrew. Little Andaman and Great Nicobar are the only places in India where leatherback sea turtles routinely come to nest. These turtles are the largest of their kind, and they travel to these islands to lay their eggs on sandy beaches.

Can you imagine that most of the islands of the Andaman group were all just one big landmass in the past? About 20,000-25,000 years ago, our world was much cooler, our poles had much larger quantities of ice, and our seas were much shallower than today. This period is known as the Last Glacial Maximum. During this period, since the sea level in the Andaman and Nicobar Islands was much lower (more than 100 m lower than today), the Andaman was one

large island, including Little Andaman Island. There were no smaller islands as we see today. The only islands that were not a part of this large landmass were South Sentinel, Narcondam, and Barren Island. As the sea level started rising again, the large landmass slowly started getting submerged. While the sea took over the shallow parts, the higher land became islands, and soon the Andamans as we know them today were formed.

The flora and fauna of the Andaman group of islands are extremely different from that of the Nicobar group. Separated by the deep waters of the Ten Degree Channel, this group of islands have remained separated since their origins. The Andaman group of islands have flora and fauna similar to the Indo-Burmese and Thai regions, whereas the Nicobar Island groups are more similar to Malaysia and Indonesia.

Why are our islands geologically susceptible?

The Alpide belt, a stretch of seismically active mountain ranges, stretching from Java through the Himalayas and Alps all the way out to the Atlantic, is the second most seismic region in the world, after the Pacific "Ring of Fire". Our islands fall within this belt and are susceptible to earthquakes, volcanic activity, and tsunamis.

While long periods of isolation from other large landmasses have made the flora and fauna of the islands special, the same condition of isolation renders them very fragile. If a large disturbance such as an earthquake or a volcanic eruption were to hit the islands, it could easily wipe out all the species of flora and fauna forever. For instance, if something were to happen to the tiny island of Narcondam, we would lose the Narcondam hornbill forever. This makes the biodiversity of the islands special and extremely fragile.

An eventful history

Humans have lived on the Andaman and Nicobar Islands for thousands of years. At present, the Andaman Islands are home to four distinct indigenous tribes, while the Nicobar Islands have two. The indigenous tribes of the Andamans likely arrived about 20,000 years ago, while the Nicobars were settled about 5,000 years ago. The Nicobarese, who are of Austro-Asiatic origin, have close links to communities such as the Karen from Myanmar, the Javanese from Indonesia, and the Htin Mal from Laos.

The earliest reference to the name Nicobar comes from the word "Nagga" in the Pali Buddhist chronicles of Sri Lanka, which means naked. Historical records for the region appear from about 1000 BCE when the Nicobars, especially the central group, appear as an important node in the maritime trade routes passing through Sri Lanka, Southeast Asia, and further to China. In the 7th Century CE, the islands appear in the Chinese traveler I'tsing's accounts. Further, it is believed that the Cholas used the Nicobars as a base around 1000 CE for warfare and control of the Malayan region. In 1014, the islands were first conquered by Rajendra Chola I, a ruler of the Tamil Chola dynasty. The archipelago referred to as Nakkavaram finds mention in the Tanjore inscription in 1250 AD and in the records of Rajendra Chola; specific mentions of places such as Kar Dipa and Naga Dipa are likely to be Car Nicobar and Great Nicobar, respectively.

The spice trade and associated trade routes gained significance in the eyes of European explorers such as Marco Polo, who passed by the islands (referred to as Necuveram) in 1290 CE, and in 1322 CE by Friar Odoric, who referred to it as Nicovaram. Ships used to stop here for fresh water and food supplies. The renowned traveller Marco Polo from Italy visited the islands and wrote about them. Arab and Malay traders used to anchor their ships here, capture the native people, and take them back as slaves. Later, in the 17th century, they are believed to have been used as a naval base for the Maratha Empire.

Among the first accounts of Europeans landing on the islands include that of William Dampier, the explorer, privateer, and naturalist, who was stranded in the islands in 1688 and stayed in the islands for a period of time. In 1754, a formal effort was made by the Danes, who started an expedition from Tranquebar on the eastern coast of India with the intention of establishing a colony in the Nicobars. A settlement colony called New Denmark was established in 1756 on the island of Kamorta, which took advantage of its position as one of the world's finest natural harbours. This was followed by the establishment of the Moravian Church in 1759. The dual ambitions of colonisation and conversion were underway in the Nicobars.

The Napoleanic Wars saw a brief period of possession (1807-1814) by the British, but following the treaty with the Danes, the Nicobars were handed back to them. The French Jesuits arrived in the islands in 1835, which initiated a period of uncertainty and loss of territory for the Danes, who made several attempts to regain control of the islands. There were also intermittent attempts by Italian, Austrian, and Norwegian colonial entities. Eventually, however, the British prevailed over both Danish and French ambitions, and in 1869, the Nicobars were annexed to the empire in the name of Queen Victoria.

Captain Archibald Blair had first established a settlement on Chatham Island and named it Port Cornwallis (later named Port Blair after him). This was abandoned, but a penal settlement was established by the British in 1858 after the first the First War of Independance. Initially, convicts from mainland India were sent here as labourers. The Cellular Jail was constructed between 1896 and 1906, after which convicts, rebels, and freedom fighters from mainland India were sent there for long, harsh prison terms.

The islands continued to be British territory until 1942 when the Japanese invasion of the Andaman and Nicobar Islands took place. The British were expelled when the Japanese invaded and occupied the islands from 1942 to 1945 during World War II. The islanders have harrowing memories of this period of suffering. With the surrender of Japan in 1945, the islands were once again handed back to the British.

Since they were part of British territories, with Indian independence in 1947, the islands became a part of a newly independent India. After Indian independence, the captive freedom fighters were released from prison, and many were settled in the islands to restart their lives. People also migrated here from different parts of mainland India for various reasons. These new settlers and subsequently the refugees from Bangladesh were provided with allotments of land for agriculture. The Andaman and Nicobar Islands were declared a Union Territory of India in 1956.

Due to its location and access to numerous nations and trade routes, the Andaman and Nicobar Islands are regarded as a strategic military base. This explains the numerous colonisation efforts throughout history, as well as India's current defence installations.

Administration

Sri Vijaya Puram is the capital of the islands as a whole. However, for administrative purposes, the islands are split into three districts—North and Middle Andaman, South Andaman, and Nicobar. These three districts are further divided into subdivisions and taluks. The Andaman and Nicobar Islands is a Union Territory and is directly governed by the centre with one elected Member of Parliament.

Occupation and economy

Fishing and tourism are the two major sources of economy for the islands. Agriculture is also a major livelihood, with paddy being widely cultivated on the Andaman Islands, while coconut and areca nut plantations are prevalent in the Nicobar. Timber cutting, logging, and exporting were once an important source of income. After the ban on logging, there has been a rapid increase in fisheries, tourism, handicrafts, and the seashell trade, along with a number of other small-scale industries. A large number of islanders also work for various government departments.

Threats to our islands

The Andaman and Nicobar Islands are endowed with rich natural resources and beauty. But the whole system is also extremely fragile. We must be aware of the many dangers the islands face. Cutting down of forests, destruction of coral reefs, clearing land for plantations, unsustainable development, overfishing, unplanned tourism, and excessive settlements are just some of the problems the islands and their inhabitants have to deal with. It is important that we understand and cherish the value of our precious heritage and gain the knowledge we need to conserve it for future generations.

CHAPTER

1 OCEANS

One big ocean

The earth has one big ocean, divided into five large connected oceans. From the largest to the smallest these are the Pacific, Atlantic, Indian, Arctic, and Southern Oceans.

The characteristics of the oceans are determined and affected by the flow of seawater and freshwater (evaporation, condensation, and precipitation through the water cycle) between them. The characteristics of the marine habitat are affected by these flows and by depth and penetration of sunlight. Various organisms, from bacteria to blue whales, have developed adaptations to these diverse and dynamic conditions. Intricate marine food webs hold together creatures through a network of dependency. Any threats to the ocean—local or global—that even affect small sections of these food webs consequently affect the health of oceans and human communities at large. Yet, there are ways to care for and protect oceans and marine resources from these disturbances.

Ocean motion

The earth is unevenly heated by the sun. The earth's climate is regulated by the movement of water from the warmer equatorial regions towards the cooler polar regions. Along with the distribution of heat around the globe, waves, tides and currents transport nutrients, minerals and even oxygen through the movement of large water masses through the deep ocean.

- Waves – driven by local and global wind patterns and factors
- Tides – caused by the interaction of the gravitational forces exerted by the moon and sun, and the earth's rotation
- Currents – depending on depth, ocean currents are caused by winds, ocean temperatures and the salinity of water

The constant movement of water:

i. erodes coastlines, picking up minerals such as sodium chloride, magnesium, potassium and calcium which are deposits sand on beaches

ii. continuously distributes and redistributes marine debris

Marine debris comprises litter that escapes landfills and ends up in waterways and the ocean, as well as trash intentionally deposited in water channels and the open ocean. It includes plastic, glass, and other packaging material from food and other consumer goods, fishing gear, paper, and an assortment of other objects, including toothbrushes and footwear, floating in open water or washed ashore, sometimes hundreds of kilometres from their sources.

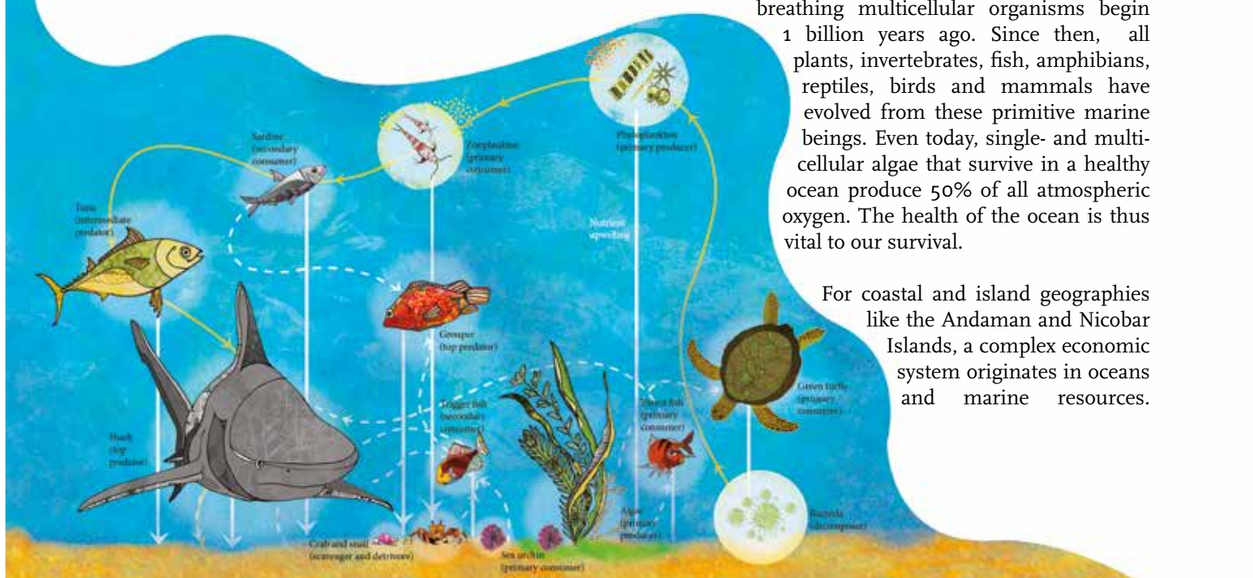
The oceans surrounding the Andaman and Nicobar Islands play an important role in the south-west and north-east monsoons. Each year, strong winds carrying monsoon clouds churn up the surface of the sea, making journeys by boat and ship between islands very rough.

As the global climate changes, the level of ocean water is also rising slowly yet steadily, and island systems such as the Andaman and Nicobar Islands must deal with the effects of disappearing coastal land.

Life depends on the oceans

Life evolved in primitive seas 3.5 billion years ago, that is 3,500,000,000 years ago! Oxygen-producing marine blue-green algae evolved in the ocean 2.7 billion (2,700,000,000) years ago. These marine blue-green algae or cyanobacteria developed the ability to perform photosynthesis and oxygen was added to the earth's ocean and atmosphere. Only when the earth's methane-based atmosphere was fundamentally changed did the evolution of oxygen-breathing multicellular organisms begin 1 billion years ago. Since then, all plants, invertebrates, fish, amphibians, reptiles, birds and mammals have evolved from these primitive marine beings. Even today, single- and multi-cellular algae that survive in a healthy ocean produce 50% of all atmospheric oxygen. The health of the ocean is thus vital to our survival.

For coastal and island geographies like the Andaman and Nicobar Islands, a complex economic system originates in oceans and marine resources.



Food, income, and recreational activities depend on oceans and marine resources. Fish are a source of animal protein, and fisheries are the economic backbone for many coastal communities.

Adaptations to ocean zones

Ocean habitats are classified by their latitude (tropical, temperate, and polar), ocean floor type, and depth. In the marine habitats around the Andaman and Nicobar Islands, life has developed adaptations based on the availability of sunlight at various depths. The photic or "sunlight" zone receives sunlight that primary producers use as energy to produce food. This zone extends from the surface to about 200 meters in most oceans. It is the warmest and brightest ocean zone, where nearly 90% of marine life resides, relying on sunlight for photosynthesis. Animals in this region have highly developed sense organs and camouflage techniques. Many exhibit countershading, like sharks and dolphins, having darker backs and lighter undersides to blend into their environment from different perspectives. Additionally, some fish have silvery sides that reflect light, while coral reef inhabitants often showcase stripes and patterns for camouflage.

Below the photic zone is the disphotic or "twilight" zone where low light prevents photosynthesis. Animals here are adapted to darkness and cold, often featuring large, light-sensitive eyes and bioluminescence. Food is scarce, primarily coming from dead organisms, leading to fewer, smaller, and non-picky eaters. They utilise sharp teeth and large mouths to catch any passing fish. Like those above, transparency and countershading help them avoid predators.

Beyond 1000 m, the ocean is extremely dark in the aphotic or "midnight" zone, where species are adapted to no light, high pressure, and freezing temperatures. Organisms are typically grey, off-white, or black, and since food is scarce, they conserve energy, resulting in sluggish behavior. They have flabby muscles, weak skeletons, and no scales, often appearing small with large mouths and small eyes. Some exhibit bioluminescence.

Marine food webs

Marine primary producers are a diverse group of organisms. In the densely populated photic zone, the sun is the primary source of energy. In the shallow waters over the continental rise, the continental slope and the intertidal zone, photosynthesising sea grass is found attached to the ocean bottom. Drifting with ocean currents, single-celled organisms (such as diatoms) and cyanobacteria comprise phytoplankton which live near the surface of the ocean and use solar energy and carbon dioxide to make food and oxygen.

Zooplankton are animals ranging in size from tiny microscopic organisms to larger jellyfish. They eat phytoplankton or other zooplankton. Most zooplankton migrate vertically every day, travelling up to the sunlight zone during the night to feed. Sea grass is consumed by primary consumers or herbivores (plant-eating animals) such as many fish, invertebrates, and mammals. These are, in turn, eaten by secondary consumers or carnivores. Top or "apex" predators in the ocean include sharks, groupers, tuna, marlin, killer whales and others.

When they die, the plants and animals of the photic zone sink towards the ocean floor. Bacteria gradually decompose them and the nutrients are released from the dead tissue. Some remains of dead plants and animals reach the ocean bottom and are eaten by scavengers and detritivores like crabs and snails.

Those that reach deeper oceans and are eaten by scavengers like deep-water sharks living there. Thus, even waste from animals in the surface waters provides nutrients to those living in the deep sea.

This downward movement of organic debris recycles nutrients. These are gradually carried back to the surface to be used by plants to make food and re-enter the food web. Food, nutrients, minerals, and oxygen are exchanged between the surface and deep layers by currents that move water up and down. Currents, both horizontal and vertical, help maintain a vital cycle of ocean connectivity.

Threats to the ocean

The oceans have been looked upon as an endless resource for fish and as a dumping ground for waste for centuries. However, research is revealing the compounding effects of such unchecked human activities in a system of habitats that is more complex than it was previously imagined.

Unsustainable fishing

People are taking out more fish from the ocean than can be replaced by reproduction. This results in the decline of several important fish populations to the point where their survival is threatened. Overfishing is the result of a growing demand for seafood, combined with poor management of fisheries and the development of increasingly efficient fishing techniques.

Pollution

Pollution has intentional as well as unintentional dimensions. Untreated sewage, garbage, heavy metals, fertilisers, pesticides, oil, industrial chemicals, and terrestrial sediments all eventually make their way into the ocean. Chemical pollution and microplastics harm the entire marine food web; once consumed by smaller organisms, it often makes its way up the food chain, even impacting humans, a process called "biomagnification."

Solid waste like plastic bags and other domestic waste that are dumped into the ocean are circulated by ocean currents. These items are confused for food and consumed by sea turtles, marine mammals, fish, and seabirds, choking them or even causing their stomachs to fill in volume but without nutrition, causing their death by starvation.

Abandoned or "ghost" fishing gear restricts the movement of marine mammals, birds, and reptiles that get entangled in it, drags them under the surface of the water and often causing them to drown.

Invasive species

Most often, marine species are introduced to new areas through the ballast water of ships. Ships have tanks that are filled with seawater to counterbalance the weight of their cargo. Water is drawn in at the loading port and discharged at the destination along with whatever organisms happen to be inside, from schools of fish to microscopic organisms. Introduced species become problematic or "invasive" when they prey on local species, compete with them for food or space, or even by introducing disease.

Climate change

Climate change is causing an increase in the average global temperatures across seasons. This is commonly termed "global warming." Increasing global and sea surface temperatures have resulted in a greater frequency of extreme weather events such as cyclones and tropical storms. Increasing water temperatures also affect organisms and their ability to survive, changing their distribution and migration routes. Marine heat waves are notoriously difficult to reverse. Climate change is also accelerating the rate of sea ice and glacier melt. As a result, increasing sea levels can lead to the submergence of low-lying coastal areas, including mangroves and coastal wetlands, an impact most urgently felt in island ecosystems.

Caring for the ocean

Caring for the vast and interconnected oceans is a complex matter. Understanding the oceans and marine resources through research is key to their conservation. How do changes in the atmosphere affect the ocean and vice versa? How do these large scale changes trickle down to changes in food webs? How can we better manage fisheries through learning about the fish and their habitats? How can we gain novel medicines and new forms of energy from the ocean?

95% of the Earth's oceans are still uncharted, and so we attempt to protect what we know and have access to. Marine Protected Areas (MPAs) are areas of the ocean where human activities are more strictly regulated than in the surrounding waters. Globally, 8% of the world's oceans are protected by designating them as MPAs. MPAs are designed to protect marine ecosystems, processes, habitats, and species, which can contribute to the restoration and replenishment of resources.

In the Andaman and Nicobar Islands, there are over 15 MPAs including the Mahatma Gandhi Marine National Park in Wandoor and the Rani Jhansi Marine National Park in Ritchie's archipelago.

Biodiversity

01. Banded Sea Krait: Venomous but docile ocean snake that feeds on small invertebrates and fish.

02. Seahorse: The head looks like a horse; it lacks scales and its skin stretches over a series of bony plates; the male carries the eggs in a pouch.

03. Dugong: State animal of the Andaman and Nicobar Islands; mammal whose diet comprises mostly of seagrass.

04. Flying Fish: Wing-like fins that enable it to glide above the surface of the water; they "fly" to gain speed and avoid predators like dolphins, tuna, marlin, and trevallies.

05. Jellyfish: Free swimming bell shaped organism with tentacles, and is 90% water; eaten by leatherback sea turtles.

06. Manta Ray: Largest of the rays – can be more than 6 meters long from fin tip to fin tip; a filter feeder that feeds mainly on plankton.

07. Dolphin: Intelligent mammal, communicates in high-pitched squeaks with a unique complex language; eats small fish and squid.

08. Octopus: Has eight arms and a body shape different from the squid; females protect and care for their eggs up until hatching; males die after mating and females die soon after the eggs hatch.

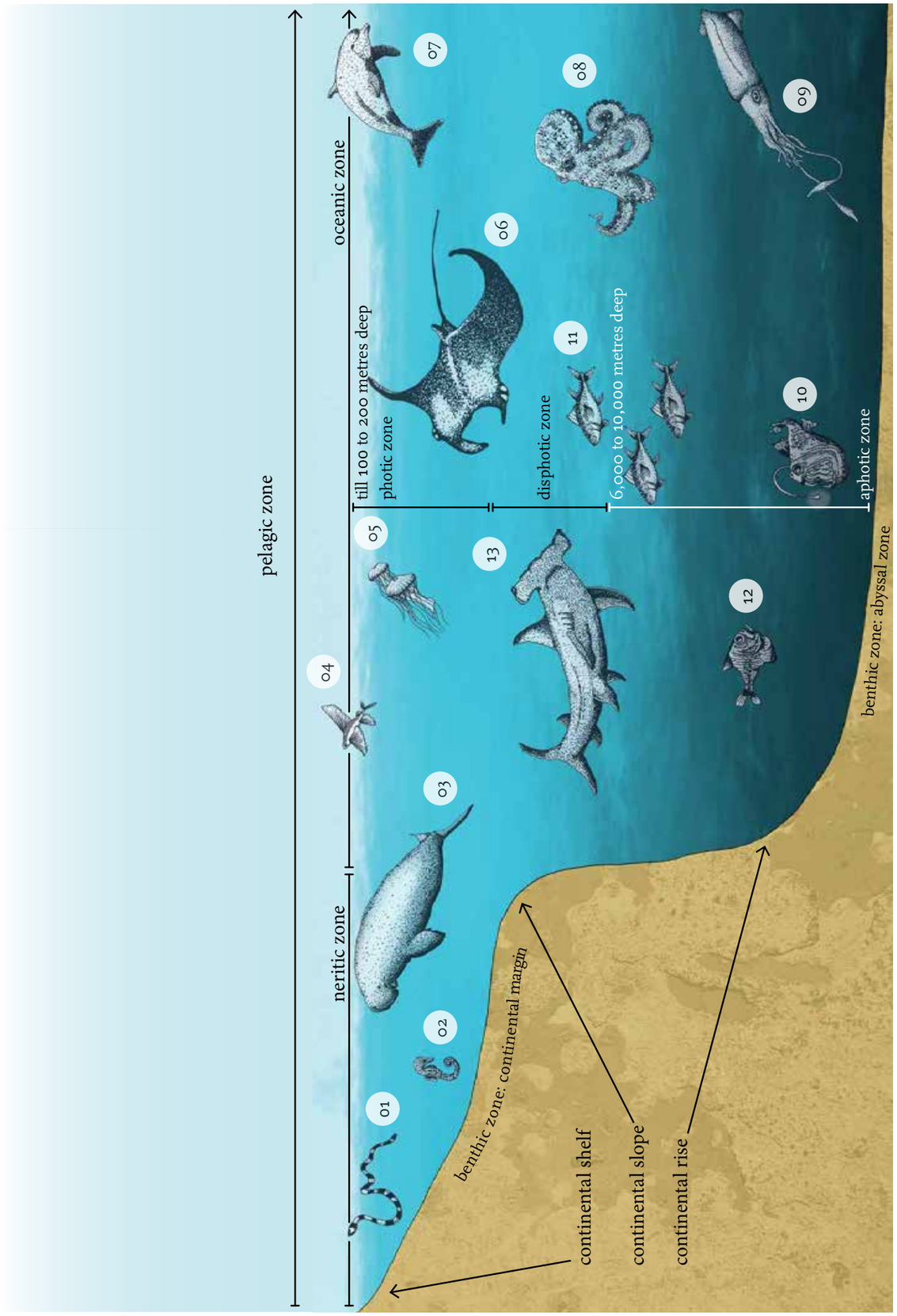
09. Squid: Closely related to octopus, the squid has eight arms, two longer tentacles and a distinct head; both squid and octopus can rapidly change colour with the help of the pigments in their skin and can squirt ink as a defence mechanism when threatened.

10. Anglerfish: Lives in the deep sea and eats fish, zooplankton, squid, and worms; females have a fleshy light-producing lure that hangs from the head to attract prey or mates.

11. Tuna: Swim in schools, often below dolphins; important commercial fish.

12. Hatchetfish: Found at depths ranging from 200-600 m; feeds on zooplankton and shrimp.

13. Hammerhead shark: The eyes are on the sides of the hammer shaped head; swims in schools in the day, solitary hunter at night.



ACTIVITY 1.1 LIFE IN THE OCEAN ZONES

CLASS	LOCATION	GROUPING	TIME
6	indoor	groups of five	20 minutes

Objective

To understand how marine organisms are adapted for survival at different depths, and represent their presence in the ocean on a collaborative diagram.

Learning outcomes

This activity will enable students to:

- match marine life to the zone it can be found in
- outline how certain adaptations help organisms survive in their respective ocean zones

Materials

- Sticky notes
- Sketch pens

Learning procedure

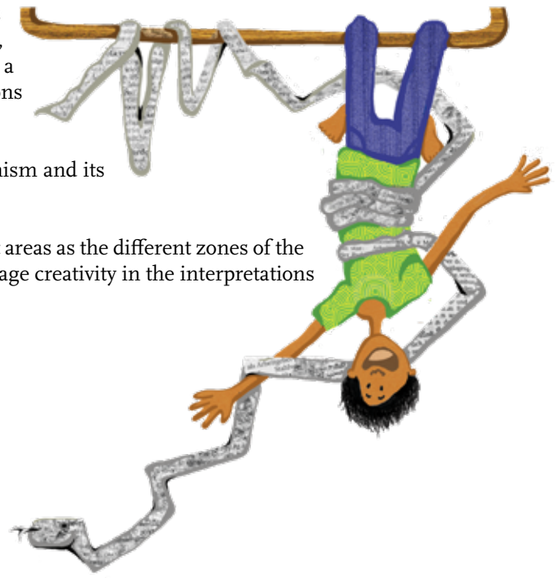
- On the board, draw a large diagram (outlines only) of the ocean floor (benthic zone) with varying depths to represent the following: (1) continental shelf and continental margin, (2) continental slope, (3) continental rise, (4) abyssal zone, and a line to represent the surface of the ocean. Preferably, use the whole board for this diagram.
- Divide students into groups of five. Give each group a name or a number. Give students a few minutes to discuss and list animals that live in the ocean.
- Instruct students that they must write the name of each animal from their list on a separate sticky note along with the name or the number of the group and be ready for the next instruction. Distribute seven to ten sticky notes per group. Assign five to seven minutes to complete this task.
- Instruct students to come to the board, one at a time, bringing one sticky note from their group and place it in the correct zone on the board. Check and correct misconceptions using the information in the chapter on Oceans. Move incorrectly placed sticky notes once the correct answer has been discussed.
- Conclude with a guided discussion:
  - What are some adaptations of marine organisms?
  - Why did they need to adapt?
  - How do sunlight, temperature, salinity, and pressure change the adaptations needed?
  - What makes exploration of the deep sea challenging?

Other variations

Art and craft: Create posters about different organisms, or create models using old newspapers, palm leaf plates, baskets, clay, broomsticks, glue, scissors, tape, colour pencils, rulers, and any available materials. Write a note on the marine organism (as in a museum) to describe its adaptations and the ocean zone it lives in.

Language and literature: Write a very brief report about a marine organism and its habitat.

Movement: Conduct the activity on the playground, designating different areas as the different zones of the ocean. Instruct students to act or pretend to be these organisms. Encourage creativity in the interpretations of their movements.



ACTIVITY 1.2 CONNECTIVITY IN THE OCEAN

CLASS	LOCATION	GROUPING	TIME
7	indoor/outdoor	whole class at once	40 minutes

Objective

To become aware of the complex interactions between organisms in the ocean.

Learning outcomes

This activity will enable students to:

- outline the complexity of marine food webs: that a single organism has a varied diet and that one organism may be eaten by many
- describe how phytoplankton and bacteria are the beginning and end, respectively, of ocean food chains and are therefore essential components of marine ecosystems
- relate human activities to instability in marine food webs

Materials

- 2 to 5 metres of yarn/twine/thick string/embroidery thread of three or four colours
- Standard two-hole punch machine
- Blank cards made from chart paper (one per student) punched with holes
- Markers or sketch pens
- A basketball or a football
- Scissors

Learning procedure

- Instruct students that they have three minutes to: (1) think of one ocean organism that they are confident no one else will think of; (2) stand in a circle.
- Standing in a circle, instruct students to say the name of the organism they have chosen out loud, together. Judge whether the same organism is repeated too often or any important organisms are missing. According to the situation, either give students a second opportunity to choose an organism or assign organisms to students to make the group diverse. Use the clues and answers at the end of this activity to help students recall and choose different organisms.
- Hand over one card per student and instruct them to write the name of the assigned organism on it. Create a name tag for each student using some string.
- Select the student who is a producer (phytoplankton or seagrass) and hand this student a loose end of string. Next, ask the "organisms" who consume this producer to raise their hands. If more than one student raises their hands, instruct them to convince the group why they should be given the food. Pass the ball of string to the selected student. Keep the string taut between the two students.
- Next, repeat the process for the next level of organism: Who is hungry?

- Continue till a trophic chain has been established. If there are students not connected by the web, take a different coloured string and repeat the process until all the students are connected to each other in some way. Some students can be included more than once, depending on the distribution of organisms.
- The more interconnections between the points in the circle, the better. Keep all the strings taut but pay attention that it is not wound tightly around anyone's finger or wrist or dangerously tight in any way. Ensure the physical safety of the students.
- Next, place the basketball on the web of strings and allow the web to hold it up. Ask students: "What human activities affect the oceans?"
- As a student names an activity, cut the string from the organisms it affects. e.g. "Plastic pollution affects sea turtles."
- Cut the string or instruct the sea turtles to all step back from the circle and let the string fall from their grip.
- Observe and discuss the way the basketball or football behaves as the strings loosen.
- Discuss with students:
  - What is the first source of energy in the marine food web? Ans. the Sun
  - What is the invisible producer? Ans. phytoplankton
  - Which plankton feeds on phytoplankton? Ans. zooplankton
  - What breaks down the dead matter in the oceans? Ans. bacteria

Other variations

Art and craft: Create posters depicting marine food webs and including white-bellied sea eagles and other birds and even humans. Posters can be created by groups of students with a diversity of animals depicted at various levels of the marine food webs.

Organism clues	Answers
I am the primary source of energy.	Sunlight
I am free floating and use energy from the sun to turn carbon dioxide gas into food and oxygen.	Phytoplankton
I am free floating and eat phytoplankton.	Zooplankton
I am rooted to the bottom and use energy from the sun to turn carbon dioxide gas into food and oxygen.	Seagrass
I may or may not live symbiotically and use energy from the sun to turn carbon dioxide gas into food and oxygen.	Algae
I contain symbiotic algae that provide most of my nutrition but I also feed on small zooplankton.	Coral
I graze on algae.	Sea urchin
I eat algae found inside corals , on their surface and on top of rocks.	Parrotfish
I eat phytoplankton and zooplankton found in the open ocean.	Flying fish

Organism clues	Answers
I eat sea urchins, crabs, shrimp, and baby lobsters on coral reefs.	Triggerfish
I eat zooplankton and dead and decomposing matter that fall to ocean depths from the surface.	Hatchetfish
I eat zooplankton in the open sea.	Sardine
I eat zooplankton, small fish and worms.	Anglerfish
I eat smaller fishes found on coral reefs.	Grouper
I eat small fish, phytoplankton and zooplankton.	Jellyfish
I only eat jellyfish.	Leatherback sea turtle
I eat small fish such as flying fish and sardines.	Tuna
I eat seagrasses.	Dugong
I eat flying fish, sardines and squid.	Dolphin
I eat sardines, flying fish and tuna.	Squid
I eat fish and crustaceans.	Octopus
I eat small tuna, sardines, flying fish, sea snakes and baby turtles.	White-bellied sea eagle
I eat large fish such as tuna, trevallies, parrotfish and small groupers.	Hammerhead shark

ACTIVITY 1.3 SUSTAINABLE FISHERIES

CLASS	LOCATION	GROUPING	TIME
8	outdoor	whole class at once	80 minutes

Objective

To illustrate the impact of overfishing on a single species of commercially valuable fish.

Learning outcomes

This activity will enable students to:

- recognise the changes in the fishing industry
- correlate these changes with an increased demand for fish
- experience and assess some of the challenges faced by dwindling fish populations
- identify the impact of overfishing on the ecosystem

Materials

- Cards of coloured chart paper (red, green, blue, yellow)
- Balls

Learning procedure

- Assign colour cards to students as follows: for every 10 students, assign 1 red, 2 green, 3 blue, and 4 yellow coloured cards. The number of coloured cards will vary with class size, but approximate the above proportions as closely as possible. Inform the students that the cards represent different fish caught by fishermen on the islands.
- Take the students to a large open area to play this game. Have them spread out as far as possible and toss a ball to each other such that it is slightly difficult to catch it. All the colours/fish need to be spread out evenly.
- Explain that the ball represents life. Have them toss around the ball for a minute. Discuss how easy or hard this is. Explain that when a species has a sustainable population, life is easy. They are close enough to each other to interact (to mate, to be protected by their school, etc.).
- Tell students that unfortunately, many species of marine animals and fish have been fished from the ocean too much. Individual fishermen or those on small boats were the first to extract animals from the sea. Fish was only available to people who lived close to the oceans and other water bodies. Tell them that two local fishermen in a small boat have entered the space to catch some fish. They have taken out just a few fish from the waters. Ask students with the red cards to sit down.
- Get the students to repeat the ball tossing activity, now without the students with the red cards. Ask students how the loss of the red cardholders affects the population. Generate a discussion about how local fishermen who only catch what they need have very little impact on fish populations.
- Continue the story by telling students that a variety of factors influenced the increased demand for seafood. Refrigeration technology and transportation by land, air, and water made transportation of fish to other areas (such as the mainland and other countries) much easier. Seafood was no longer food for only coastal inhabitants. As technology improved, larger boats went out to sea with larger nets and could catch more fish from the sea. Tell the students that fishermen have now come back in to fish with their improved technology and ask students with the blue cards to sit down, while the rest continue tossing the ball.
- Discuss what is happening with the game (some students are farther away from other students than they previously were, and it is hard to toss to them; more difficult to have interactions with members of their species).
- The demand for fish increases as the population of the world increases. This, coupled with the improvements in fishing technology, enables fishermen to become much more efficient. Fishing vessels can hold tons of fish, can stay out at sea longer, and can catch and store thousands of fish during one fishing trip. These vessels usually target one species of fish during a certain time of year and extract tons during the fishing season. Also, no matter when they fish, the vessels have bycatch (animals that are not the target of the fishing operations) in the nets or on the fishing lines. Not only are the populations of the target species quickly declining, but other species are negatively affected as well.
- Inform the students that fishermen have come back in again and have all the students with the yellow cards sit down.
- Have the remaining green card students briefly toss around the ball. Discuss what happens to the game when so many people can no longer participate in the game.
- Use the game to discuss the effects of overfishing with the class by asking questions such as
  - What problems could occur for the remaining fish (green card students) that are spread apart? (Lot more difficult to find a mate and reproduce)
  - What could happen if a disease breaks out among the population?
  - What could happen if an oil spill or other toxic event occurs?
  - What is the impact on the rest of the food web?
  - What could happen if we keep fishing this way?

CHAPTER 2

CORALS AND CORAL REEFS

Coral reefs are diverse and dynamic ecosystems where organisms ranging from microscopic plankton to megavertebrates such as sharks and sea turtles thrive. Fringing the coastlines of our islands, coral reefs support over a thousand types of fish and innumerable invertebrates. They also influence the lives and livelihoods of people that reside by them.

Often called rainforests of the sea, coral reefs are living structures made by colonies of tiny animals over thousands of years. Corals are sensitive, specialised animals and most grow well only in warm (about 24-29 °C), clear and shallow waters where sunlight penetrates to the bottom. They are found mostly in the region extending from 30°N to 30°S of the equator. Given the right conditions, reefs can grow to many kilometres. For instance, the Great Barrier Reef, off the east coast of Australia, is so big that it can be seen from the moon!

While the Great Barrier Reef is the largest reef structure in the world, the Coral Triangle, an area near Indonesia, Malaysia, and the Philippines, is the most diverse. It contains about 600 species of corals, making up 76% of all the species found in the world. Fifteen of these coral species are found only in this region and nowhere else in the world! The Coral Triangle is also home to over 3,000 species of fish.

The coral reefs of the Andaman and Nicobar Islands are not far behind. Over 1,200 types of fish and more than 400 species of corals have so far been recorded from the seas around these islands.

In addition to the Andaman and Nicobar Islands, India has three other major areas where coral reefs are found – the Gulf of Mannar (Tamil Nadu), the Gulf of Kutch (Gujarat), and the Lakshadweep Islands. Other isolated patches are found elsewhere along the Indian coast.

What are corals?

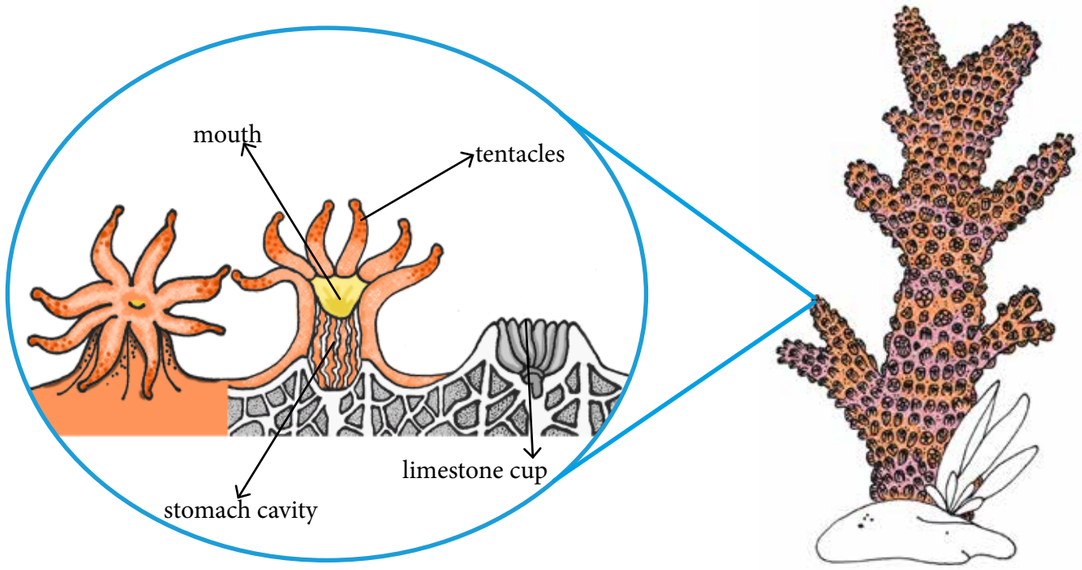
Locally known as *pathar/chaad* or rocks, coral reefs are not actually rocks, but built by and made up of thousands of tiny animals called coral polyps. Related to sea anemones and jellyfish, polyps usually live in large colonies and work generation after generation to create entire reef structures and islands.

Hard corals, or reef-building corals, are able to build skeletons out of calcium carbonate (also known as limestone), which they obtain from seawater. Individual polyps use this limestone to build protective cups around themselves. Each tiny individual polyp lives inside its protective limestone cup.

The polyp has a sac-like body that is usually attached to a firm object. The top of the body has a mouth which is used to take in food and remove waste materials. The mouth is surrounded by tentacles that are used to sense their surroundings and to capture prey. Polyps extend their tentacles, particularly at night, and use internal stinging cells called nematocysts to pierce and paralyse their prey and consume them. In times of danger or when it is resting, the polyp can withdraw its tentacles into its cup. A coral polyp cannot move and remains fixed to its cup throughout its life.

The limestone cups help cement each tiny animal of the colony to its neighbour. When a polyp dies, the skeleton remains and new polyps grow over the dead layer. With the addition of more and more limestone, a large solid mass is formed with only a thin layer of polyps on top, which remain alive.

Corals come in attractive shades of blue, orange, red, and more. These colours are not the corals' own. They are the colours of the different types of single-celled algae living in the corals. Corals share a mutualistic relationship with



these algae called zooxanthellae. The zooxanthellae can photosynthesize and provide the corals with most of the food they produce, helping the corals make their skeletons grow faster to form reefs. Corals, in turn, provide the algae with a safe place to live, where they receive plenty of sunlight and nitrogen-rich waste products. Some corals depend so heavily on these algae that they obtain up to 90% of their energy supply from them.

Development of a reef

Corals reproduce sexually as well as asexually. During sexual reproduction, coral colonies produce eggs and sperm, which fuse together in water to form a larva or baby coral called planula. The planula drifts in the sea until it finds a clean, hard surface (like dead coral) to settle on and grow into a new polyp. Once an adult polyp is formed, small buds appear on the body, grow larger, and break off from the parent body. Each bud then produces its own limestone skeleton and helps the colony grow in size. Since budding is asexual, all the polyps are identical to each other.

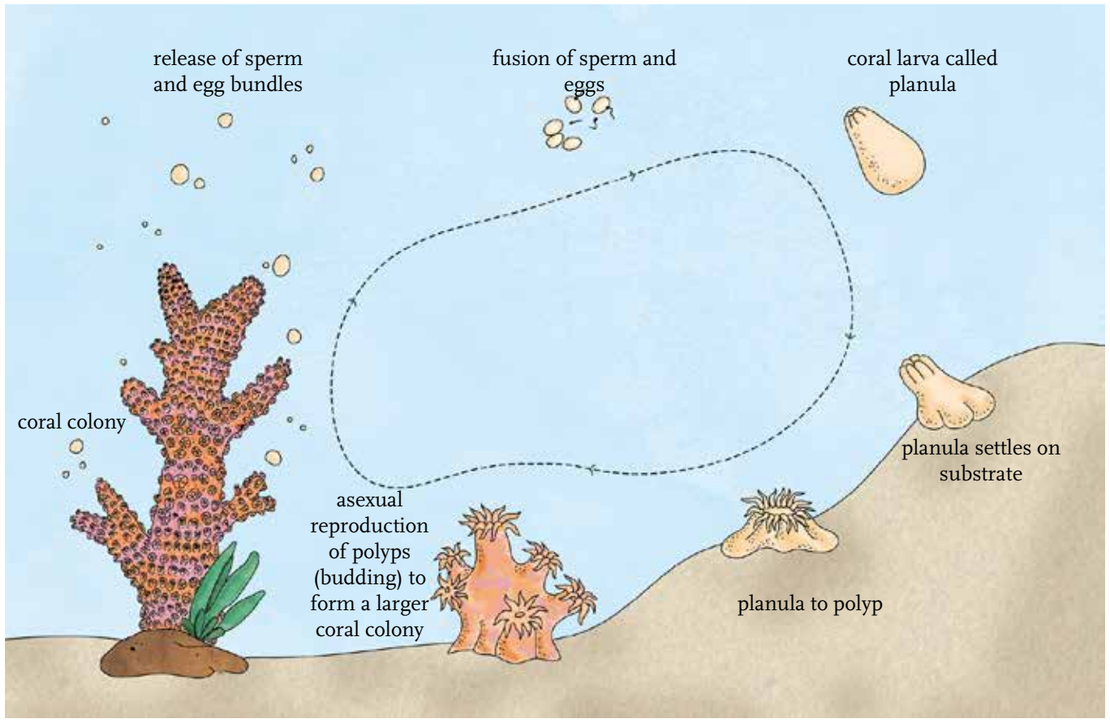
Roles on a reef

Organisms on a reef are diverse, but they don't live in isolation. They are constantly interacting with each other– eating, competing, hiding, and mating. They fulfil several roles, providing a range of services to the entire ecosystem.

Zooxanthellae play a critical role and are vital to coral reef ecosystems. They live inside corals, providing them with food by harnessing the sun's energy, but when corals "bleach" due to stress such as high temperatures, these organisms are expelled, severely reducing the coral's health. Crustose coralline algae help build the reef structure and offer places for new corals to settle. Turf algae provide a major food source for many reef creatures, though they can also trap sediment, making it harder for corals to grow. Overall, algae are central to the reef's structure and how it functions, influencing coral health and growth and providing food to many of the reef's habitants.

While some organisms on a reef are herbivores, keeping algal growth on corals in check, others are carnivores, keeping the herbivores in check. Sharks, groupers, and other predatory fish keep populations of smaller fish and other organisms in balance. Cleaner fish and shrimp keep other fish healthy by freeing them of parasites, while crabs and sea cucumbers crawl about, scavenging and cleaning up detritus on the reef and ocean floor. Even marine worms and snails perform important roles in the reef ecosystem, filtering organic matter in the water and sediments. Animals such as giant clams help filter the water on a reef by eating phytoplankton. Sponges act as recyclers, taking in the nutrients they filter from the water and producing waste products that feed lots of other reef species. Sponges themselves become a shelter for many small invertebrates and food for nudibranchs, sea stars, and hawksbill turtles.

The diversity of the reef can be seen in the survival strategies which extend beyond the usual adaptations of camouflage, spines, stingers, and other physical features to aid survival. Adaptations include relationships that can benefit one or all members of these interactions. Coral reef systems are known to have some of the most important and interesting symbiotic relationships, including those that are mutualistic, commensal, and parasitic. Examples include the relationships shared between zooxanthellae and coral, clownfish and sea anemone, cleaner wrasses and larger fish and more!



Importance of reefs

Providing shelter

Covering less than one percent of the ocean floor, reefs support an estimated 25% of all marine life! To date, over 60,000 reef-living organisms are known to us, and there may be more we don't know about yet. The beauty and biological wealth of coral reefs is a wonder in itself.

Reefs are important spawning, nursery, breeding, and feeding habitats for a whole range of organisms. Corals create complex three-dimensional structures that provide homes for a large variety of fish and other animals.

Livelihoods

Fisheries centred on coral reefs create valuable economic income for coastal communities. They also provide jobs and income to the fisheries, tourism, and recreational sectors; coral products are also highly valued as jewellery and decorative pieces. Nearly one billion people depend—directly and indirectly—on coral reefs for their livelihoods, food, and other resources.

Guardians of the coasts

Coral reefs protect our coasts by acting as natural barriers against wave action. As waves reach the shallow waters of a reef, they break and lose most of their energy. Without the protection of coral reefs, our coast would be exposed to large waves and could slowly erode away.

Threats

The entire reef ecosystem faces continuous threats—some caused by human activity, others that are natural.

Natural threats

Reefs can be damaged or destroyed by events such as cyclones, earthquakes, or tsunamis. Wave activity can break apart corals; branching corals are more susceptible to damage than mound-building corals. The 2004 December earthquake and tsunami caused 60-70% damage to live coral cover and considerable damage to the associated marine life. The damage was greater in the Nicobar group of islands compared to the Andaman group.

Diseases also sometimes affect reef species. Increasing sea surface temperatures have also increased the frequency of disease over the last several years, causing widespread death of reef-building corals.

Human-induced threats

Corals experience stress from an increase in temperature caused by climate change. Global warming causes them to release the zooxanthallae that live in their polyps. This results in what is known as bleaching. It is so named because the coral colony loses its colour and becomes white. This does not mean that the coral is dead; however, if it is not able to find new zooxanthellae soon to supply it with energy, a bleached coral is likely to die. In 2010, due to a sudden increase in the sea surface temperature (by just 2 °C), there was a loss of 35% to 70% of live corals in the Andaman and Nicobar Islands.

A number of other human activities present serious threats to corals. Pesticides and fertilizers from agricultural fields are especially damaging because they cause plankton to multiply so fast that they can block out sunlight for the corals.

Sedimentation is a major problem that affects live corals. The clearing of forests and mangroves accelerates the transport of terrestrial sediments into the sea, getting trapped among the turf algae which affect productivity, herbivory, and coral settlement.

Badly managed tourism and development can also be harmful to our reefs, especially since these industries are growing so quickly. Tourism can cause direct destruction of corals through increased physical damage by humans and boat anchors. Increased tourism also increases the demand for coral and shells as decorative pieces.

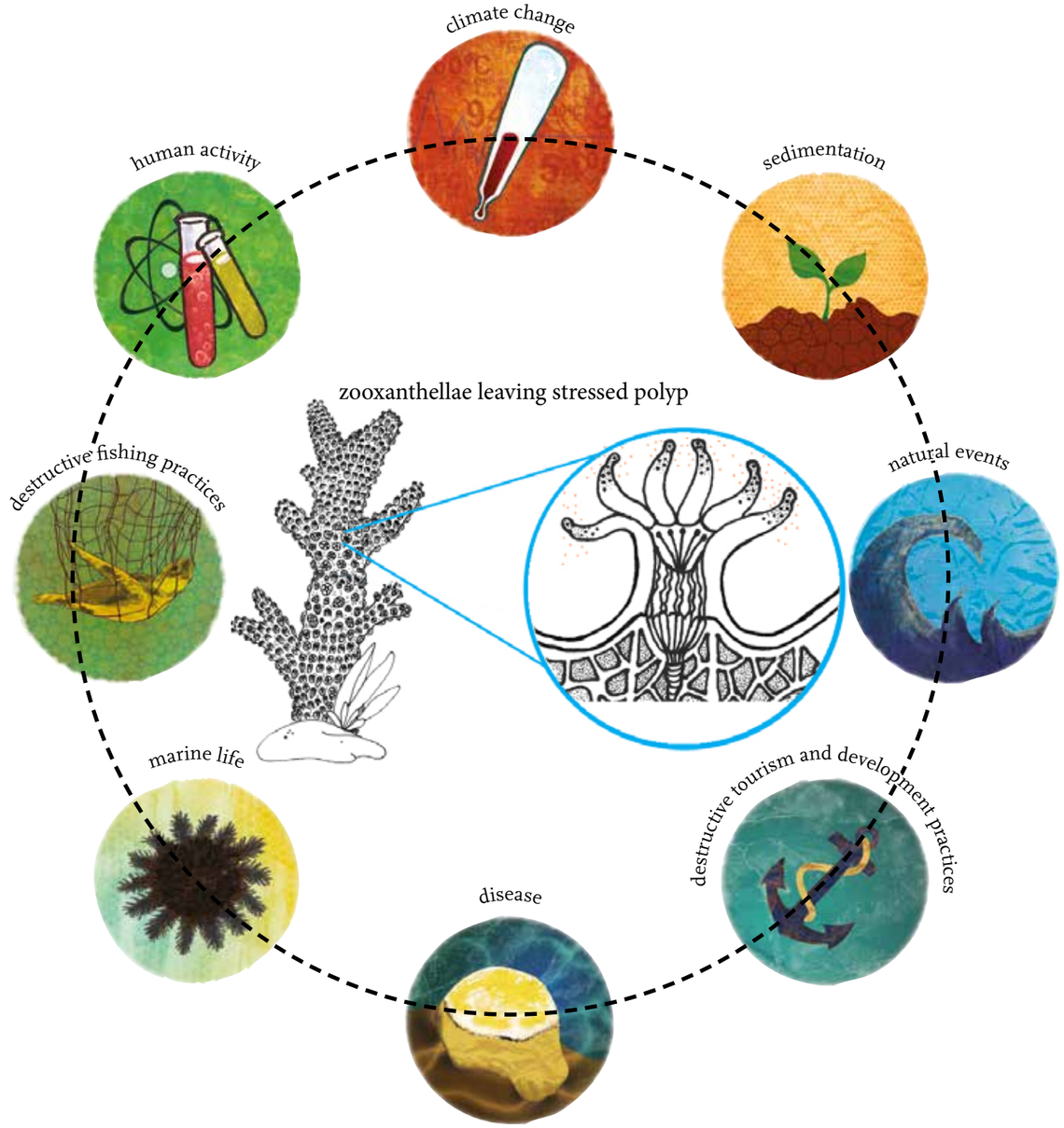
Destructive fishing practices are also extremely harmful to the reefs, fish and the other organisms that live there. Trawling and other kinds of large-scale fishing also kills animals like sea turtles, dolphins and rays that are accidently caught in nets. Overfishing ultimately upsets the balance of the food web, by removing certain species completely.

Conservation action

With so much destruction occurring in our reef ecosystems, we need to try our best to help protect them. Two big sources of income for islanders are fisheries and tourism, and both of these depend heavily on healthy coral reefs. Therefore, it is critical to manage them properly and prevent any further destruction.

To combat some of the natural and human impacts on reefs, marine protected areas have been established where fishing, hunting or the collection of marine creatures is banned. Examples include the Mahatma Gandhi Marine National Park and the Rani Jhansi Marine National Park.

To be able to protect our reefs better, we still need to know more about them. Scientists who conduct research on our reef ecosystems have begun to understand how quickly they are being destroyed. In areas where they are not being directly impacted by human activity, however, there is better recovery of corals. This still means that we need people to try and understand how we can protect them, and reduce impacts on them to help them recover from the disturbances they face.



Biodiversity

01. Whitetip reef shark: Nocturnal, group hunter of fishes, crustaceans, and octopus; unregulated fishing is reducing populations.

02. Hawksbill sea turtle: One of the few animals that can feed on sponges with its sharp, curving beak-like mouth; shell has a saw-like edge.

03. Damselfish: Mostly territorial fish that feed on plankton, algae, and small crustaceans and defend their food and reproductive sites from intruders.

04. Staghorn coral: Mostly reproduce asexually; new colonies can form when branches break off a colony and reattach to a substrate; grow and spread quickly, helping populations recover from physical disturbances such as storms.

05. Giant moray eel: Found hiding in crevices during the day and actively feeding on fish and crustaceans during the night; relies on a highly developed sense of smell to ambush prey.

06. Bluestreak cleaner wrasse: Bold fish that enter the mouth of large predators to groom or clean them and form 'cleaning stations'; feed on what they remove, including dead tissue and parasites.

07. Yellow-back fusilier: Occurs in large schools in mid-water over the reef during the day; use upper jaw to feed on plankton.

08. Mushroom coral: Is one single polyp with a mouth in the centre; adults are not attached to the bottom and can be moved around by waves.

09. Dollar or leopard coral grouper: The most fished grouper in the Andaman and Nicobar Islands; one of the top predators of the reef, hide and ambush their prey; they swallow prey using a powerful sucking system created by their mouth and gills.

10. Raccoon butterflyfish: Called so because of their brightly coloured and strikingly patterned body; they eat coral polyps and are called corallivores.

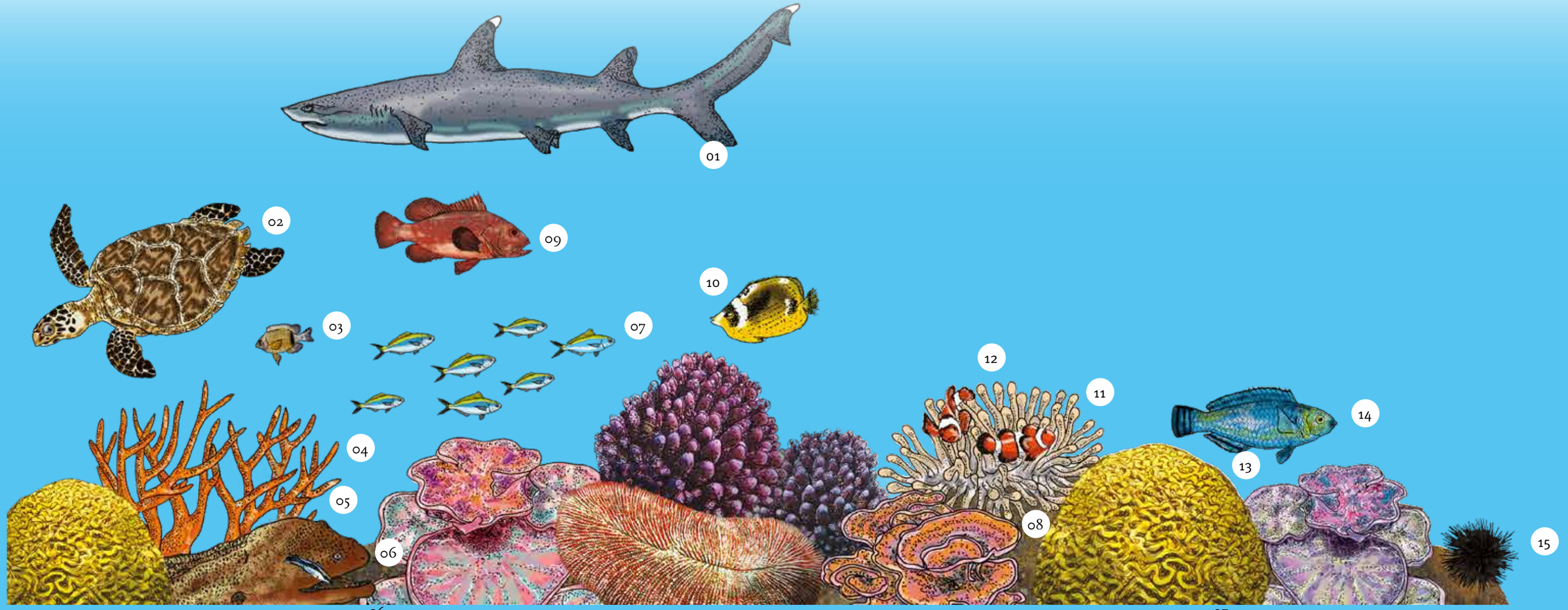
11. Sea anemone: Sea anemones are related to corals and jellyfish and form mutualistic relationships with single-celled algae that live within their cells. They have stinging cells in their tentacles that paralyse prey so the anemone can move it to the mouth for digestion.

12. Clownfish: A type of anemonefish in a mutualistic relationship with sea anemones; they defend the anemone from predators and parasites in exchange for food and protection; females can lay hundreds or thousands of eggs, which are taken care of mostly by the male parent.

13. Brain coral: Named because of its shape and grooved surface, which resembles a brain; the dome shape protects it against crashing waves and hurricanes; large brain corals can live up to 900 years.

14. Parrotfish: Parrot-like beak used to graze algae from coral and other rocky surfaces; secrete a mucus covering at night to protect themselves from predators; excrete undigested rock as sand; a large portion of coral sand is formed from this process.

15. Sea urchin: Common colours include black, green, red, purple, and blue; nocturnal in nature and move slowly, and feed mostly on algae, eaten by triggerfish.



ACTIVITY 2.1 POLYPS COME TOGETHER

CLASS	LOCATION	GROUPING	TIME
6	indoor	individuals, followed by groups of five	80 minutes

Objective

To explore the structure and feeding strategy of reef-building coral. To understand the role and importance of the mutualistic relationship that exists between coral polyps and zooxanthellae.

Learning outcomes

This activity will enable students to:

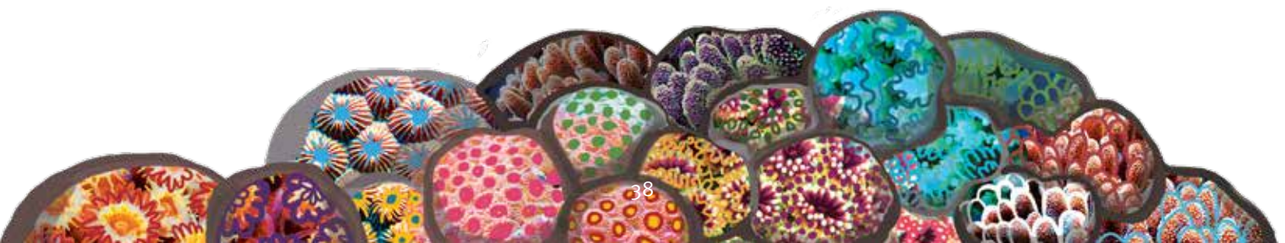
- describe a polyp and state the functions of its anatomy, including that of the calcium carbonate shell
- recognise that corals are made up of a lot of polyps
- describe the relationship between polyps and zooxanthellae
- explain what makes corals animals

Materials

- Different coloured balls of clay (or atta that can be painted after it has dried), 1 per student
- Medium-sized rock, glue bottle (or wet maida/ cooked rice) per group

Learning procedure

- Encourage students who have seen coral to describe their structures and colours and ask students, "Do you think coral is one large organism?"
- Give each student a ball of clay. Instruct them to divide it into two balls (2/3 + 1/3). Explain to them that they will learn about the structure of a polyp by building one.
- Ask the students to use the larger piece of clay to build the base of the coral as a column which is wider at the bottom than the top. Describe the base as a sac-like structure that houses the stomach cavity and the mouth. Ask students to make the mouth by making an opening on the top of the base.
- Ask students to pinch off smaller pieces of the other ball of clay and make them into long, thin, and pointed tentacles and attach them to the top of the base, around the mouth.
- Show an image of a coral polyp or draw the structure on the board, if needed. Compare the image to their models and discuss the function of each (tentacles, mouth, base), allowing them to generate their own ideas.
- Ask the students if they know what type of relationship this is where both organisms help each other. Introduce the terms symbiotic relationship and mutualism if they don't already know it.
- Now ask students to work in groups of five. Give each group a rock and some glue. Have each student glue their polyp to the rock. Explain that this is how reef-building corals grow. Inform them that polyps attach themselves to each other by secreting calcium carbonate cups that also protect them. Once the polyp dies, the skeleton remains and new polyps attach themselves on top of this structure.
- Ask students to think about some ways in which a hard skeleton can help a soft coral polyp. Show them the coral polyp diagram again and help them infer that polyps can retract into their calcium carbonate cup to protect themselves from predators.



ACTIVITY 2.2 EXPLORING AND BUILDING INTERACTIONS ON A CORAL REEF

CLASS	LOCATION	GROUPING	TIME
7	indoor	groups of five	160 minutes

Objective

To explore, identify, and represent relationships between organisms on a reef, and to demonstrate an understanding of reef structure and species interactions through building models.

Learning outcomes

This activity will enable students to:

- match common reef organisms to their characteristics
- recognise and classify relationships between reef organisms
- relate reef organisms to each other through a food web
- outline the ecological and practical importance of coral reefs

Materials

- Empty shoebox (or any similar-sized box), one per group
- Clay or atta (can be painted once dry)
- Paints, glue, scissors, string, tape, paper
- Sand, pebbles/rocks, blue streamers/ribbons
- Old magazines, waste materials, craft supplies
- Reference materials/images of coral reefs and reef organisms

Learning procedure

- Begin by asking students to recall the structure of a coral polyp and how it gets most of its nutrition. Guide the discussion until students recall the mutualistic relationship between coral polyps and zooxanthellae. Continue by revisiting other types of relationships discussed in previous lessons (mutualism, commensalism, parasitism) and encourage students to provide examples.
- As they work, draw a blank version of Table 1 on the board. If students are unable to provide examples, prompt them using the answers given in Table 1.
- Help the groups classify each relationship, supporting them if they are unsure about types. Once the tables are filled, have a representative from each group share their findings. Facilitate a class discussion to confirm the accuracy of the classifications.
- Then, using the organisms and relationships identified, work together as a class to draw a food web on the board.
- Encourage discussion around key ecosystem questions such as:
  - What is the energy source for this food web? (Sunlight)
  - Who eats the phytoplankton? (Zooplankton, filter feeders)
  - What happens to dead organisms? (Decomposed by bacteria and returned to the food web)
- Once the students have a firm grasp of the relationships and structure of coral reef ecosystems, instruct the same groups to construct models of coral reefs. Provide each group with a set of the collected craft materials.
- Ask them to incorporate into their model:
  - The physical structure of coral
  - A variety of organisms found on the reef
  - At least three types of interspecies relationships from the earlier part of the activity
- Students must include a key or legend in their model explaining what each item represents and the relationships shown.
- Fish and corals can be made using clay or atta, or cut from magazines. Use string to suspend fish and glue for seabed design. Provide creative freedom as long as scientific concepts are accurately represented.
- After completion, each group presents their model and describes:
  - The organisms and features included
  - The types of relationships represented
  - How the reef structure supports marine life

- Facilitate a reflection discussion on why coral reefs are important. Prompt students to think about:
  - How reefs provide shelter and biodiversity
  - Their role in islander food and livelihoods
  - Coastal protection from strong waves

Table 1

Organisms in the relationship	Explain the relationship	Who is benefitting?	Who is being harmed?	Who is unaffected?	Type of relationship
coral polyps	coral polyps protect zooxanthellae; zooxanthellae provide nutrients to the polyps	coral polyps, zooxanthellae			mutualism
zooxanthellae					
anemone		anemone, clownfish			
clownfish					

ACTIVITY 2.3 HEALTHY OR NOT?

CLASS	LOCATION	GROUPING	TIME
8	indoor	groups of five	80 minutes

Objective

To consider the various actions that lead to the maintenance or destruction of a healthy coral reef system.

Learning outcomes

This activity will enable students to:

- classify different types of activities associated with the reef into 'harmful' or 'beneficial'
- list some of the actions of human beings that destroy coral reefs
- list some actions that humans can consider that will lead to the restoration/conservation of coral reefs
- brainstorm ways in which threats to reefs can be reduced

Materials

- Game board to be drawn on the board: grid of 12 columns and rows equal to the number of teams. A start line should be drawn in the middle of the grid. Each team will be positioned along a row. The six columns to the right will be "Healthy Reef" and the six columns to the left will be "Damaged Reef." Each square in the grid represents one step.
- Sticky notes or multi-coloured sticks of chalk

Learning procedure

- Ask students to form groups of five. Inform them that they will play a game to learn about some of the ways in which reefs are maintained or damaged.
- Assign each group a different symbol, a sticky note or a uniquely coloured chalk. Assign each group a row of the game board.
- At each turn, one member of a group will pick up a card.
- The group as a whole needs to decide if the clue benefits or harms the reef ecosystem. Once decided, you need to read out the clue and your decision to the class. If there are any doubts, the groups can have a discussion utill all are able to agree.
- Once the decision is finalised, take as many steps as listed on the card towards the Healthy Reef line if it is seen to benefit the reef or towards the Damaged Reef line if the clue is seen to harm the reef.
- Each group gets a turn untill all the cards run out. The team with the healthiest reef wins.
- Ask students to stay in their groups when the game is done and keep the cards that they picked up.
- Ask one student in each group to copy Table 1 on a sheet of paper.
- Tell them to use the cards they picked to fill up this table within their group.
- Read out the two examples that have been provided. For natural activities that benefit the reef, the 'Impact' and 'Ways to Reduce Threats' sections do not need to be filled out. Ask students to provide at least one impact, and more if they can think of others.
- Give students a few minutes to discuss and write their points in their groups.
- Encourage one member from each group to share their opinion. Generate a class discussion in cases of disagreement or incomplete information.

A tsunami just hit the island. Take 3 steps.	The reef is full of young fish that use it as a shelter and feeding ground. Take 2 steps.	Global warming has caused a significant rise in water temperature. Take 3 steps.	A forest has been cut down causing soil erosion. Take 2 steps.
A cancer medicine has recently been discovered from the reef. Take 2 steps.	The number of fishermen on the reef has doubled in the last year. Take 3 steps.	Fishermen do not catch fish that are young and have not yet reproduced. Take 2 steps.	The government has launched a reef awareness program for the local public. Take 2 steps.
A film about coral reefs has been released and is running successfully. Take 1 step.	An accident with a ship has caused the release of a large amount of oil. Take 3 steps.	A snorkelling trip for students has helped students learn about the reef. Take 1 step.	Untreated sewage is being released into the sea at different points on the island. Take 2 steps.

Sharks have been given protected status and cannot be fished anymore. Take 2 steps.	Bottom-trawling (pulling a net over the sea floor) is being more widely used to catch fish. Take 2 steps.	A trash collection program makes sure that trash does not flow into the sea. Take 1 step.	A new disease is spreading all across the reef. Take 1 step.
Many hotels have started treating their sewage before they dump it in the sea. Take 1 step.	Excessive pesticides and fertilisers are being used by farmers on the islands. Take 2 steps.	Many researchers are permanently setting up equipment on the reef to monitor it. Take 2 steps.	The crown of thorns sea star have multiplied rapidly. Take 1 step.
Increased tourism leads to more boats and some throw their anchors on coral reefs. Take 1 step.	A newly introduced species of fish that eat coral polyps has no predators. Take 1 step.	Turtles are being killed in large numbers for their meat and their shells. Take 1 step.	Many more people are getting dive certified so they can appreciate the beauty of coral reefs. Take 2 steps.

CHAPTER 3

ROCKY SHORES AND SANDY BEACHES

In the 572 islands, islets and rocks of the archipelago, coasts comprise rocky outcrops, sandy shores and mangrove swamps. Shores of every kind are subject to the action of waves that we can see even in a few minutes of observation, and tides which take longer to observe.

Waves

Waves continuously break on the shore, either noisily and forcefully or very gently. They carry sand, seashells, and even garbage. They wear rocks down to rubble and erode soil from around tree roots, causing the trees to eventually topple. Waves also bring in nutrients for plants and animals that live in the intertidal area. The intensity of the waves and the features of the land influence the kinds of plants and animals that can live there.

Tides

Twice a day, due to the gravitational pull of the moon and the sun, the level of the sea creeps up to a typical high point and then goes out until it reaches a typical low point. There are two high tides and two low tides every 24 hours, each roughly 6 hours apart.

The intertidal zones

The area between the highest and lowest levels of water—that is between the high tide line and the low tide line—is called the intertidal zone. Observatories maintain detailed records of the tides, and printed time tables can be sourced from any harbour-related department. Updated tide tables can easily be viewed on several online databases such as http://tides.mobilegeographics.com or http://www.tide-forecast.com. Field trips to sandy beaches, rocky shores, mangroves, and coral reefs are best planned for low tide.

Locally, the tides are known as *bada paani* (high tide) and *chota paani* (low tide). They govern the everyday lives of islanders, especially fishers. Knowing the timings of local tides and the precise level to which the water will rise or ebb helps fishers to decide the best time to fish, to know where to avoid shallow reefs while navigating boats in coastal waters, and where to tie their boats at the end of a day at sea. Tidal fluctuations are also important to keep in mind when building jetties, bridges, and planning construction projects by the sea.

Areas that are more inland are exposed (to sun and wind) for longer and are covered with water only during high tide. Locations closer to the low-tide mark are submerged for longer periods of time and are exposed only during low tides. Organisms in these areas have to deal with changes in temperature and moisture for different lengths of time, causing distinct zones of habitation with distinct adaptations. From shore to sea, they are: upper intertidal, middle intertidal, and lower intertidal.

Life in the intertidal

Environmental conditions change drastically, rapidly, and cyclically. Lots of sunlight helps plants in the intertidal grow quickly, but it desiccates soft-bodied animals like molluscs during low tide. Salinity in tide pools changes with the tide, requiring organisms to be able to tolerate a wide range of fluctuations. Waves bring in nutrients and moisture, but they also dislodge and carry out unprotected animals to the sea. When nutrients are plentiful, organisms in the intertidal reproduce quickly and compete for space, light, and food.

The lower intertidal zone has relatively stable temperature and salinity as it is almost always submerged. The greatest number and diversity of organisms are found in this zone, resulting in competition, predation and other interations between organisms.

Life on the rocky shores

Patches of rocky shore are common as our islands are part of a mountain range that was submerged in the sea. These shores, made of solid rocks, are exposed to wave surges when submerged, and extreme heat when exposed. Organisms in the rocky intertidal face the challenge of holding on tightly to slippery surfaces to prevent themselves from being washed away or smashed by the waves.

Barnacles, mussels and even some crabs and starfish are able to cling or permanently attach themselves to rocks. The hard outer shells of molluscs and crabs help to protect them from the waves. Other smaller crabs and brittle stars hide in cracks and crevices between the rocks. Seaweeds, however, bend with the waves to prevent being broken.

Seaweeds and other algae are the most visible primary producers on rocky shores. Some organisms, such as barnacles and oysters, are more likely to be found near the low tide line. Others, such as crabs, whelks, and sea stars move across the rocks preying on other animals. Yet others, like the limpets, periwinkles, and chiton, go where there is algae to graze on, often leaving deep cavities or depressions as they scrape a part of the rock when they feed.

Depressions in rocky coasts which remain filled with seawater even when the tide goes out are called tide pools. Each tide pool is a small world on its own and is an excellent site for observation. The smallest gaps between rocks can protect organisms from extreme temperatures and exposure to air: algae, anemones, sea urchins, sea cucumbers, hermit crabs, sea stars, limpets, barnacles, and many kinds of juvenile fish are likely to be present in them.

Life on the sandy beaches

On sandy shores, organisms are unlikely to find support and shelter as they do among the rocks. Sandy beaches are dynamic habitats: the sand, seashells, bits of coral, and small pebbles that make up a beach are rearranged constantly by wind, waves, and tides. Sandy beaches may appear to be devoid of life in comparison to rocky shores, but careful observation will reveal many creatures.

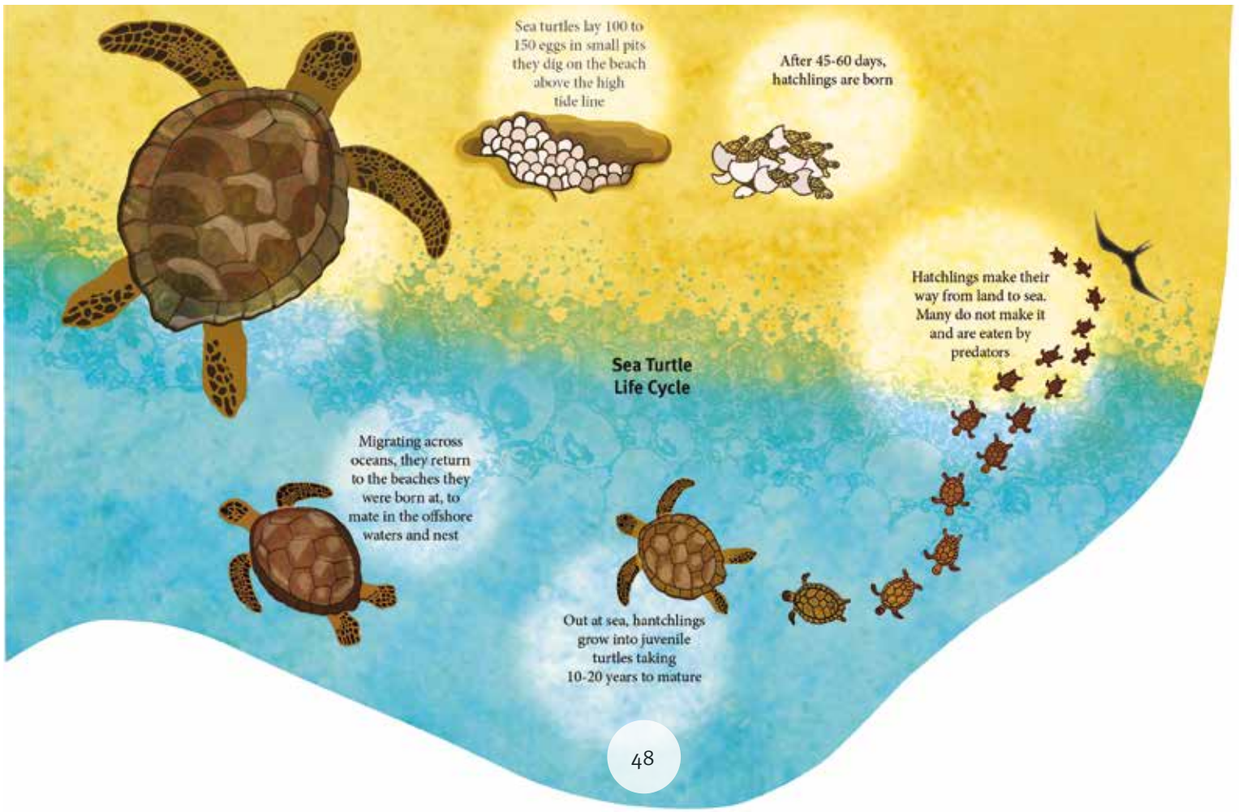
Clams, snails, sand dollars, crabs, sea cucumbers, and other creatures live on or in sandy beaches. Many feed by filtering plankton found in the water. Some creatures in the sand are so small that they can move around in the spaces between the sand grains and can only be seen under a microscope.

Most organisms in the sandy intertidal zones need to be able to quickly burrow into the sand or move rapidly with the tide. Many kinds of snails, clams, and crabs are specialised in chasing the surf and then digging rapidly into the surface of the sand. However, some creatures, like ghost crabs and lug worms, can dig deep into the sand to protect themselves from the heat and waves.

Sea turtles

Sea turtles are not permanent residents of the sandy beach but come to sandy shores for an important part of their life cycle.

Sea turtles travel hundreds or even thousands of kilometres from their feeding to their breeding grounds. After mating in offshore waters, the female turtle crawls ashore slowly, dragging herself with her flippers. She selects a spot to lay her eggs and digs a nest using her back flippers to scoop out the sand. Sea turtles usually lay about 100 to 150 eggs. The female turtle covers up the nest with sand to camouflage it and to keep the eggs warm and moist, and then goes back into the sea.



The eggs hatch approximately 45-60 days after they are laid. The hatchlings or baby turtles dig their way out of the nests together and make their way to the sea, which they find using the reflection of the stars or moonlight on the water. As they make their way to the sea, many predators eat them, including dogs, monitor lizards, sea gulls, and crabs. Even when the hatchlings reach the sea, large fish and sharks may eat them.

Very few turtles actually reach adulthood. Of the ones that survive, the adult females migrate back to the beaches where they were born to nest, thus completing a full circle.

There are four different species of sea turtles which nest on the coasts of the Andaman and Nicobar Islands. These are the green turtle, the olive ridley turtle, the hawksbill turtle, and the leatherback turtle. The islands have the largest nesting populations of leatherback, hawksbill and green turtles in India! Leatherbacks in India only nest on the beaches of the Andaman and Nicobar Islands and are known to migrate long distances. To find out how far they go, scientists have tagged turtles nesting on Little Andaman Island and tracked them all the way to the west coast of Australia and the south-east coast of Africa! The leatherback population in the Andaman and Nicobar Islands is closely related to those found in the Indo-Pacific region.

All four turtle species are listed in Schedule 1 of the Indian Wildlife (Protection) Act. This means that they get the highest level of protection from the government.

Shells

Creatures with shells belong to a group of animals called molluscs, which make up 23% of all marine organisms! Molluscs with two-part shells, like oysters and clams, are known as bivalves. Animals with one shell, such as snails, conches, and whelks, and animals with no shell at all, such as slugs, are called gastropods. The shell is formed by and grows along with the animal that lives in it. These organisms are found in rocky and sandy intertidal and sub-tidal zones.

Threats and their mitigation

Natural threats

Storms, cyclones, and earthquakes may have negative effects on intertidal zones. For example, in 2004, the tsunami changed much of the coastline. In many places, regions of the lower intertidal were pushed up by the earthquake. They now remain permanently exposed. Plants and animals that could not withstand too much exposure died.

Conversely, certain regions of the upper intertidal were permanently submerged by the earthquake.

Although natural disasters are out of our control, learning about them may improve our planned responses and our strategies for protection and restoration. Coastal and intertidal areas such as sandy beaches, sand dunes, mangroves, coral reefs and seagrass meadows are critical in protecting our coasts from the harshest effects of such natural disasters.

01. Scorpion shell
02. Olive shell
03. Turbo shell
04. Cone shell
05. Neritid shell
06. Mangrove whelk
07. Opened oyster

Human-induced threats

Disturbance due to collection is a threat in the intertidal zones. Trochus (top shell) and Turbo (turban shell) were collected for their shells and meat. Populations of these commonly found gastropods in shallow waters and the intertidal zone of the Andaman and Nicobar Islands went into significant decline due to unregulated collection. Now, as Schedule I species, the top shell snail and the turban shell snail are protected by the Wild Life (Protection) Act, 1972. Any collection and trading of the snail or the shell is illegal.

Sand mining, or the illegal excavation of sand from beaches, weakens our coast and exposes it to erosion from the sea. Sand mining permanently destroys nesting sites for turtles and feeding grounds for shore birds. Any construction using this salt-rich sand is likely to develop cracks very soon. Updated laws seek to control the amount of sand removed from the coasts. Current laws also state that no construction is permitted within 200m of the high tide line in ecologically sensitive zones, which further protect the beaches.

Refer to the Notes for Field Trips to help plan for a visit to the rocky shores and sandy beaches.

Biodiversity

Sandy beach

01. Lugworm: Segmented worm related to earthworms; lives in a U-shaped or J-shaped burrow and spends its life in the sand.

02. Sand dollar: Related to sea urchins and sea stars; covered with tiny bristles on its body which help it move and dig rapidly into the sand; lives in groups, creating a neighbourhood of sand dollars.

03. Sea cucumber: Soft, cylindrical-shaped animal, related to sea urchins and sea stars; when threatened, some sea cucumbers eject all of their digestive organs to distract the predator; sea cucumbers are eaten as a delicacy in many parts of the world but are protected under the Wild Life (Protection) Act in India.

04. Ghost crab: Burrows deep just above the high-tide mark during the day, comes out when it is cooler at night; gets its name because it resembles sand and is difficult to spot; needs to wet its gills in the seawater periodically.

05. Mole crab: Can be seen burrowing backwards rapidly into the sand when the waves recede; extends eyes and feathery antennae remain above the sand; uses its antennae to trap tiny bits of food from the water.

06. Clam: Soft-bodied animal with two hinged shells; when the waves wash small clams out of the sand, they can dig back in again quite rapidly; filters plankton from the water.

07. Sand plover: Small, wading shorebird; found eating insects, crustaceans, and annelids in the intertidal; a migratory bird that winters on tidal flats, sandy beaches, estuaries, mud-flats, and streams.

Rocky shore

Living close to the low tide line

08. Peacock's tail seaweed: A kind of yellow-brown algae; body is fan-shaped and tough; commonly found attached to rocks and boulders in clusters or large mats.

09. Barnacle: Soft-bodied animal with a hard shell attached to rocks on the head; related to crabs, shrimps, and lobsters; filter-feeder that unfurls feathery legs to trap plankton during high tide.

10. Oyster: Most oysters are edible and are a delicacy; some oyster varieties produce valuable pearls that are harvested; feeds by filtering the plankton from the water.

Living close to the high tide line

11. Limpet: Soft-bodied animal with a cone-shaped shell; holds on to rocks and roots with its foot; feeds during high tide by moving across rocks and scraping up algae.

12. Periwinkle: A small snail found commonly on most rocks, pillars of jetties, and mangrove trees; many huddle together in crevices on rocks, generally above the water level.

13. Hermit crab: Crab with a soft exoskeleton and a soft abdomen; lives in an empty snail shell, which it carries as it moves along; withdraws body completely into shell at the sign of danger; changes shells from time to time.

ACTIVITY 3.1 ZONATION IN THE INTERTIDAL AREA

CLASS	LOCATION	GROUPING	TIME
6	indoor	individuals, followed by whole class	40 minutes

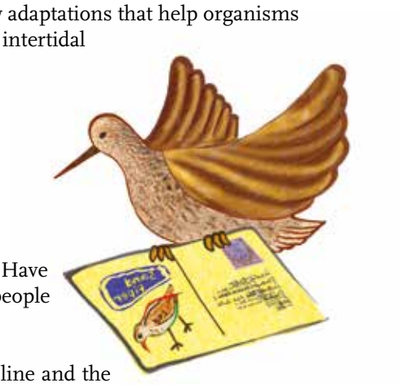
Objective

To correlate the zonation of the intertidal area with the organisms that occur there.

Learning outcomes

This activity will enable students to:

- recognise and describe commonly found organisms in the intertidal area
- recognise that organisms in the intertidal are distributed into three zones
- understand that exposure to air, heat and waves dictates where certain organisms can be found in the intertidal
- describe a few adaptations that help organisms survive in the intertidal



Materials

- Sticky notes or pieces of paper and tape for each note
- Sketch pens or crayons

Learning procedure

- Ask students what they think the terms *bada paani* and *chota paani* mean. Have they heard it from anyone they know? In what way are these important to people and their livelihoods?

- Draw the diagram of the intertidal area on the board, marking the low tide line and the high tide line. Add the labels of *bada paani* and *chota paani* at the high and low tide lines, respectively. Check students' understanding: how many times do the tides change in a twelve-hour period? What causes the tides to rise and fall?

- Ask students to recap the names and adaptations of organisms living at various levels of the intertidal zone. Hand out some sticky notes to each student and ask them to draw the organisms and come to the board and attach their notes with the appropriate organism in its appropriate position on the intertidal diagram on the board.

- Allow about 20 minutes to draw and paste the sticky notes. Once all the students have placed at least one organism, ask the class to survey the answers with their hands behind their backs. They are not allowed to move any sticky notes yet. Ask students "Do you see any organisms where they should not be? Which ones? Why?"

- Invite students to discuss the organisms placed correctly and incorrectly and why. Invite them to move the sticky notes which are incorrectly placed after justifying their choices.

- Assess the completed diagram using the information in the chapter.

Other variations

Ask students to write a short jingle for a survival skill that every organism has in the format of a social media advertisement.

ACTIVITY SHEET 3.1 ZONATION IN THE INTERTIDAL AREA

Date: Name:

Use the clues provided to predict which zone the listed organism lives in. If you think there is more than one, list that too. Remember, your answer options are upper intertidal, middle intertidal and, lower intertidal.

1. _____ I am a sea anemone. I am a predatory animal that uses my tentacles to help capture my dinner, or depend on algae in my body to help make food. I prefer being covered in water but can handle air exposure for a little while, as long as it isn't too hot outside. Unlike some others who also live in the intertidal, I don't have a shell to protect my body from drying out and I am strongly attached to the bottom.

2. _____ I am a crab with 10-legs and walk sideways over the rocks in the intertidal. I have an exoskeleton that offers some protection from heat and predators. I breathe air, so, I prefer drier areas. I can also squeeze into tiny crevices and little sheltered areas so I don't get washed away by crashing waves!

3. _____ I am a sea urchin, an invertebrate that lives attached to the rocky seafloor with the help of my stick tube feet. I also use these to move around looking for algae to feed on. I like to be covered in water, but I can handle a little bit of exposure. I have a spiny, hard shell that protects me from predators, and there are plenty of them where I live.

4. _____ I am a sea star. I have a hard skin but no shell, so I dehydrate quickly, especially on a hot day. I really prefer to stay wet or moist. I am carnivorous and am usually found feeding on oysters and fish. I like to stay right below the oysters so that I can move up and eat them when the tide comes in. I have hundreds of tube feet on my underside, which helps me move and hang on tightly to rocks.

5. _____ I am a periwinkle, a soft-bodied animal with a hard, protective shell that offers protection from desiccation (drying out), and from predators like birds. I can't breathe under water which means you will always find me above the water line.

6. _____ I am a whelk, a type of carnivorous snail with a spiral shell. I eat oysters and barnacles which I can pry or drill into. I don't like to be too hot and retreat to lower areas when the tide is low, and move higher to find prey when the tide is higher.

7. _____ I am an oyster, a soft-bodied animal that is protected by two hard shells. I am a filter feeder and I filter seawater for plankton. My shell provides some protection from the heat, but I can get hot and I don't like being exposed to air for too long.

8. _____ I am a barnacle and love hot and dry days. My shell and my high tolerance help me survive. When I am young, I attach to the rocks and and remain stuck in that one spot for the rest of my life. I am one of the few species that can live in the hottest area of the intertidal.

9. _____ I am a limpet and I am a type of snail! I like to find cooler areas such as crevices but also like dry areas in which the seawater only reaches me sometimes. I walk around looking for algae when the water level is high, and then glue myself down to save moisture when the water level goes down.

10. _____ I am an algae and I make my own food. I do like being covered with water most of the time, though and you'll find me in large groups. When the water level drops, I tend to droop over in a large bunch to help save moisture.

ACTIVITY 3.2 HEADLINES FROM THE SHORE

CLASS	LOCATION	GROUPING	TIME
7	indoor/outdoor	groups of three to five	40 minutes

Objective

To raise awareness of the interlinkages between the organisms that share the intertidal ecosystem.

Learning outcomes

This activity will enable students to:

- match the organisms of the intertidal areas to their zones
- identify events and interactions which may be important to the various organisms
- describe adaptations that help organisms survive in the rocky and sandy intertidal zones

Materials

- Chart paper
- Sketch pens, fine-tipped pens or pencils
- Sheets of blank paper
- Glue
- Sticky notes

Learning procedure

- Draw a diagram of the intertidal zone on the board and mark the high and low tide lines. Invite students to quickly recap the names of organisms in each zone of the intertidal.

- With the whole class, help students think of news headlines and items reported in the local newspaper or news media. E.g. "Monsoon Delayed For Another Week", "Prime Minister Visits Local Museum." Note these on the board and, if possible, help students see how a headline captures the most important information to understand the basic framework of the story that is to follow.

- Next, divide the class into groups of three to five. Groups can be assigned areas of the intertidal or even organisms or seasons. Each group must produce a newspaper containing the following:

1. A minimum of one news item per member (total, three to five) for events and phenomena related to the rocky shores and sandy beaches. The news item should contain a headline and some lines of text.

2. The date or season in which the newspaper is being "published".

3. Illustrations or visual representations of each story.

- In case there is any confusion, instruct the students to come up with one or two examples as a trial. E.g. "Hermit Crab Housing Crisis", "Full-moon Festival; Plankton Visit the Shore in Large Numbers".

- Display the Intertidal Newspapers and have students walk around and read the newspapers prepared by their peers. Students can use sticky notes to write responses, comments, and share, constructively, what they thought about the articles in each group's newspaper.

ACTIVITY 3.3 WILL I SURVIVE?

CLASS	LOCATION	GROUPING	TIME
8	indoor/outdoor	individuals	30 minutes

Objective

To correlate human activities with the impacts they may have on various organisms.

Learning outcomes

This activity will enable students to:

- list items introduced in the rocky and sandy intertidal ecosystems by human activity
- identify how organisms are affected by human activities in the rocky and sandy intertidal ecosystems

Materials

- Cards prepared with the names of various organisms (hermit crab, turtle, bird), blank cards made from paper of a different colour

Learning procedure

- Ask students: On a visit to a rocky or a sandy shore, what did you see there that was created by people? What activities do you think these items came from? Are all these things deliberately thrown here? What are all the things that you can see on the rocky and sandy shore that came from human activities?
- List all the activities and their byproducts on the board. Elicit responses from students that cover the following: broken and discarded nets, toothbrushes, bottles, bottle caps, plastic bags.
- Ask students if there are any other activities on the beach that could be of concern. Issues could include:
  - ► Construction on sandy beaches reduces space for nesting turtles and feeding birds; lights at the beach disorient turtle hatchlings.
  - ► Sand mining weakens beaches, increases erosion and reduces space for nesting turtles and feeding birds.
  - ► Collection of shells reduces habitat for hermit crabs and other organisms that use them as shelter.
- With the help of some students, create cards to represent all the responses that the students shared of human-made materials on the shore, as well as actions that harm the shore. Place all these cards, face down, mixed up, on a table. Also, mix up the animal cards on a separate table.
- Invite students, in pairs, to come to the front of the class. One from each pair should draw a card from the cards with the organism on it, and the other student will draw a card from the human activities stack.
- The pair of students should discuss the impact card in relation to the organism and share what the impact of the action will be on the organism with the rest of the class. Some examples are given below.

Chit	Crab	Turtle	Bird
A piece of discarded net is on the ground	feet and pincers get entangled	no harm	no harm
A sea star is out in the open	no harm	eats a sea star and isn't harmed by the sea star	eats a sea star and isn't harmed by the sea star
A small crab has come to the surface	eats the smaller crab and isn't harmed	eats the crab and isn't harmed	eats the smaller crab and isn't harmedstar
A building is being constructed on the beach	habitat is lost	nesting area is lost	habitat is lost
Bright lights have been installed on the beach	no harm	confuses the hatchlings	no harm
A plastic bag is discarded on the beach	no harm	gets entangled in flippers	confuses the plastic bag for food and chokes on it
Sand is being removed from the beach	habitat is lost	nesting area is lost	habitat is lost
Seaweed has washed up on the beach	no harm	no harm	no harm

ECO CLUB: ROCKY SHORES AND SANDY BEACHES

Objective

To recognise organisms that are commonly found in the intertidal zone (rocky shore and sandy beach) and observe the interactions between them within the different zones.

Learning outcomes

The students should be able to:

- recognise and describe commonly found organisms in the intertidal area
- observe and record the behaviour and interactions of organisms in the intertidal
- understand that organisms in the intertidal are connected in several ways

Materials

- A copy of the Activity Sheet EC3 per student
- Pencil, notebook, clipboard (optional), water bottle, cap, sandals to be brought by students

Learning procedure

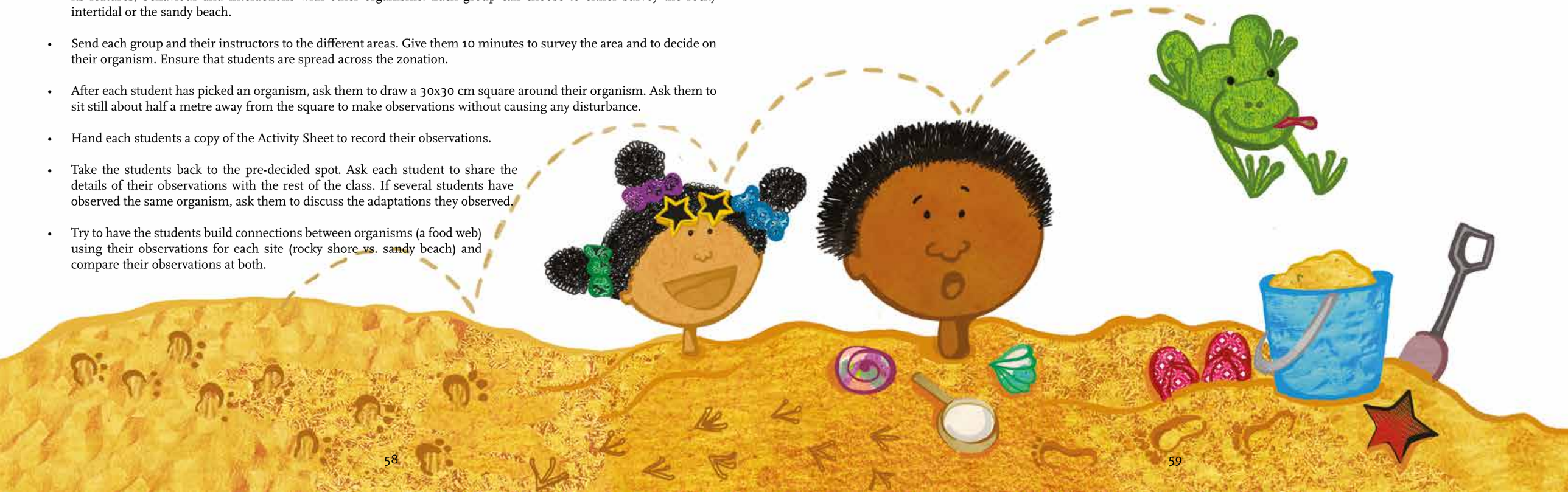
- Go over the rules that need to be followed at the intertidal areas, as well as the ways in which they can prevent causing any damage to the organisms there.
- Head to the site and gather at the pre-decided spot for a discussion in order to reinforce the rules to be followed for the day.
- Introduce the chosen site to the students. Ask them questions such as: "Have you been to an area such as this before? What have some of your observations been? What are some of the most marked features of this area? What are the major influences on organisms in this area?"
- Inform the students about the plan for the day. They will survey the intertidal to observe an organism of their choice, its features, behaviour and interactions with other organisms. Each group can choose to either survey the rocky intertidal or the sandy beach.
- Send each group and their instructors to the different areas. Give them 10 minutes to survey the area and to decide on their organism. Ensure that students are spread across the zonation.
- After each student has picked an organism, ask them to draw a 30x30 cm square around their organism. Ask them to sit still about half a metre away from the square to make observations without causing any disturbance.
- Hand each students a copy of the Activity Sheet to record their observations.
- Take the students back to the pre-decided spot. Ask each student to share the details of their observations with the rest of the class. If several students have observed the same organism, ask them to discuss the adaptations they observed.
- Try to have the students build connections between organisms (a food web) using their observations for each site (rocky shore vs. sandy beach) and compare their observations at both.

Date: Name:

Activity Sheet EC3 - What Am I Doing?

Location: Tide:

1. What type of intertidal area are you at?
2. What is your organism of choice?
3. What substrate is it found on?
4. Is it covered with water?
5. Is it being hit by waves?
6. Is it alone or in a group?
7. Is it interacting with other organisms?
8. Is it moving?
9. Is it feeding?
10. What is its diet?
11. What is its behaviour?
12. What other organisms are around it?
13. Do you think it interacts with any of them? If yes, in what way(s)?
14. What activity can you observe around this organism? Do you think this activity is influencing it?



CHAPTER

4 MANGROVES

Mangrove swamps are usually found in areas where freshwater from streams, rivers or rivulets mixes with seawater. These swamps experience the regular ebb and flow of seawater, rising and falling with the tide.

"Mangrove" refers to special types of trees that can grow in salty water and coastal soils. Of the world's total mangrove cover, India has three percent of these fascinating and productive systems, comprising a total area of over 4500 km². In fact, the world's largest, single continuous stretch of mangrove forest is the Sundarbans, and is shared between India and Bangladesh. Within India, the Andaman and Nicobar Islands have the third largest mangrove forest, covering almost 10% of the islands.

Mangrove ecosystems support a diverse community of plants and animals with structural, physiological, and reproductive adaptations to survive despite the salty, waterlogged conditions.

Adaptations

Different types of mangrove trees distribute themselves within a tidal habitat based on varying factors like water level, wave action, and sediment movement. Their structural, physiological, and reproductive adaptations are the reason for their survival in these dynamic regions.

Roots

A structural adaptation of the roots of mangrove trees is to form a dense maze to anchor them firmly against the shifting of the waterlogged soil and the movement of the tides. When the tide goes out, the roots get exposed, and they facilitate gas exchange or breathing for the trees. The roots also function as nutrient traps.

Fringes of red mangrove (*Rhizophora*) trees occur in areas most prone to harsher tidal action. Their roots are the sturdiest among all mangrove trees, forming a dense network of wide and arching stilts. For additional support, prop roots grow down from the branches and anchor themselves into the soil.

In white mangrove (*Laguncularia racemosa*) trees, the roots emerge vertically from the waterlogged soil, like snorkels from water, or like pencils. These trees require complete exposure every six to eight hours in order to survive, as the pencil roots emerge only about 15 cm above the ground. These are aerial roots or pneumatophores, and each one is covered with little bumps that have breathing pores called lenticels. Rising ocean levels force these trees further and further inland.

The orange mangrove (*Bruguiera*) trees are the tallest of the true mangrove trees. Along with the grey mangrove (*Avicennia*) trees, they grow in areas with less tidal action. They can be spotted by their knee roots and peg roots. *Bruguiera* and *Lumnitzera* have adapted to deal with saline soil but less frequent tides. *Avicennia* are often found in groves influenced by tides.

Aside from the structural adaptations, the roots also exhibit physiological adaptations.

An innate reverse osmosis (RO) water filtration system in the roots allows them to draw in only desalinated water. A high salt concentration, maintained in the plant's sap, makes this complex process possible.

Leaves

The leaves of mangrove trees, too, have physiological adaptations to strengthen their chances of survival in salty conditions. Salt glands underneath the leaves remove excess salts that enter the plant. The loss of precious freshwater reserves through transpiration is reduced because the leaves are waxy and fleshy.

Reproduction

Mangrove trees have reproductive adaptations to increase chances of survival in an ecosystem that is always in flux and regularly flushed by seawater.

It is equally possible for a seed to drop straight into the mud and get stuck there, or float along a creek or in coastal waters. So, mangrove trees produce flowers, fruit and seeds like all other flowering plants do, but with one crucial difference: the seeds themselves do not fall to the ground or get carried away. Instead, after flowering, the seeds of some mangrove species remain on the tree, and continue to grow or germinate while still attached to the mother plant. This is called viviparity.

The sapling drops only once it has developed, to be dispersed by seawater until it anchors in appropriate soil. The baby tree is called a propagule, and it is designed with an additional bean-like growth that functions as its float and anchor. The structure ensures that the sapling remains upright while afloat. Seeds have also adapted sails and keels to help them travel efficiently through water.

Importance of mangroves

Mangroves may smell strange, and the slush may look suspiciously black, but they are an irreplaceable link in maintaining stability between land and sea.

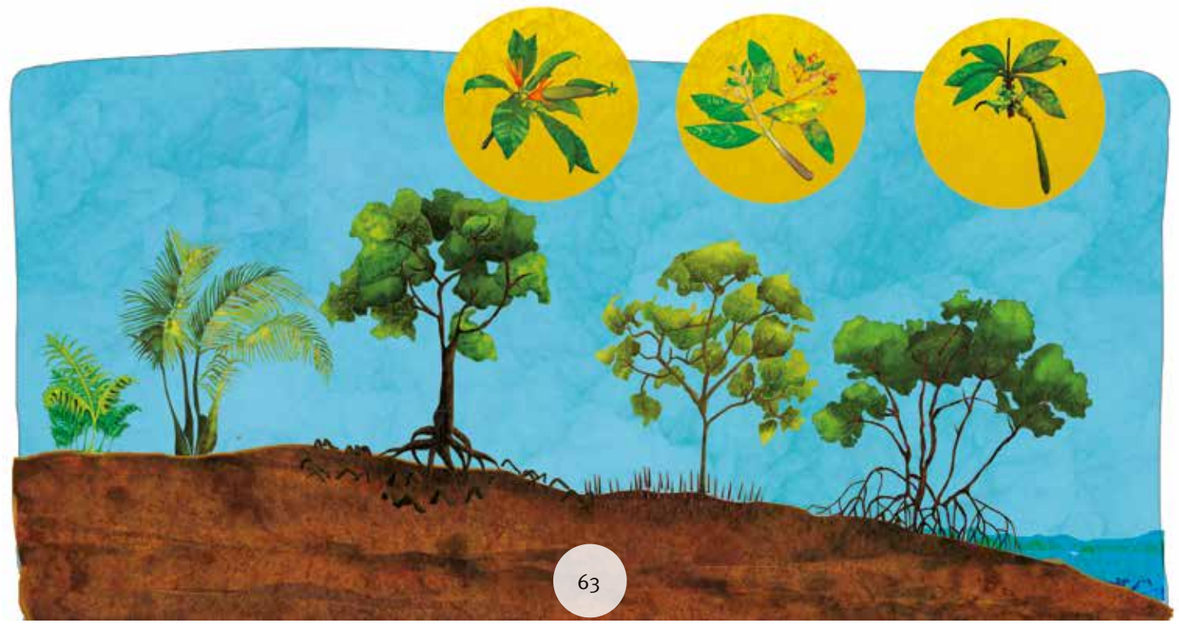
Nutrient cycling

The dead leaves, branches and seeds of mangrove trees decay and form the basis of the detritus food chain, which supports a variety of mangrove animals. Any organic matter trapped at various stages of decay is food for many species of worms, insects, crabs, molluscs, and fish. Bacteria and fungi first decompose this dead matter, which, in turn, forms the food for larvae and juvenile fish growing up in the mangroves. Animals like crabs and snails feed on everything that falls on the wet ground. These smaller animals are then eaten by larger fish, reptiles, birds and other carnivores, thus supplying the mangrove food chain with nutrition at every level.

Carbon and nitrogen created during the process of bacterial action supply the plants in this region with essential elements for their growth. In the mangroves, strong-smelling gases are produced in the mud during anaerobic decomposition which often remain trapped underground until the mud shifts around.

Storm barriers

Mangroves stand like shields between inland areas and climatic events such as huge waves, strong winds, and cyclones that are known to batter the coasts of the Andaman and Nicobar Islands during both the southwest and northeast monsoons.



Silt Traps

Freshwater that flows from land to sea carries with it fine mud called silt, along with leaves and other nutrients. A large amount of this silt is trapped by the dense network of mangrove roots. Without mangroves, this silt is known to blanket coral reefs and sea grass meadows, blocking sunlight and other basic requirements in these shallow sea habitats. The collected materials provide a source of nutrition for mangrove organisms.

Natural nurseries

Fish, prawns, and crabs find mangrove waters safe to breed in. Their young have a better chance to survive and grow here—plenty of food, shelter from strong winds and ocean currents, as well as protection from large predators. Even those mangroves where the water recedes completely during low tides are useful, because they act as temporary shelters.

Feeding grounds

Mangroves are an important feeding ground for a wide range of visiting animals—birds, monitor lizards, snakes, predatory fish, and crocodiles—that forage and feed on the many diverse organisms that live there.

Flood Control

Mangroves, like all wetland systems, slow down flowing water. Water loses velocity and spreads out, getting further slowed down by thick vegetation. This restricts the erosion of riverbanks and damage to coral reefs.

Threats to mangroves

Thirty five percent of the world's mangroves are already gone. Mangroves are threatened by a range of factors, and a threat to mangroves can go on to impact local fisheries.

Clearing

Mangroves were considered unproductive and therefore were cleared and reclaimed for agriculture, urban and industrial development, including settlement, and harbours.

Mangrove trees are routinely cut down to be used as firewood and matches, to make ropes using their bark, and to make pillars for jetties and other small structures that are exposed to water. For short-term economic gains, mangroves are often cleared for the development of aquaculture and tourism.

Changes in water supply

Construction affects the flow of seawater, freshwater or both, causing the salinity of water in the mangroves to fluctuate, leading to the drying and death of mangrove trees. Deforestation inland increases soil erosion and the amount of sediment flowing into rivers, causing mangrove forests to be smothered.

Pollution

Pesticides, fertilisers and other chemicals created and used by humans are carried by rivers. These poison animals living in mangrove forests.

Coral reef destruction

Currents and strong waves coming towards the shore are slowed down by coral reefs. Without coral reefs, the force of water can wash away important nutrients and prevent mangrove saplings from settling.

The 2004 tsunami

The earthquake of 26th December, 2004, and the tsunami that followed caused great damage to the Andaman and Nicobar Islands, especially mangrove forests. Seawater surged in with great force, battering the fringing mangroves and flooding the coastal areas with sand and debris. In several areas, land was submerged, and the aerial roots got permanently covered in seawater, causing them to perish.

On South Andaman Island, the land submerged by about 1.25 m, resulting in mangrove roots getting no exposure to sunlight and air even during low tide. In Middle and North Andaman, the land rose to an extent where forests were completely out of reach of the tide.

Both situations resulted in damage to mangrove forests. Similar scenarios were also witnessed in the Nicobars, where parts of the land were submerged, and some had risen, causing extensive damage to mangroves. In other parts of the islands, mangroves have emerged in new locations, due to waterlogging.

Overfishing

Overfishing can greatly affect the balance of mangrove systems, since they are used as a nursery ground by fish. The removal of young fish can have a strong negative impact on the marine food web.

Bringing mangroves back to life

Mangrove forests are now gradually recolonising patches where they previously existed and, in some cases, new areas that are now influenced by the tide. Such patches are on their way to rapid natural recovery and should be left undisturbed to be nurtured back to healthy, productive systems.

To aid this recovery process, several initiatives have been undertaken by the Forest Department:

- They have initiated the restoration of degraded mangroves by establishing nurseries and replenishing degraded mangrove areas through artificial regeneration. Importantly, several species of mangrove has been planted in a some areas.
- Mangrove walkways have been established on several islands that allow tourists to observe and explore mangrove ecosystems without causing damage to them.
- Mangrove wood extraction and sale of mangroves have been legally stopped, thus resulting in a reduction in dependence on mangroves for resources.

Refer to the Notes for Field Trips to help plan for a visit to the mangroves.

Biodiversity

01. Fiddler crab: Locally known as *khaadi kekda* or *gananja*; they feed on detritus, leaving behind filtered silt in the shape of little balls; males have one enlarged, brightly coloured claw which they use to wave about to attract females or to mark their territory.
02. Periwinkle: A small snail which feeds on algae and bacteria; found attached to the upper parts of mangrove roots, leaves; some species might choose damp soil.
03. Ruddy kingfisher: A bird with a rust red body, generally deepening to purple at the tail.; easily recognisable by its large, bright red bill and legs; feeds on fish, crustaceans and large insects.
04. Cinnamon bittern: Solitary bird that hunts quietly, mostly on foot and at dusk; feeds on insects, fish, and amphibians; very well camouflaged but most easily spotted while flying.
05. Oysters: The two shells meet in a zig-zag, interlocking formation; they remain glued to roots, snail shells or rocks and depend on the tide to bring in nutrients; oysters are sequential hermaphrodites – male one year and female the next!
06. Mudskipper: An amphibious fish that spends long spells hopping about on land; have special water storage sacs behind their eyes to keep their gills wet and oxygenated; large eyes perched on the top of their head can rotate in all directions.
07. Eel: Fish with a long, snake-like body; breeds in the sea; the young grow up in freshwater and return to the sea as adults; mostly nocturnal and feed on plants and animals.
08. Mud crab: Large, squarish mossy coloured crab, with a jagged and sharp shell; hard shelled crabs, known to eat other crabs that are moulting and, thus, soft-bodied.
09. Mangrove whelk: Large snail that lives in brackish waters and on mud-flats; an easily recognisable cone shaped shell that is most common to spot in the mangroves; often huddle in large clusters either while feeding on fallen leaves or to retain moisture during low tide.
10. Saltwater crocodile or 'Salty': World's largest living reptile, males can reach up to 6.7 m and weigh as much as 2,000 kg; feed on fish, turtles and small animals that visit the water's edge; large salties capture really large prey includnig humans; after being hunted for their meat and skin, they are now given protection as a Schedule-I species.

ACTIVITY 4.1 GUESS WHO IN THE MANGROVES

CLASS	LOCATION	GROUPING	TIME
6	indoor	groups of four	40 minutes

Objective

To raise awareness of the connections between organisms and their adaptations in the mangrove ecosystem.

Learning outcomes

This activity will enable students to:

- identify which mangrove organisms display certain adaptations
- compare and contrast the various organisms in the mangrove forests
- choose the correct organisms based on adaptation clues

Materials

- A slate per team
- Chalk
- Rag cloth to erase answers between rounds
- Cards with the given clues printed out

Learning procedure

- Recap the features of a mangrove forest with students. Give students adequate time and practice with spelling names such as "rhizophora."
- Divide the class into groups of four. Instruct students that they will be working in these teams. All team members will all discuss the answer to a clue as quietly as possible. For every clue, a new team member will be responsible for writing the answer on the slate. The team which writes and displays the answer the quickest wins the round. Maintain a scoreboard if students are keen to have a more formal competition.
- Distribute the slates and chalk to the groups. Test the comprehension of the instructions by doing a mock run of the game to follow. E.g. amphibious fish which stores oxygen behind its eyes. Ans. Mudskipper. Reflect with students which behaviours help when having to answer rapidly in this format.
- Use the clues and play the game with students. As the objective of the activity is to strengthen concepts related to the mangrove ecosystems, swap the questions and answers and have students answer variations of the same question, if the need arises.

Further work

Challenge students to write out more clues and answers related to organisms and their unique adaptations to life in the mangrove ecosystems. This can be done for other ecosystems as well.

A	B
Decaying plant parts	Form mangrove swamps
Sunderbans	Mangrove in India and Bangladesh
Fresh and salt water	Low and high tides
Salt glands	Leaves remove excess salt
Knee roots	*Bruguiera*
Pencil roots	Pneumatophores
Saltwater crocodile	World's largest reptile
Lohabarrack Crocodile Sanctuary	South Andaman Island
Ruddy kingfisher	Fish during high tide or in tide pools
Natural nurseries	Fish, prawns, and crabs
Rhizophora	Stilt and prop roots
Leaves are waxy and fleshy	Save freshwater
Plastic bottle	Human activity

ACTIVITY 4.2 WHAT'S THE MATTER WITH THE MANGROVES?

CLASS	LOCATION	GROUPING	TIME
7	indoor	pairs	40 minutes

Objective

To critically examine a picture of a mangrove ecosystem and identify which images are out of place.

Learning outcomes

This activity will enable students to:

- detect which organisms are not usually present in a mangrove ecosystem
- explain what adaptations make survival in the mangroves possible for organisms in the mangroves
- compare and contrast the various organisms in the mangrove forests
- choose the correct organisms based on adaptation clues

Materials

- A printout of the activity sheet per pair

Learning procedure

- Draw a table with five columns on the board as shown below:

Ocean	Coral Reef	Rocky Shore and Sandy Beach		Mangrove

Ask students to recap the organisms that live in each of these spaces. You may permit students to refer to their notes in order to make this a low-stress activity.

- Divide the class into pairs. Instruct the students that they will be receiving a diagram that they must study together with their partner. In the first two minutes, the pair must only look at the picture, silently. Next, they will be permitted to discuss the question "What organisms are not supposed to be in the mangroves?" Instruct learners to clearly label the organisms which are not supposed to appear in the mangroves.

- Once all the organisms are marked out, instruct learners to flip the sheet and draw a picture of the mangroves with appropriate organisms. They may colour this picture, too. Remind students to pay close attention to the locations and ranges of the various mangrove tree species with respect to the shoreline. E.g. A red mangrove tree should be drawn more in the water than towards the land.

- Once all the pairs have completed spotting the organisms that do not belong in the mangroves, invite them to share their answers with the rest of the class.

Further work

Draw a food web for a mangrove community based on the food chain that you have already drawn. Classify every organism in the food web as a herbivore, predator, detritivore and provide an example of a competitor for each.

ACTIVITY 4.3 MIGHTY MANGROVE TREES

CLASS	LOCATION	GROUPING	TIME
8	indoor	groups of three to five	40 minutes

Objective

To learn about the structures that help mangrove trees adapt to their habitat.

Learning outcomes

This activity will enable students to:

- name the different types of roots seen in mangrove trees
- list the adaptations seen in leaves that help the trees survive in a salt-saturated habitat

Materials

- Waste material collected from personal consumption (plastic bottles, paper straws, juice tetra packs, chips packets, toothbrushes, toothpaste boxes)
- Cloth rags for cleaning
- Glue
- Newspaper
- Scissors
- String

Learning procedure

- Instruct students to collect and bring to class the waste from their consumption of snacks and other dry waste household items. Each student should also bring a piece of rag cloth to clean the materials before they are used. They can also wipe their hands on this cloth during the activity. Students should be instructed to be careful about littering when they bring these materials to class.

- Divide the class into groups of three to five. All the group members will collectively use the materials brought by the members of their group.

- Recap the types of mangrove trees and their roots with students. Instruct them to draw the different types of mangrove trees in their notebooks. These should be quick drawings; assign only five minutes for the drawing activity. Instruct students to plan how they will use the trash to make a model of any one mangrove tree they have drawn.

- Students should plan which materials they will use for what part of the tree and be able to share their reasoning with the class. E.g. "The leaves of the mangrove tree are made from packets of chips and the silver side is where the salt is deposited by the leaf."

ECO CLUB: MANGROVES

Objective

To recognise organisms that are commonly found in the mangroves and observe the interactions between them.

Learning outcomes

The students should be able to:

- recognise and describe commonly found organisms in the mangrove area
- observe and record the behaviour and interactions of organisms in the mangrove
- understand that organisms in the mangrove are connected in several ways

Materials

- Pencil, notebook, clipboard (optional), water bottle, cap, sandals to be brought by students

Learning procedure

- Go over the rules that needs to be followed at the intertidal areas, as well as the ways in which they can prevent causing any damage to the organisms there.

- Head to the site and gather at the pre-decided spot for a discussion in order to reinforce the rules to be followed for the day.

- Introduce the chosen site to the students. Ask them questions such as: "Have you been to an area such as this before? What have some of your observations been? What are some of the most marked features of this area? What are the major influences on organisms in this area?"

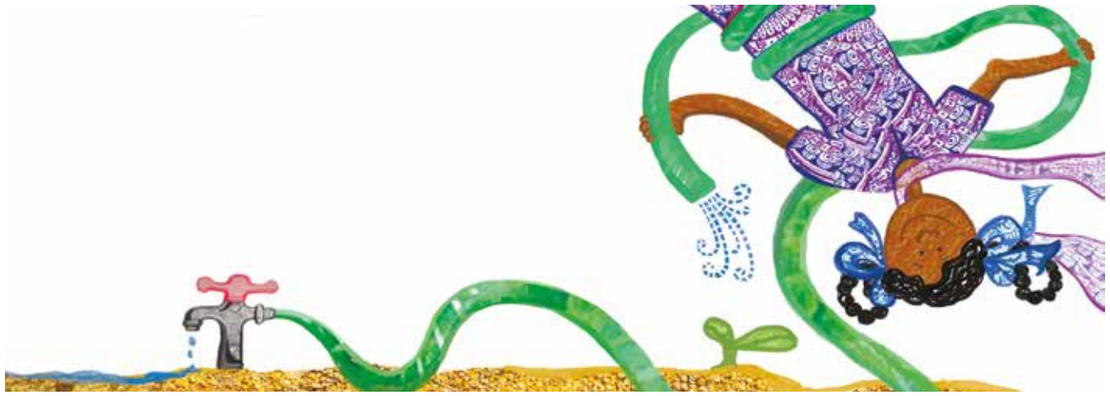
- Use the following prompts to facilitate students' observations:

After the first 20 minutes: List the organisms that you observed.

After having encountered some deep mud: "What does the soil feel like when you walk on it? Is it the same in all places? Why?"

Observing trees: What did you see more—trees or shrubs? How many of each? Why? Which part of the mangroves had trees? Is there a connection between the kind of soil and their presence? Compare at least two types of roots. Where did the roots arise from and what was their shape?

At the end of the visit: Are there any other peculiar structures that you have observed on or around the mangrove trees? Describe some if you have. What are the organisms around the roots of the trees?



CHAPTER

5 TROPICAL FORESTS

In the Andaman and Nicobar Islands, over 80% of the total land area is covered by forests, both inland and coastal. The forests in the islands exist along a continuum of environments from the highest inland regions to the coast. Inland forests could range from tropical evergreen forests comprising species of trees that remain green throughout the year to deciduous forests comprising leaf-shedding varieties of trees. Coastal forests are restricted to the edges of the islands and their characteristics vary depending on their proximity to the sea. Brackish water forests are called mangrove forests. Forests growing on the sandy beaches are called littoral forests.

Forests that grow between the Tropic of Cancer and the Tropic of Capricorn in high rainfall conditions are called tropical evergreen forests. Th first tropical forests appeared during the Paleozoic era (over 350 million years ago!). The forests we see today with flowering plants only appeared during the Cretaceous period (145 to 66 million years ago), and started spreading around the world about 40 million years ago. They occupy only 2% of the Earth's surface today but contain 50% of all species of the living world!

A littoral ecosystem exists along the fringes of the islands, higher inland than the intertidal zone. Littoral trees grow even in the sand and have greater tolerance to salt content in the air and soil. *Sundari, sea mohwa, poon, karanj* and various types of *Pandanus* are some of the common species of trees of the coastal littoral belt. *Nypa* palm and mangrove ferns are found along the creeks.

Littoral forests are similar in construction to tropical evergreen forests, but they are adapted to life much closer to the sea. For instance, the leaves are lighter green than in the tropical evergreen forests since more sunlight reaches this belt.

Strata in tropical evergreen forests

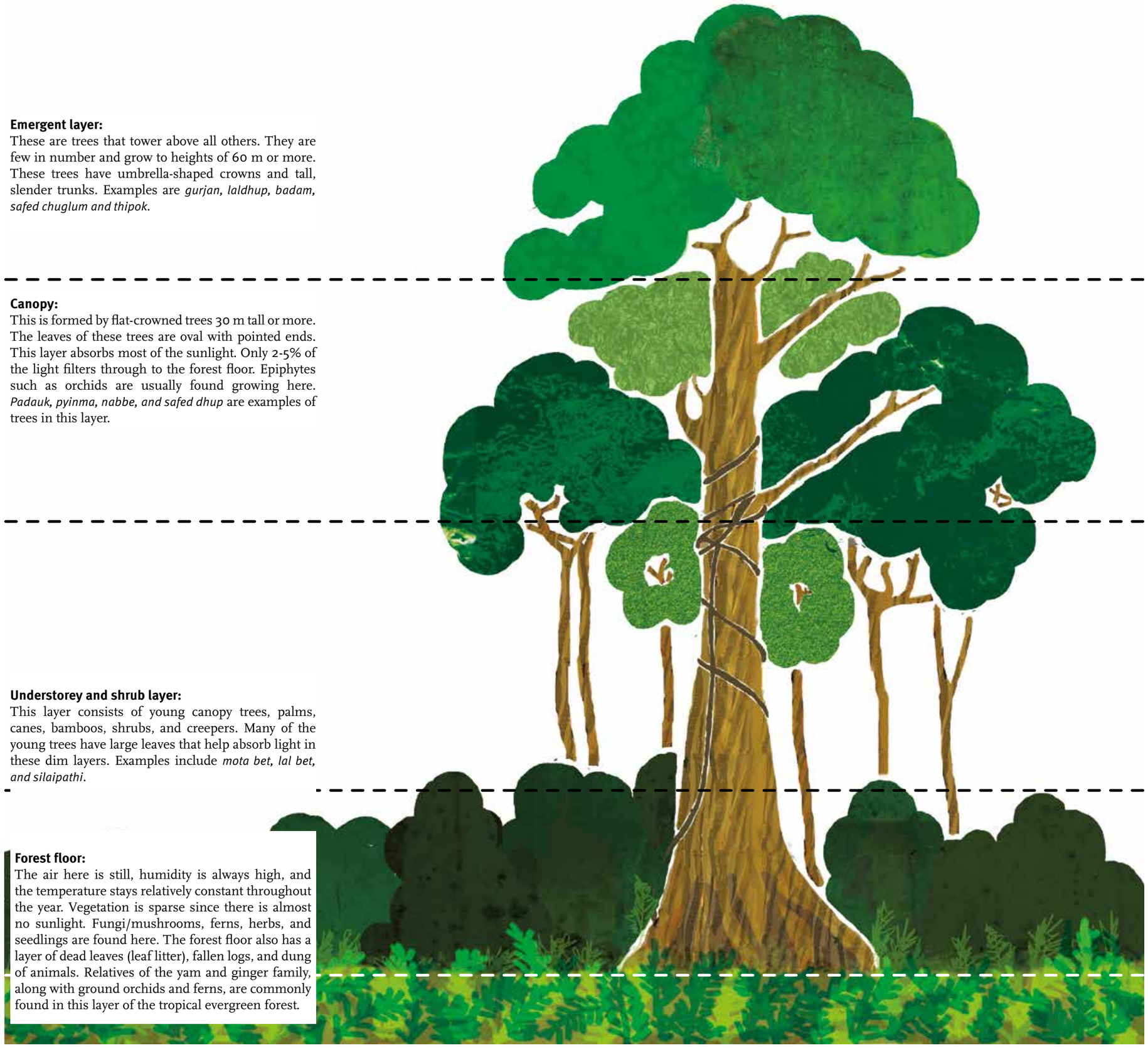
Even though the visible forest can tower over 60 m high, it extends below the ground, too.

Interactions in a forest

Forest ecosystems are interconnected; each organism depends on a network of others, as well as on abiotic components for food, shelter, survival, and dispersal. Each layer of the forest participates in a cycle of production and consumption of food.

The detritus food web begins with the fallen leaves, logs, and dead animals on the forest floor. Bacteria, fungi, and insects consume what they need and release the nutrients stored in these biotic remains. These nutrients are almost immediately taken up by living plants, setting the cycle to repeat itself.

Fungi and plant roots in the forest form a mycorrhizal network (myco = fungus; rhiz = root). This network, attaching plant roots to each other, manages the demand, supply, and uptake of nutrients in all the plants in the forest. In return, plants provide the fungi with sugars and shelter among their roots.



Emergent layer:
These are trees that tower above all others. They are few in number and grow to heights of 60 m or more. These trees have umbrella-shaped crowns and tall, slender trunks. Examples are *gurjan, laldhup, badam, safed chuglum and thipok.*

Canopy:
This is formed by flat-crowned trees 30 m tall or more. The leaves of these trees are oval with pointed ends. This layer absorbs most of the sunlight. Only 2-5% of the light filters through to the forest floor. Epiphytes such as orchids are usually found growing here. *Padauk, pyinma, nabbe, and safed dhup* are examples of trees in this layer.

Understorey and shrub layer:
This layer consists of young canopy trees, palms, canes, bamboos, shrubs, and creepers. Many of the young trees have large leaves that help absorb light in these dim layers. Examples include *mota bet, lal bet, and silaipathi*.

Forest floor:
The air here is still, humidity is always high, and the temperature stays relatively constant throughout the year. Vegetation is sparse since there is almost no sunlight. Fungi/mushrooms, ferns, herbs, and seedlings are found here. The forest floor also has a layer of dead leaves (leaf litter), fallen logs, and dung of animals. Relatives of the yam and ginger family, along with ground orchids and ferns, are commonly found in this layer of the tropical evergreen forest.

In tropical evergreen forests, there is a particular species of wasp that lays its eggs in the flower of a particular species of fig tree. The larvae grow inside the developing fruit. In turn, pollination of the fig tree takes place. The plant-animal interaction is so strong that if one species is threatened, the other is also equally affected.

From the layers of leaf litter and the bark of trees to the layers of branches and the sunny canopy, habitats exist at all scales for a variety of living things in the tropical evergreen forest. Any small change in the forest could mean a big change in the life of many organisms. This could result in the extinction of many sensitive species. Most often, humans are responsible for these changes. The most numerous creatures of the forests, as anywhere in the world, are insects. Although the Andaman wild pig and the Nicobar crab-eating macaque are native mammals of the archipelago, there are no large predatory mammals like leopards or tigers. Spotted deer and elephants were introduced to the islands by the British.

Forests in our lives

We know so little about our forests. Scientists are discovering something new about them constantly. Yet, we are so dependent on them for our needs. These needs may be direct, such as firewood, or indirect, such as using a chemical from a tropical evergreen forest plant to produce a life-saving medicine.

Let us look at some benefits we derive from forests:

- Tropical evergreen forests help in attracting rain clouds. It is almost certain that an area that loses its tropical evergreen forests will lose an important source of freshwater.

- The thick cover of tropical evergreen forests allows rainwater to seep down slowly into the ground and remain there. This helps in building a supply of fresh water known as groundwater. This ensures perennial water flow in the streams coming from it.

- They stop the force of the rain from washing away the fertile topsoil into the sea. This helps protect our coasts from erosion and keeps coral reefs and sea grass meadows sediment-free.

- A large diversity of plants and animals have made these forests their home, having adapted to survive within this ecosystem.

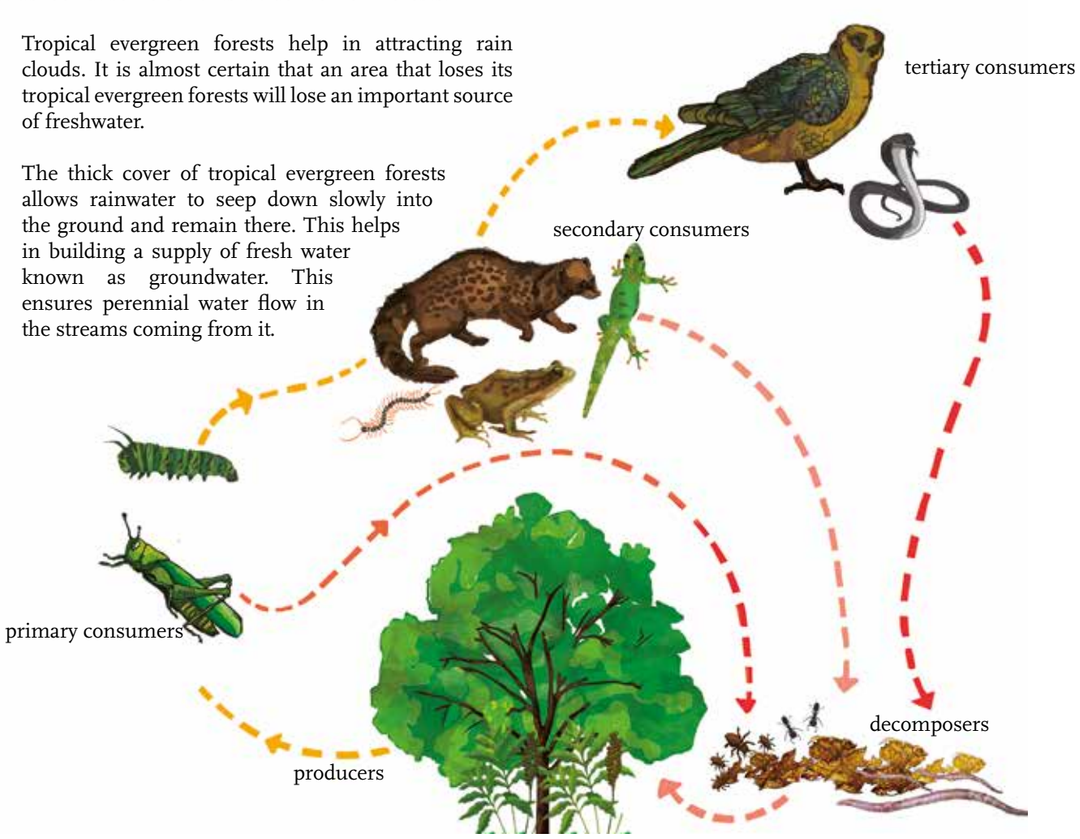
- Tropical evergreen forests are nature's own pharmacy, filled with species that are of great value to medicine and science. A list of some commonly used medicines from the forests is provided in the table.

- A lot of food of great nutritional value, like wild fruit, tubers, honey, and spices, comes from tropical evergreen forests.

- The wild relatives of many cultivated tropical crops are found in tropical evergreen forests. They are useful in plant breeding programmes needed for crop improvement. For example, *jungli supari* is a wild variety of the cultivated one.

- Tropical evergreen forests provide us with cane, bamboo, and other grasses and leaves that are used in making shelter, furniture, and other articles.

- Various kinds of wood for innumerable uses are derived from tropical evergreen forests.



- Littoral forests are important on their own. They act as coast guards and barriers to natural calamities like tsunamis. They protect the tropical evergreen forests from harsh winds and rough waves.

- Littoral forests also filter soil from stormwater, protecting coral reefs from siltation.

Scientific name	Common name	Uses
Pajanelia rheedii	*Jingam*	Leaf paste or extract is applied for foot cracks and wounds
Amorphophallus campanulatus	*Jungli guiyan*	Leaf and tuber paste is applied for centipede bites
Curcuma aromatica	*Jungli haldi*	Tuber paste is applied for sprains
Tabernaemontana crispa	*Koroya root*	Whole plant paste is applied for body pain
Lannea coromandelica	*Nabbe ped*	Bark paste is consumed for dysentery
Heritiera littoralis	*Sindri*	Bark paste is consumed for dysentery
Pongamia glabra	*Karanj*	Seed oil is applied on the skin for boils, cuts/wounds, and itching

Threats to forests

Tropical evergreen forests, which are so essential for our survival, face many threats to their existence. Illegal logging, introduced species, and encroachment for houses and agricultural fields pose immediate dangers to the functioning of the forests as a whole.

While tropical evergreen forests are highly productive, they have poor soil for agricultural purposes. It might be hard to believe, but it is true! The high temperature and humidity help decomposers living in the soil to break down plant and animal matter rapidly. These nutrients are rapidly taken up by the shrubs and trees for their use. Hence, at any given time, the soil stores a negligible supply of nutrients. People who clear tropical evergreen forest for agriculture do not realise that its soil may be unfit for cultivation of crops. The exposed soil soon dries up. Nutrients are washed away by the rains, leaving the land barren, with no forest cover.

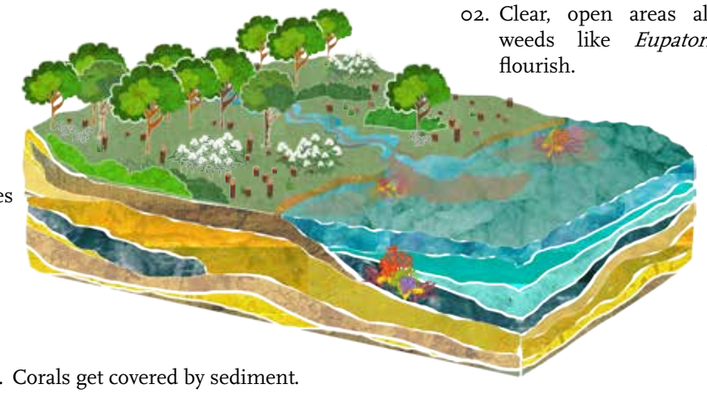
Littoral forests, picturesque and vital in their own right, and located along the coast, are also rapidly being cleared for commercial projects such as resorts.

Saving the forests

Forests take centuries of natural processes to grow into the vast interconnected ecosystems that they are. Human actions such as planting trees can scarcely recreate the complex phenomena by which animals and plants disperse seeds and prompt trees to grow. The Department of Environment and Forest in the Andaman and Nicobar Islands is entrusted with the protection of the forests. Numerous protected areas, in the form of national parks, wildlife sanctuaries and reserved forests, encompass large and small stretches of tropical evergreen forests, littoral forests and mangroves.

01. Fewer trees equals lesser rain.

02. Clear, open areas allow for weeds like *Eupatorium* to flourish.



03. Water rushes into streams to cause floods and siltation.

05. Ground water does not get recharged.

04. Corals get covered by sediment.

Biodiversity

01. Andaman wild pig: Endemic to the Andaman Islands; omnivore, eats grubs, tubers, and other animals; can only be hunted by tribal communities for personal consumption.

02. Giant wood spider: Also called golden silk-orb weaver; the body of females can reach up to 2 inches long, not including leg span; males are smaller in size than females.

03. Andaman pit viper: Endemic to the Andaman Islands, found on the forest floor and in the lower canopy; gives birth to live young; venomous, feeds on frogs and small mammals.

04. Nicobar crab-eating Macaque: Endemic to the Nicobar Islands; found between the forest floor and the canopy; social animal that lives in groups; feeds mostly on large *Pandanus* fruit.

05. Asian common toad: Seen hopping around moist areas of the forest floor; secretes a toxic substance to deter predators; feeds on tiny insects and especially loves flies.

06. Andaman water monitor: Relative of the Komodo Dragon; endemic to the Andaman Islands; feeds on small mammals and birds.

07. Andaman bronzeback: Endemic to the Andaman Islands; found on the forest floor and in the understorey; slim, green tree snake, active during the day; non-venomous; feeds on frogs, geckos, and small birds.

08. Andaman clubtail: Commonly encountered endemic butterfly; lays pale orange spherical eggs; caterpillars are velvet black and crimson.

09. Greater racket-tailed drongo: Found in the forest, forest edges and bamboo thickets; makes sounds from harsh to mellow musical calls; excellent mimic.

10. Masked palm civet: Omnivore, feeds on birds, frogs and fruits; nocturnal predator found between the forest floor and the lower canopy; prays a musk-like liquid when attacked.

11. Nicobar sparrowhawk: Bird of prey found only on a few islands in the Nicobars; found perching on the tops of tall trees; threatened due to habitat loss.

12. Andaman woodpecker: Endemic to the Andaman Islands; lives in forest and forest edges and sometimes in the mangroves; holes made in tree trunks are often inhabited by other birds; near threatened due to habitat loss.

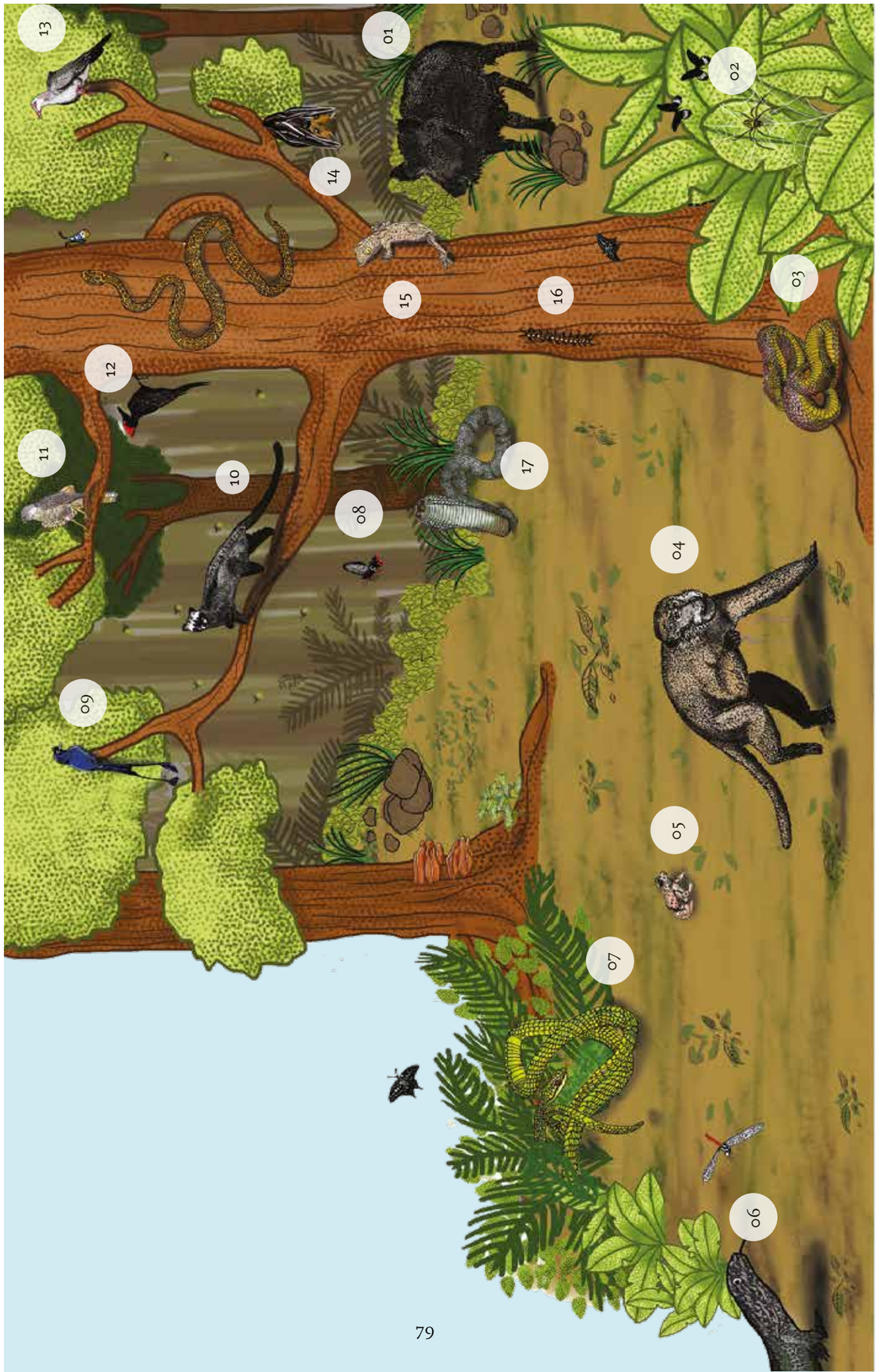
13. Andaman wood pigeon: State bird of Andaman and Nicobar Islands; eats fruits, especially figs and berries.

14. Lesser short-nosed fruit bat: A small bat that weighs between 20–30g; found in the lower canopy; eats only fruits; plays an important role in pollination.

15. Andaman giant gecko: Endemic to the Andaman Islands; one of the world's largest geckos; can grow to over one foot in length; relies on toe pads to help it climb large tree trunks.

16. Giant centipede: Largest Asian centipede; usually found under logs and rocks; nocturnal predator with modified claws on its head used to deliver venom to its prey.

17. Andaman cobra: Endemic to the Andaman Islands; found on the forest floor and in the understorey; three colour forms in adults – light brown to black; venomous, feeds on mammals, frogs and chickens.



ACTIVITY 5.1 DESIGN A SEED

CLASS	LOCATION	GROUPING	TIME
6	indoor/outdoor	pairs	30 minutes

Objective

To utilise knowledge of the various dispersal mechanisms to design a new kind of seed for a tropical evergreen forest tree.

Learning outcomes

This activity will enable students to:

- recall the structures of seeds from past experiences
- analyse seeds from their immediate surroundings
- determine how particular seed structures are useful for different seeds

Materials

- Some seeds from a range of familiar plants and trees
- Blank sheets of paper
- Crayons
- Sketch pens and other drawing material
- Tape, sticky notes

Learning procedure

- Draw the diagram of the tropical evergreen forest on the board. Ask students to name the layers of the forest before labelling the diagram or even write the incorrect labels and instruct students to correct them.

- Ask students about how dispersion of seeds may occur in the various layers of the forest. E.g. birds for trees in the canopy layer, wind for emergent layer trees and so on. This is an exercise in imagination grounded in information and so, permit learners to explore some hypothetical situations.

- Divide the class into pairs. Instruct learners that they should design seeds for trees and plants at different heights. On their sheets of paper, they must have a labelled diagram of the seed, as well as the type of tree and level of forest it comes from. They must also try to depict the way in which the seed is being dispersed, e.g. a bird eating it or the wind carrying it.

- Distribute the blank sheets of paper to the students and allow them enough time to thoroughly discuss and draw their ideas out on sheets of paper. Instruct pairs to come to the head of the class and show their seed design to the others, as well as answer one or two questions from their peers.

ACTIVITY 5.2 INSECTS AND RELATIONSHIPS IN A FOREST ECOSYSTEM

CLASS	LOCATION	GROUPING	TIME
7	outdoor	individual	40 minutes

Objective

To learn about insects and the role the play in a forest ecosystem, specifically understanding their role in the forest nutrient cycle.

Learning outcomes

This activity will enable students to:

- observe the variety and diversity of insects
- infer the various roles played by insects in a forest
- recognise the role of insects in a tropical evergreen forest food web

Materials

- Magnifying glasses
- Gloves
- Pencils
- Notebooks or clipboards, and sheets of paper

Learning procedure

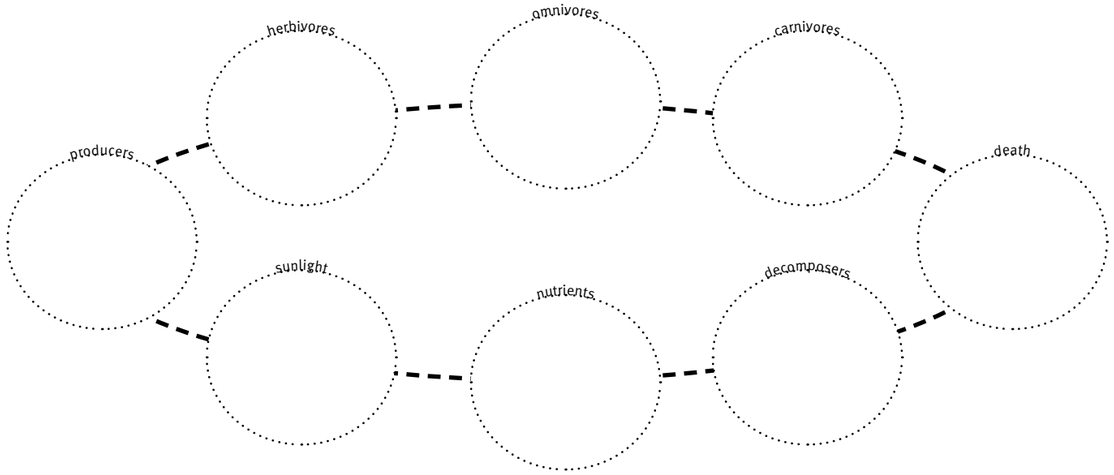
- Introduce ad lib (ad libitum) observation as a data collection method to students. In ad lib observation, the observer notes everything in the frame of observation without any filters. Instruct students that they will be making ad lib observations of the life on the bark of a tree.

- While still in the classroom, ask students to predict what they may see on the bark of a tree and what easy shapes they can rely on to make a drawing, on the spot, of what they see. E.g. closely grouped circles of different sizes for lichen, small ovals for ants. Communicating the movements and relationships between the organisms on the bark of a tree is the focus of the activity. Reassure students that the neatness or beauty of the diagram is not the primary goal.

- Instruct students they will be doing this activity individually and silently. Take students outdoors to a safe area where they can, possibly, sit on the ground to observe their selected tree.

- Once outside, guide students' first observations of the bark of the tree before starting the time for the individual activity.

- After a maximum of 15 minutes of careful observation, take students back to the class to discuss their observations. Draw a large outline of the tree trunk or branch on the board and ask students to share what all they saw. Instruct them to describe the movements of the various organisms and any feeding behaviour they may have seen.



ACTIVITY 5.3 NOWHERE TO SLEEP IN THE FOREST

CLASS	LOCATION	GROUPING	TIME
8	indoor	groups of three to five	60 minutes

Objective

To contextualise the effects of herbivory on the tropical evergreen forest ecosystem.

Learning outcomes

This activity will enable students to:

- identify types of trophic interactions
- infer the effects of trophic activities on an ecosystem
- explain the importance of native species and their links in a tropical evergreen forest ecosystem

Materials

- Chart papers of different colours
- Scissors
- Sketch pens and other writing material
- Glue
- Twigs and sticks (in case these are not accessible, sticks can be made by tightly rolling newspaper)

Learning procedure

- This learning experience can be spread out over two sessions. In the first session, recap the following with students: the structure of the tropical evergreen forest, a basic food chain with a focus on herbivores and their diet. Ask students if they have been to Netaji Subhash Chandra Bose Dweep (Ross Island) and seen the deer there. Ask students whether they noticed any grass or small plants growing on Ross island.

- Draw the diagram of the tropical evergreen forest on the board. Ask students to name the layers of the forest. Ask students, which of these forest layers will the spotted deer (*Axis axis*) get its nourishment from? Draw a basic figure of a spotted deer in the understorey layer of the forest and tell students that the deer are voracious herbivores, browsing extensively on all the plants in the understorey.

- Ask students which other organisms may be present in the understorey. List their responses on the board. Tell students that one of the organisms living in the understorey is the Bay Island lizard (*Coryphophylax subcristatus*), which they may have observed basking or running in certain green areas. Add this to the list.

- Divide the class into groups of three to five students. Instruct students that each group will be responsible for creating cut-outs of the various organisms that live in the understorey. Distribute the papers, scissors, and other drawing material to the various groups. Mount each cut-out on a stick or a stand made from a tightly rolled newspaper, which is stiff and tall like a stick.

- During the second session, draw the diagram of the forest on the board once again. Instruct the students, in their groups, to enact an ordinary scene from the forest using the cut-outs. Next, invite one member of each group to the board with two deer cut-outs each.

- Instruct students to enact how the deer eat using the cut-outs, erasing the trees that the deer may have eaten as they browse in the forest. Send the students with the deer back to their seats after a significant portion of the understorey has been erased.

- Next, invite other members of the groups to come to the board with cut-outs of other species which live in and use the understorey, such as insects and reptiles. Ask these students whether they have any resources to consume now that the deer have eaten all the understorey plants. Discuss their response, focusing on the aggressive browsing of deer in the forests.

- Next, specifically invite students with only cut-outs of Bay Island lizards to the board. Tell the class: "It is night time and the forest is dark. Bay Island lizards have the funny behaviour of sleeping on the leaves of certain plants in the understorey. They even select the same plant to return to night after night. The Bay Island lizard is a native species in our islands and the deer is an introduced species which we will learn about later. Now that the deer have eaten all the plants in the understorey, where will the lizards sleep?"

- Students may suggest that the lizards find different spots higher in the canopy. Ask students whether there can be any predators of the sleeping lizards at higher levels. What happens when they are close to the ground?

- Discuss with students how changes in the number of animals in any trophic level can have disastrous effects on the others and, eventually, the whole ecosystem.

ECO CLUB: TROPICAL FORESTS

Objective

To become familiar with the architecture, fauna, and flora of a tropical rainforest.

Learning outcomes

The students should be able to:

- list the characteristics that describe a tropical evergreen forest
- identify, define, and explain terms associated with layers of a tropical evergreen forest
- identify flora and commonly observable faunal groups such as worms, insects, reptiles, birds, and mammals

Materials

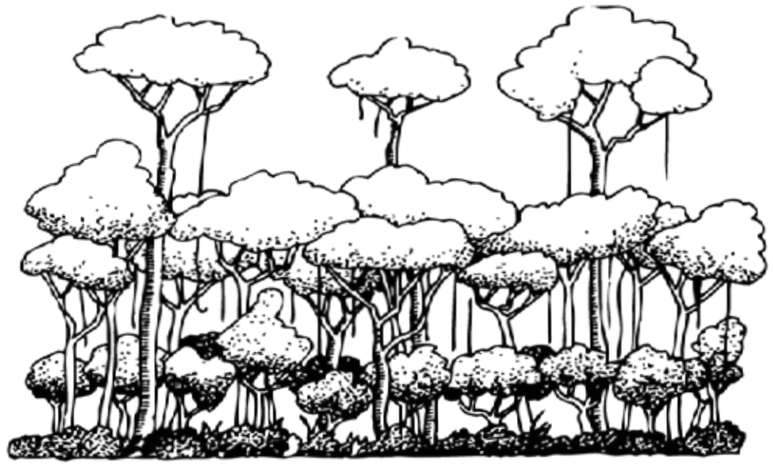
- A copy of the Activity Sheet per student
- A blank sheet of paper per student
- Pencil, notebook, clipboard (optional), water bottle, cap to be brought by the students
- Hand lens, binoculars, identification guides per group

Learning procedure

- Give each student a copy of Activity Sheet EC 5(1) and Activity Sheet EC 5(2). Tell them to record the observations they make on these activity sheets.
- Introduce the students to the architecture of a typical rainforest and give an example of a plant that represents each layer of the stratification, such as: Emergent layer – *gurjan*, Canopy – *badam, dhup,* Understory – *surmai patti*, ginger.
- Ask the students to pay close attention to the characteristics of plants during their walk while using all their senses – sight, sound, smell, and touch. Don't allow students to touch anything without supervision, and definitely not taste anything in the forest!
- Read through the worksheet with the class to make sure they understand it completely. Remind them that their observations, as noted in their worksheets, will be based on their senses. For example:
    - Using their sense of sight: variety of birds, insects, mammals, flowers, leaves, and roots, sizes of leaves, trunks and roots.
    - Using their sense of smell: rotting wood and fruit, ripened fruits, wet earth, animal droppings, etc.
    - Using their sense of touch: temperature, humidity, mud, mosquitoes biting, smooth leaves, different textures of the barks on trees.
    - Using their sense of hearing: bird calls, woodpeckers pecking away crabs foraging, or ants moving, lizards rustling through dead leaves.
- Ask the students to make bark markings of at least three different trees on their sheet of paper to compare different textures. They can do this by placing their sheet of paper over the bark of a tree and rubbing the paper with a blunt pencil to get bark markings.
- Pause at places for closer observations of birds in the canopy or even the bushes, insects such as ants, beetles, butterflies, bugs, grasshoppers, katydids, termites, flies, or some pond skaters in water, frogs, snakes, mushrooms, bracket fungi, spiders, millipedes, etc. Give the students quiet during these pauses to allow them to experience and document their sensory perceptions and organism behaviours.
- Point out the difference in leaf sizes of tall trees versus those in the understorey, also difference in trunk sizes and shapes and the sizes of roots.
- Once back in class, or in a clear spot where students can sit, gather them together and have each student narrate their experience and any sensations that surprised them. The students can mimic sounds of the forest, or actions of animals that they saw. Discuss the biodiversity observed during the walks and some of the features of plants seen.
- You may use some of these questions during discussion:
    - Did they notice anything different about the leaves in the understorey?
    - Where are tropical forests likely to be found on this planet?
    - What are some of the characteristics observed by you in the forest which helps you define it?

Activity Sheet EC 5 (1) - Stratification

Date: Name:



Layer name	Layer description
	This is the densest layer and is made up of bushes, shrubs, and young trees that have adapted to living in the shade of the layer above.
	This layer consists of a few scattered trees that tower over the canopy. These tall trees are subject to the most sunlight.
	This layer consists of decomposing leaves, animal droppings, dead trees, and animals, all of which decay to create new soil and provide nutrients for the plants. Examples of flora found here include: ferns, grasses, mushrooms, and tree seedlings.
	This layer is formed by the mass of intertwined branches, twigs, and leaves, appearing as an immense green carpet. It forms a shady, protective umbrella over the rest of the forest and receives most of the sunlight. Much of the forest life exists here.

Answer Options: Understorey and Shrub layer, Canopy, Emergent layer, Forest floor

Date: Name:

Activity Sheet EC 5(2) - Forest Sightings

	Insects	Birds	Mammals	Trees	Flowers	Fruits	Fungi	Soil
General features								
What was it doing?								X
Activity on it	X	X	X					
Where was it found?								
Any other observations								

The crosses in some columns indicate that observation is not necessary for the given points. Under the point what was it doing, you may record activities to do with feeding, movement, nest building, etc. Activity on them refers to what may be seen on them, like an insect on a flower, wasp in a fig, digging into the soil, etc.

CHAPTER

6 OUR BIODIVERSITY

Surrounded by teeming seas, fringed by coral reefs and mangroves, and covered by dense rainforests, the Andaman and Nicobar Islands are home to a diversity of ecosystems within a small, isolated space. These ecosystems support an even larger diversity of life.

Species very gradually develop unique characteristics to survive in their ecosystems through a process called evolution. Organisms have variations in characteristics and some of these are more helpful for survival and reproduction in a particular environment. Individuals with these characteristics leave behind more offspring and thus these organisms 'adapt' to the environment over time. Thus, very slowly, over numerous generations, organisms develop particular characteristics that suit their ecosystems. Charles Darwin and Alfred Russel Wallace, who first proposed this idea in the mid 1800s, called this process natural selection or 'survival of the fittest'.

For instance, let us consider a species of bird that eats seeds. If the seeds are in limited supply and the only other food source is nuts with a tough casing, then those birds which have strong beaks to crack open the nuts will survive. Each generation changes a little bit at a time; these changes add up to make a big difference and produce new species.

Native and endemic species

Native species have successfully resided in the islands since the earliest days of their formation. Due to being completely cut off from neighbouring landmasses for an extended period of time, some of these native species have developed certain characteristics or adaptations to suit their island ecosystem. These new adaptations make them especially suited to their location. Such extremely unique species are found nowhere else in the world; they are called endemic species. They are also extremely vulnerable to extinction. In the Andaman Islands, the Narcondam hornbill (*Rhyticeros narcondami*), a large and magnificent bird, is endemic to only Narcondam Island. Likewise, the Andaman day gecko (*Phelsuma andamanensis*) is endemic to the Andaman Islands. A list of endemic species is provided at the end of this book.

Threats to our biodiversity

Introduced species

Quite the opposite of endemic species, many species of plants and animals were brought to the islands from other places. They are introduced or exotic species. Intentionally or unintentionally, humans brought these species to the islands over the last few centuries.

When introduced species have no natural predators, their population may grow unchecked, till they eventually become pests. They may even pose a threat to the survival of other plants and animals, especially to endemic species that are already vulnerable. Introduced species become invasive in a particular ecosystem when their numbers grow so large that native and endemic species are unable to cope with the sudden emergence of large numbers of these exotics in their habitat.

For example, the British deliberately introduced the spotted deer or *chital* (*Axis axis*) to the Andaman Islands. Very soon, it became a threat to native plant species, and even small reptiles such as lizards, by altering the forest structure. When the deer browse (eat) on the understorey, they remove the plants and therefore the organisms that live, feed and breed in that space.

Eupatorium is an invasive plant. Due to the lack of competition with other plants, *Eupatorium* has now reached weed status. Under the open canopy (where a lot of sunlight reaches the forest floor), shade-loving plants begin to die, allowing *Eupatorium* to take over.

Human activities

Several human activities—clearing of forests for space and resources, hunting, pollution, and more—affect species and their health. The numbers of both native and endemic species start to decline sharply due to these threats, and we refer to them as threatened species. In the case of endemics, there is a fear that, if no protective measures are taken, these organisms may become extinct, which is a great loss to the biodiversity of the world.

For example, the Nicobar treeshrew (*Tupaia nicobarica*), endemic to the Nicobar Islands, is under threat due to habitat loss and predation by domestic cats and dogs. If measures are not taken to protect such species, there is a possibility that they might be lost forever.

Conservation of species

Each species of plant, animal, fungus, and microbe represents a building block of our natural world. Removing any of these building blocks will weaken the entire natural world we live in. We are unable to predict, with certainty, what will happen if this natural building were to wobble or collapse due to species becoming endangered or going extinct.

Conservation of species must take place with the conservation of their habitat and the ecosystems that support them. At the national level, the Government of India has set up national parks and wildlife sanctuaries across the country to help protect the island ecosystems and the wildlife they support. There are over a hundred national parks and wildlife sanctuaries in the Andaman and Nicobar Islands. In the Andaman Islands, these include the Mahatma Gandhi Marine National Park, Lohabarrack Saltwater Crocodile Sanctuary and Interview Island Wildlife Sanctuary, among others. Much of Great Nicobar Island is under some kind of protection, including Campbell Bay National Park and Galathea National Park. Both are part of the Great Nicobar Biosphere Reserve. The Forest Department also helps ensure the protection, conservation, and regeneration of natural resources.

Several organisations such as Dakshin Foundation and Andaman Nicobar Environment Team (ANET), Nature Conservation Foundation, Indian Insitute of Science and Wildlife Institute of India (WII) run local initiatives to study, understand, and communicate the importance and impacts of various organisms, native or introduced.

Together, with the efforts of these and several other organisations and researchers, we hope to mitigate the various threats that affect the health of ecosystems on the island.

Remember, your role is important in keeping the ecosystems and their species safe.

01 Narcondam hornbill

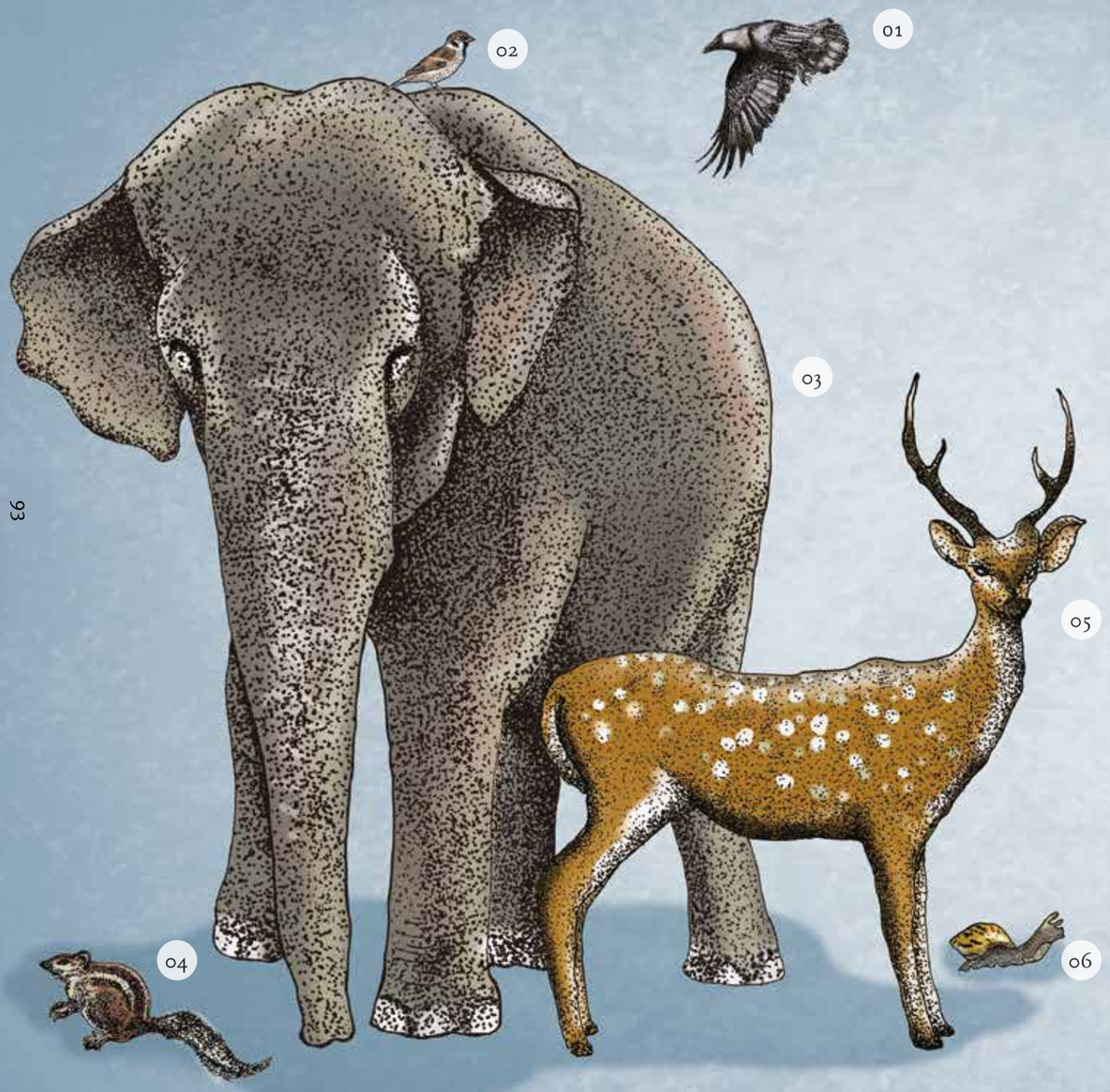
02 Andaman *padauk*

03 Andaman bronzeback

04 Bay Island forest lizard

05 Nicobar treeshrew

Common name	Scientific name	Likely time of introduction	Purpose	Current location	Threat to/Affecting
Plants					
Congress grass	*Parthenium hysterophorus*	Mid-1950s or later	Accidental; contaminant of wheat	A&N	Native plants
Devil weed	*Chromolaena odorata*	1850s or later	Ornamental plant	A&N	Native plants
Water hyacinth	*Eichhornia crassipes*	1890 or later	Ornamental plant	A&N	Native plants
Invertebrates					
Giant African snail	*Achatina fulica*	1943	Food item	A&N	Native plants, snails
Birds					
Common myna	*Acridotheres tristis*	1867		South Andaman	Competition for nesting holes and roosting places
House sparrow	*Passer domesticus*	1892/1895		Port Blair	Native birds (possibly)
House crow	*Corvus splendens*	2002		Port Blair, Car Nicobar	Agricultural crops; can spread disease
Indian peafowl	*Pavo cristatus*	1947		Ross Island	
Mammals					
Domestic cat	*Felis catus*	1850s	Pet	A&N	Predator of endemic birds
Domestic dog	*Canis lupus familiaris*	1850s	Pet	A&N	Predator of sea turtles
Spotted deer (*chital*)	*Axis axis*	1905-1930	Game	Andamans, including Little Andaman	Forest regeneration
Barking deer	*Muntiacus muntjak*	1905-1930	Game	Middle Andamans	Forest regeneration
Five-striped palm squirrel	*Funambulus pennantii*	1940s	Pet	South Andaman	Seed predator
Asian elephant	*Elephas maximus*	1962	Timber operations	Interview Island, North Andaman	Forest regeneration



01 House crow
02 House sparrow
03 Asian elephant
04 Five-striped palm squirrel
05 Spotted deer
06 Giant African snail

ACTIVITY 6.1 HOW DID IT GET HERE?

CLASS	LOCATION	GROUPING	TIME
6	indoor	whole class	40 minutes

Objective

To build context for the changing organisms inhabiting the ecosystems of the islands.

Learning outcomes

This activity will enable students to:
- create a story about an invasive species using prompts
- explain the meaning and impacts of invasive species
- understand the significance of their impact on endemic and threatened species

Materials

- Sheets of paper
- Hole punch
- String
- Art supplies

Learning procedure

- Instruct students to sit in a circle. Ask them to create a story about the introduction and spread of the spotted deer, an invasive species on the Andaman and Nicobar Islands. Give them the following background information:

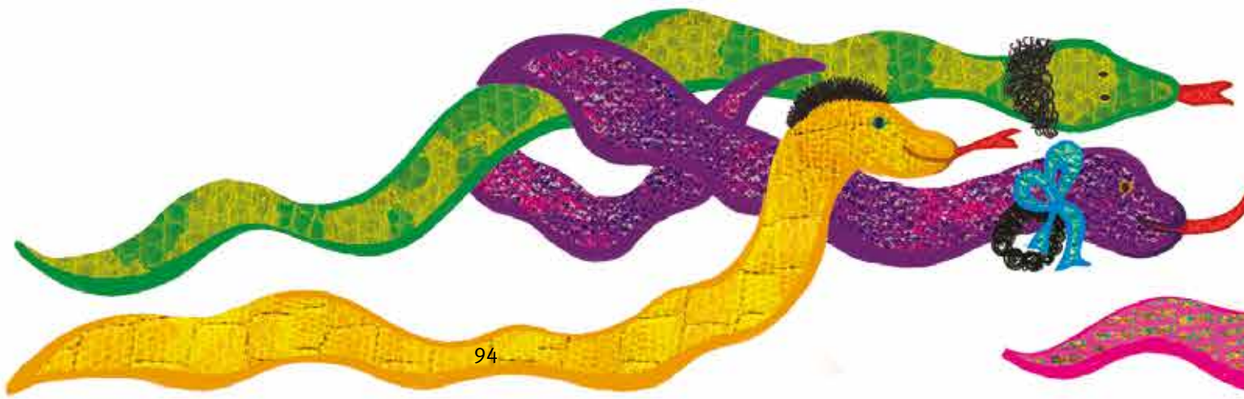
- Spotted deer were introduced sometime between 1915 and 1930 by the British for game hunting. They have now spread all over North, Middle, and South Andaman Islands, including the islands close to the coast. They are found in Ritchie's archipelago as well. They are good swimmers and are often seen out at sea. They have also been established on islands with no known freshwater sources.

- An example of what can happen when deer spread on an island can be observed on Netaji Subhash Chandra Bose Island (Ross Island) near Sri Vijaya Puram. There is practically no undergrowth, and no new growth of trees is seen anywhere on the island. Since there are no plants on the ground, there is a lot of soil erosion and no hiding place for lizards and other insects. The spotted deer encolsure in the Chidiyatapu zoological facility is also devoid of understory vegetation.

- Ask one student to start the story and have each student add on a sentence to continue the story about how the deer came to the islands, how they spread, what they eat and thus how they survive.

- Through the story, prompt them with questions and points such as:

  - What are they eating? The understorey.
  - Who are they impacting? Forest structure and other organisms that depend on it, such as the Bay Island forest lizard.
  - How have they spread? Swimming between islands.
  - Why are they not in the Nicobars? The Ten-Degree Channel is very wide, and also because nobody has taken them there.

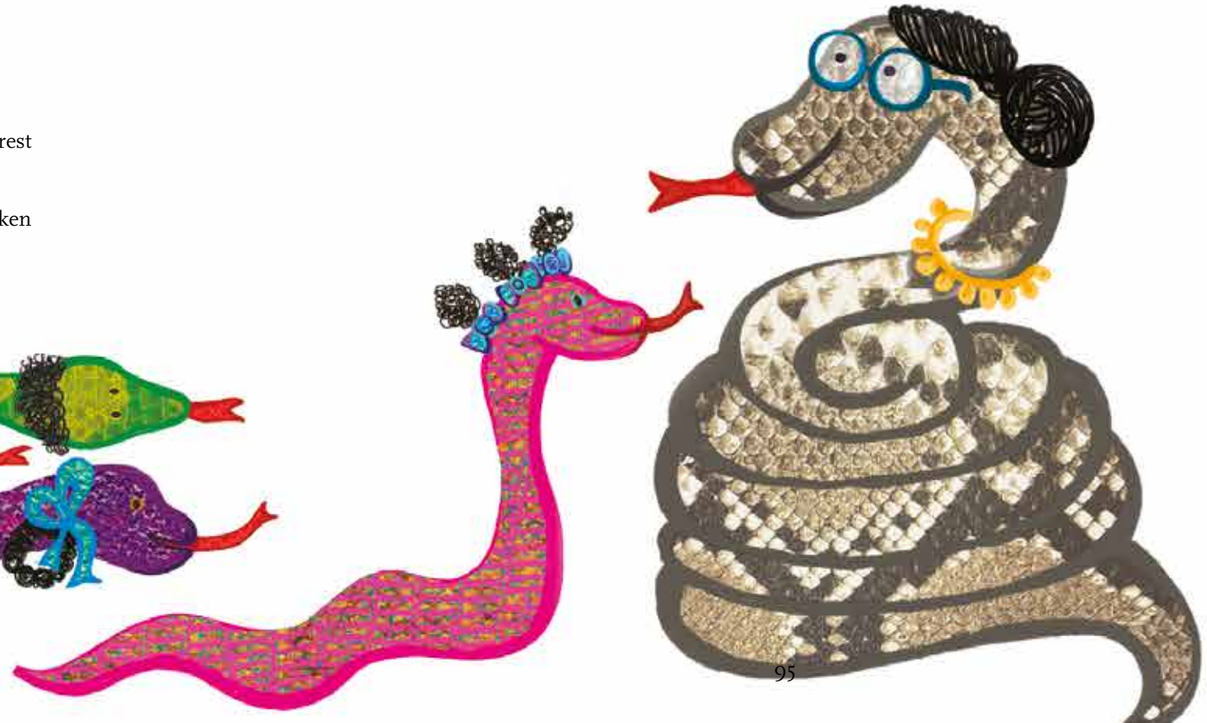


- Ask one student in the group to write down the story as it is being built. When done, ask them to write out the story neatly on a few pages, illustrate it, and make it into a booklet.

- Read out the story to the rest of the class. Go over any discrepancies in information, misconceptions, and answer any questions they might have.

- End the class by reminding students of the term endemic species. Write the term on the board and ask if they know what it means. Explain that endemic species are those that are found nowhere else in the world except in one region, and that the islands have a lot of endemic species of trees, birds, snakes, etc.

- Ask the class what they think would happen if the deer were to eat all the plants of an endemic species and leave no trace of it for it to grow back.



ACTIVITY 6.2 ALL FALL DOWN

CLASS	LOCATION	GROUPING	TIME
7	indoor	whole class	30 minutes

Objective

To demonstrate the effects of changes in the structure of the food pyramid through a simulation.

Learning outcomes

This activity will enable students to:

- state the relationships between organisms in an ecosystem
- understand that all organisms in an ecosystem are interdependent
- recognise that an imbalance in a food web can impact more than one species, especially endemic and threatened species

Materials

- Emptied and cleaned packaging for food and other consumables such as cups, cans, and boxes

Learning procedure

- Instruct students to bring emptied and cleaned packaging such as cups (curd and yoghurt, noodles), tetra packs (juice) and other packaging materials for consumable products they may have used. They may also bring pencil boxes and other packaging which is rigid and can be stacked.

- Classify the different materials by size, and group similar sizes together. With students, determine which category will be used to represent each of the following: producers, primary consumers, secondary consumers, tertiary consumers, apex predators. Ask students to name some under each category and note these responses on the board.

- Using the information on the board, along with the categories of materials, instruct students to build a pyramid with the producers at the bottom and the apex producer at the top. Let students know that the reason that the base of the pyramid (producers) is the widest is because the volume of plant material required for the same amount of energy as consuming another animal is much higher. Therefore, the number of boxes comprising the layer of plants is much more than the number of apex predators at the top of the pyramid.

- Once the pyramid is complete, ask the students if they think it is stable. Ask them what would cause instability to the pyramid without referring to the categories of organisms they represent.

- Next, invite students, one at a time, to remove one box at a time from the producer layer.

- Observe and discuss what happens to the pyramid.

- Next, invite students, one at a time, to remove two boxes at a time from the primary consumer layer.

- Observe and discuss what happens to the pyramid.

- Challenge students by asking them what might happen if the apex predator is removed from the ecosystem.

- Remember to stress that in the case of endemic species and/or threatened species, if they're removed from the web due to any reason, they can never be replaced and will have been lost forever.

ACTIVITY 6.3 DEER CONTROL

CLASS	LOCATION	GROUPING	TIME
8	outdoor	whole class	20 minutes

Objective

To represent the relationships between ecosystems, prey, and predators with reference to the deer and crocodiles that inhabit the islands.

Learning outcomes

This activity will enable students to:

- relate the limitations of habitat and populations of various organisms
- interpret the predator-prey relationship between crocodiles and spotted deer in the islands' threatened species

Materials

- Chalk, string, rope or coloured tape

Learning procedure

- Recap with learners, the information about the spotted deer or *Axis axis* in the islands. (1) Native or introduced? (2) How are the deer protected?

- Remind the students that the spotted deer were introduced to the islands when they were never a part of the native ecosystem. Ask students, in the mainland, which animal depends on the spotted deer as prey? Instruct students that, in the mainland, the natural predators of the spotted deer are leopards, tigers, wild dogs, and even pythons. Ask students, how many predators of the spotted deer are there in the islands? The answer is one, the saltwater crocodile. Spotted deer receive the highest degree of protection. In the islands, their numbers are thriving. Why does this happen?

- Draw a picture of a large island on the board. In the centre, mark tropical forests. Ask students which layer of the tropical evergreen forest is affected by the spotted deer? How? Do they have enough food? Do saltwater crocodiles come into the tropical forests? Can they successfully prey on large numbers of deer? When can crocodiles prey on deer? Discuss the responses with students.

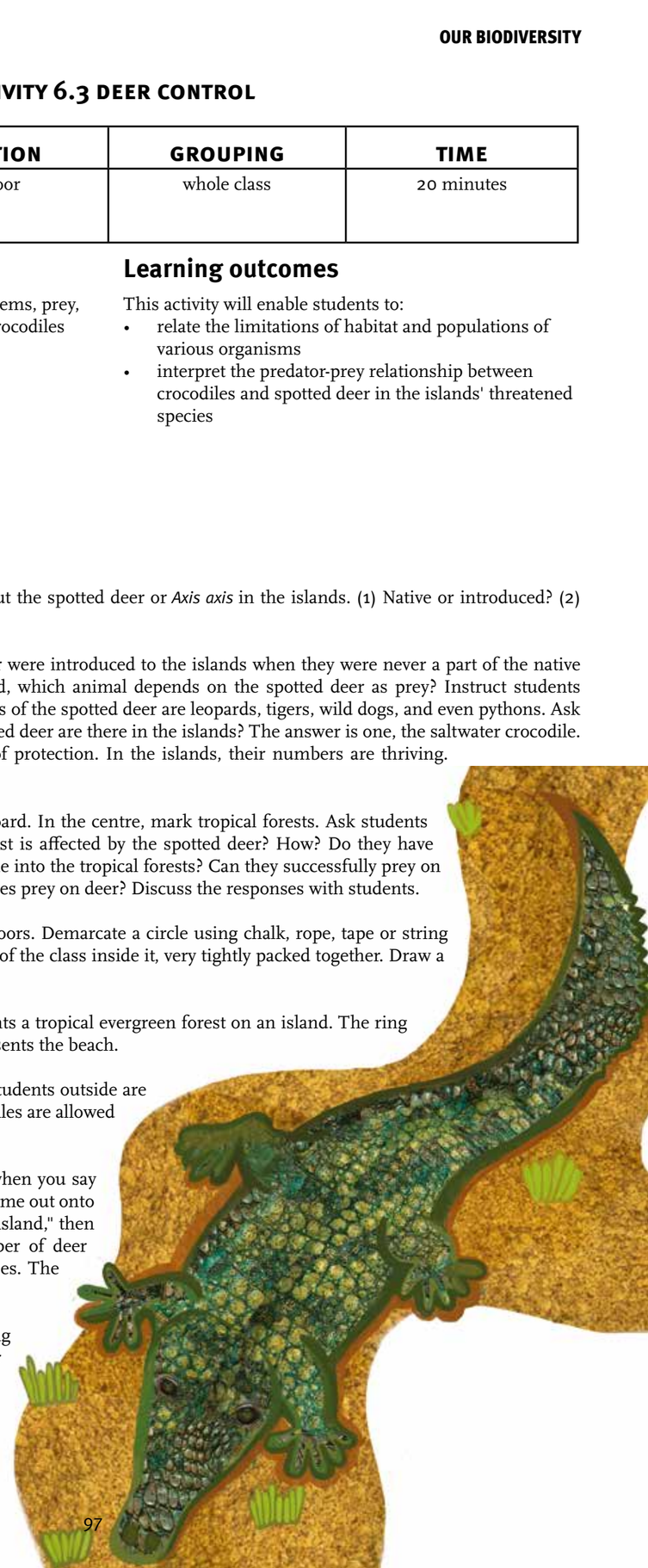
- Arrange for the class to play a game outdoors. Demarcate a circle using chalk, rope, tape or string just big enough to accommodate one half of the class inside it, very tightly packed together. Draw a slightly wider ring around it.

- Tell students that the inner circle represents a tropical evergreen forest on an island. The ring around the tropical evergreen forest represents the beach.

- Students inside the two circles are deer. Students outside are saltwater crocodiles. Both deer and crocodiles are allowed to use the beach.

- Instruct all the students to walk around when you say "start." If a crocodile sees that a deer has come out onto the beach or into the "water" around the "island," then the crocodiles may tag them. The number of deer reduces and that of the crocodiles increases. The deer cannot tag a crocodile.

- Increase the challenge level by shrinking the size of the forest and drawing another island some distance away.



CHAPTER 7

HUMANS OF THE ISLANDS

Original islanders

Some groups of people have inhabited the Andaman and Nicobar Islands for tens of thousands of years. They are the indigenous people of the islands and once used to live throughout the Islands.

In the Andaman Islands

The original people living in the Andaman Islands have very different histories and cultures from the people living in the Nicobar Islands. The original communities of the Andaman Islands are:

Great Andamanese – There were ten distinct Great Andamanese groups in Great Andaman (North Andaman, Interview Island, Middle Andaman, Long Island, Baratang Island, South Andaman, and Rutland Island). Only a handful of people remain, and are restricted to Strait Island.

Jarawa – The Jarawa refer to themselves as the Ang. The name 'Jarawa' came from the Akabea tribe who used the term to refer to the other people who coexisted with them in North and Middle Andaman.

Onge – The Onge refer to themselves as En-iregale. They live on Little Andaman and are now confined to small reservations.

Sentinelese – The Sentinelese live on North Sentinel Island. This group of islanders have had limited contact with outsiders and are also typically hostile to visitors.

In the Nicobar Islands

Nicobarese – The Nicobarese are an indigenous community, settled on twelve islands of the Nicobars. Cottages, canoes, and plantations used to fringe the shores of the islands where they lived until the earthquake and tsunami of December 2004. Several thousand people died or were reported missing in the aftermath, and villages were moved further inland.

Food such as fish and other marine life comes from the ocean. Forests were the providers for a range of resources: timber for canoes and construction, and wild pigs, bats, and birds as additional protein. Coconut, areca nut, bananas, *pandanus* tubers and taro come from large plantations. Pigs, chicken, cows, and goats are reared both as special food for feasts and festivities and to supplement livelihoods.

The Nicobarese from various islands are well-known canoe-builders. The Nicobarese from Chowra are known for their racing canoe-building skills. Other Nicobar islanders build outrigger canoes with variations in design. Large outrigger canoes with sails were common half a century ago as they were the main transport for trade and communication. Today, symbolic races are sometimes held during festive occasions.

Christianity and Islam are the mainstream religions practised in the Nicobars. However, Nicobarese also continue to celebrate the festivals of their old traditions and cultures. The language varies from island to island. Despite linguistic variations, there is considerable interconnectedness and interdependence between the island communities.

The Nicobarese systems of village and island governance have been transformed to accommodate a modern lifestyle. The Nicobarese have taken up opportunities as teachers, clerks, police personnel, drivers, doctors, and government officers and officials. Their language is distinct and spoken only among the Nicobarese.

Shompen – In the Nicobars, the Shompen are a small community dispersed in small groups, living in the interior regions of Great Nicobar Island. They arrived in the Nicobar Islands long before the Nicobarese community. Their family groups live in forests, occupying various regions: some are deep in the interior of the forest, but close to freshwater and their kitchen gardens. Shifting living locations periodically provides them an opportunity to change foraging and hunting grounds. They hunt wild pigs and other animals of the thick tropical evergreen forests and freshwater streams on the island for food. A few crops are grown for subsistence.

The Nicobarese along the Great Nicobar coast and the Shompen in the forests have historically interacted with each other largely through barter, and until many decades ago, also warfare. The Shompen are often compared to the Nicobarese, yet the two groups are different. The Shompen prefer anonymity, following their discreet way of life without being overtly hostile. Their language, previously thought to be a variation of the Nicobarese, is now considered a distinct one.

Indigenous identity and lifestyle

Nature and community are deeply interlinked in the belief systems of the indigenous peoples in the Andaman and Nicobar Islands. They have come to understand the environment and how it works in their own ways. Through their hunting and gathering, or foraging, these communities carefully observed the interlinkages between the various elements that make up an ecosystem. Rules for the community are based on treating the community as part of nature and nature as part of the community. The indigenous, especially—the Ang/Jarawa, Sentinelese, Shompen and many Onge—continue to maintain lifestyles in which their communities' rules, taboos and norms determine if and how any resources can be used.

These taboos can be based on a range of factors including the place where they live, the season or time, or life stage of the person who is about to hunt or gather the resource and even on the method of hunting or gathering the resource. In some of the Andamanese communities, young people are required to abstain from key foods of the community—honey, wild pig and turtle—one after the other, and in certain circumstances, even for several years. Fasting is ended with feasting and the food which was forbidden is eaten to break the fast.

Several of the Andamanese communities believe that when the seas are rough during the monsoon, they must hunt pigs and gather honey, because only the spirits could hunt in the sea. Different regions are out of bounds for fishing during other occasions. In the Nicobars, where most fishing is done during the day, there are occasions when night fishing is carried out.

Currently, hunting is a right exclusively reserved for the original islander tribes. They conduct hunting expeditions using bows and arrows for wild boar, palm civets, and monitor lizards. They also hunt sea turtles and dugongs with harpoons (practiced by some communities), fish in the creeks and the sea, collect honey from beehives, gather fruit from the forest, and glean shellfish from the mangroves. There are strict community rules about consumption and treatment of food resources, thus generating as little waste as possible along the way, as well as at the end. Those people who have chosen to move away from traditional lifestyles find themselves increasingly dependent on food and clothing provided by government agencies.

Honey was and continues to be an important resource for all the communities. The Onge of Little Andaman and the Ang/Jarawas have certain honey-gathering practices, such as smearing the juice of the *Tonjoghe* tree all over their arms and legs, which prevents bees from stinging them. To deter bees from buzzing around the hive without killing them, the collectors blow out the strong fumes of leaf juice from their mouths.

Fishing is done with arrows, spears, and harpoons as well as hooks and lines, and even nets made of fibres from the bark of certain specific trees for specific species and occasions. From ancient times, the Nicobarese communities were excellent canoe makers. The *Ap*, the canoe made by the craftsmen of Chowra, was considered as the best and the most desirable. In fact, the canoe is considered a living being. Among the Onge, special shells believed to have beneficial powers are taken on canoe trips.

The indigenous islanders had different names for places on the islands. Many of these names were based on the natural and spiritual significance of the places. Many of the names we use today, especially for the different places on the islands, were not the names given by the original islanders.

The disappearing lifestyles of the indigenous peoples

Different colonial powers were interested in governing the islands in the last three hundred years. The British were eventually successful in overcoming the others and seized control of the islands just like they did with the rest of India. Once the British arrived in the Andamans, thousands of indigenous islanders died in a very short span of time due to war and disease.

In 1899, a British naval officer, Maurice Vidal Portman, recorded that even though the indigenous islanders were otherwise very healthy, they had no resistance to numerous diseases such as measles and influenza which were only brought in by outsiders. The British also used alcohol and tobacco as a way to make the indigenous peoples easier to suppress and to entice them. As a result, the indigenous communities have had to struggle over the long term with addiction and dependency.

The Great Andamanese, Onge and Nicobarese were eventually befriended and introduced to "modern culture". The Nicobarese used changes in their lifestyle to their advantage. They were able to do this because their own history of interactions with outsiders through trade relations gave them an ability to cope with changes.

The indigenous belief systems that linked nature and community were also changed. In the 1950s, through the work of missionaries, many from their community took to Christianity.

The lifestyles of the indigenous communities have been challenged by the pressures of shrinking space, losing it rapidly to incoming migrants and the changing availability of resources other than their traditional resources. Forest lands which once were the source of life and the basis of the belief systems of indigenous communities were cleared to make space for the new settlers.

This made them rapidly dependent on rations supplied by the Tribal Welfare Department such as rice, dal, sugar, oil, tea, and masalas. The administration is trying to support the indigenous communities' needs but their independent way of life has been severely compromised and, in many cases, lost forever.

Did any indigenous communities resist change?

Most Andamanese communities were hostile to outsiders in the beginning. The Great Andamanese communities were nearly totally destroyed in the conflicts that occurred. Today, the Ang/Jarawa and Sentinelese communities have survived the repercussions of their resistance relatively better. Indigenous communities all had their own conflicts with each other as well. For instance, the name we use for the Ang people—'Jarawa'—came from the Akabea community who referred to the Ang people as 'strangers.'

Did any indigenous communities respond to change differently?

The Ang/Jarawa traditionally lived in the interior of South Andaman Island. It is believed that the ancestors of the Jarawa had migrated from Little Andaman many centuries ago. When they landed in South Andaman, the Jarawa found that the coast was already occupied by the Andamanese who were not very friendly. So, they moved into the forests and adjusted themselves to life there.

The Jarawas were wary of outsiders because of the conflicts with the coastal Andamanese. They also had a fear of strangers because of the terror caused by the Malay pirates and slave traders of the past. During their reign, the British very cunningly used the traditional enmity between the Andamanese and the Jarawa to overpower some of the latter. Many attacks and killings resulted from this. All this made the Jarawa mistrust the outside world even more. Their only form of defence was to try and isolate themselves. They also attacked any intruder into their territory to protect themselves.

The Andaman Trunk Road (ATR) was built right through their land without their permission. The construction of this road from the late 1970s up to 1989 resulted in many violent incidents when the Ang/Jarawa attempted to defend their homes and lifestyles by attacking and chasing away the construction labourers and the elephants that were used for forestry operations within their forests. The cruelty, betrayal, and plunder that the Ang/Jarawa have had to endure are at the root of their hostility to outsiders who are effectively seizing the land and resources in the western part of the Middle and South Andaman, leaving them with few to no options.

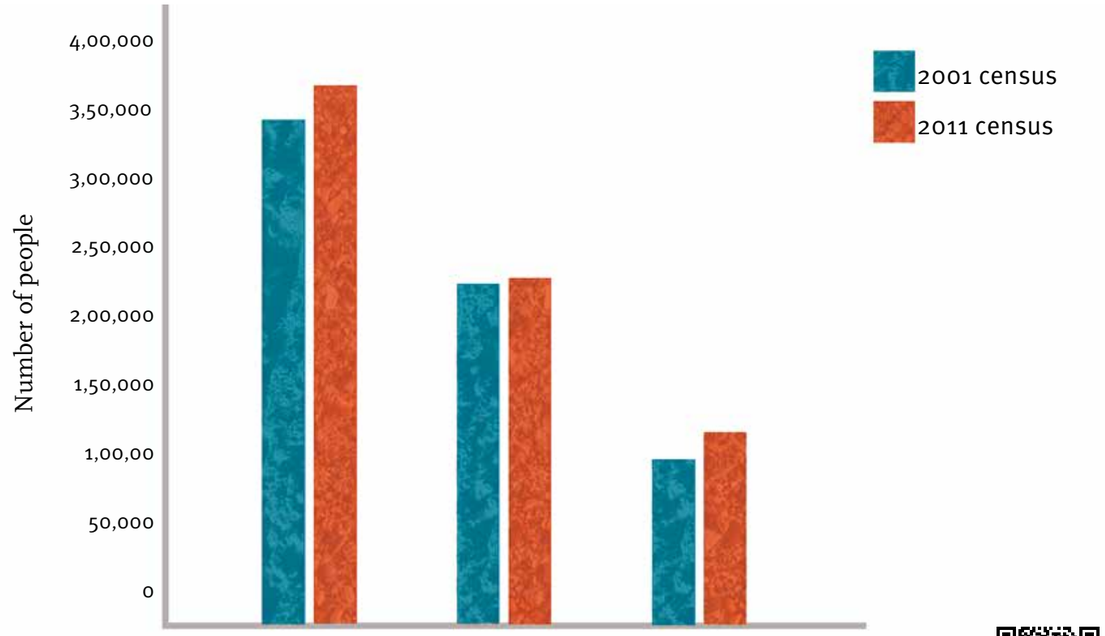
Today, Ang/Jarawa living close to the road use it to their advantage in a range of ways which are well-documented and researched. Anthropologists and government institutions are working towards documenting, researching, and supporting the Ang/Jarawa. Yet these actions do not make up for the loss of their lifestyle and knowledge systems.

Settler communities

Andaman Islands

In the last ten years, there has been a growth of nearly 7% in the population of the islands. The maximum increase has been in South Andaman Island.

Tribe	Island(s) of Residence	Population	
		2001 census	2011 census
Great Andamanese	Strait Island, Andaman	43	44
Onge	Little Andaman	96	101
Sentinelese	North Sentinel	39	15
Jarawa/Ang	South and Middle Andaman	240	380
Nicobarese	Nicobar Islands	28,653	
Shompen	Great Nicobar	398	229
		29,469	
	TOTAL	29,469	



(These figures include the tribal population in ANI)
Source: http://censusindia.gov. in/2011-prov-results/paper2/data_ files/ani/Document_19.pdf

In 2011, the Census of India recorded the population of the Andaman and Nicobar Islands as just over 3,80,000. In 2001, the population of the Andaman and Nicobar Islands was about 3,50,000. Of these, 3,15,000 lived in the Andaman Islands while the population of all indigenous people in the Andaman Islands was only 418 people. This meant that, in the Andaman Islands, the ratio of indigenous people to settlers was 1:750. So, who are these other locals in our islands?

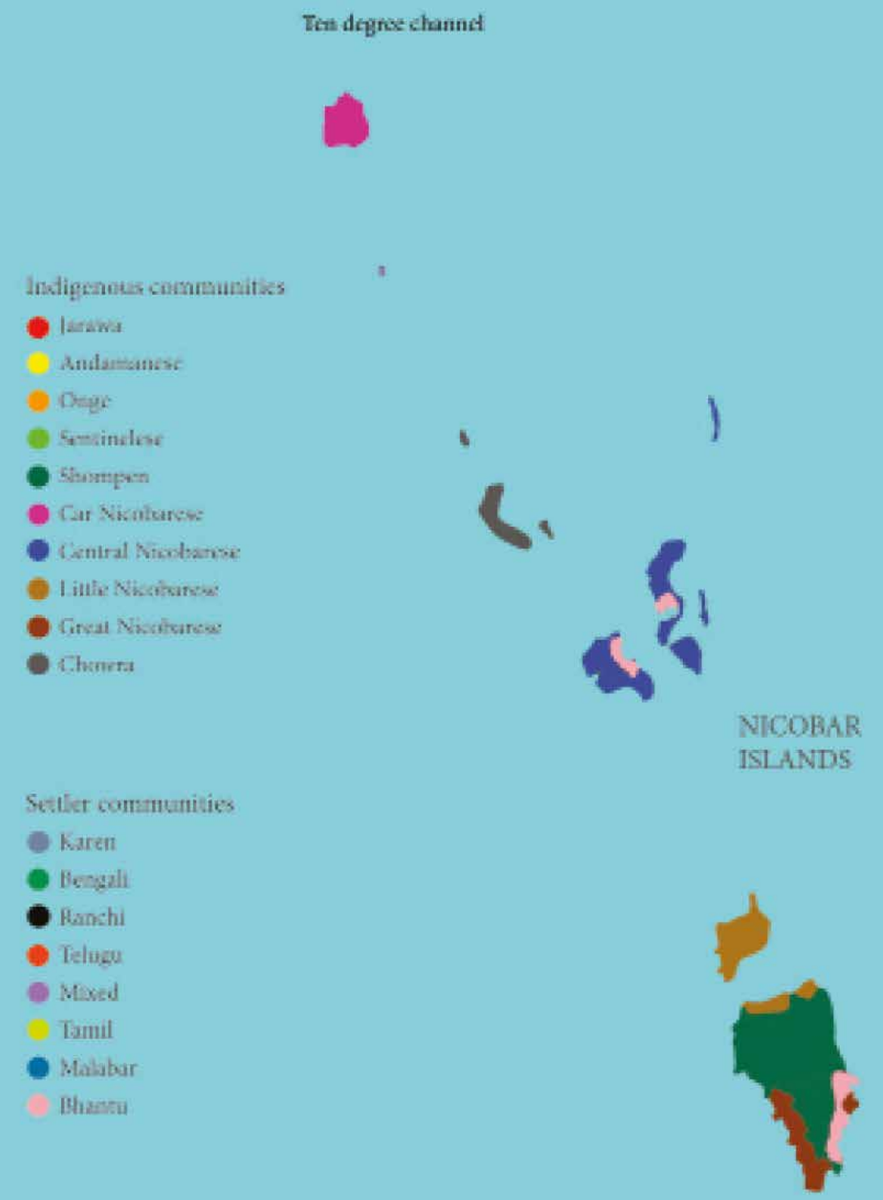
Over the last few centuries, people from many different regions were brought here by the British Government from different places, or were settled here by the Indian Government or migrated here on their own. Settlers are immigrants from various states of the Indian subcontinent, descendants of freedom fighters and convicts housed at the Cellular Jail, who stayed on after Indian Independence, and war refugees who were rehabilitated. These large numbers of settlers came in to the islands in just a fraction of the time that the original islanders have been on these islands. The coming together of people from so many different parts of India has made it into a mini-India.

The settler population includes the Karen community from erstwhile Burma and war refugees from Bangladesh, people from the Chota Nagpur region of Jharkhand who came to be referred to as 'Ranchis', as well as people from Andhra Pradesh, Tamil Nadu, Punjab, Kerala, Bengal, and more. Most people in these communities practice agriculture, fisheries or trading, or work in the government services and work together with each other for the islands' prosperity.

Nicobar Islands

Many people from various mainland regions, especially Punjabi and Marathi ex-servicemen, were settled on Great Nicobar in the early 1970s, and later Tamil refugees from Sri Lanka were settled on Katchal Island by the Government of India. While the communities settled on Great Nicobar Island were largely dependent on agriculture and government service, today private enterprise and employment is growing after most of the farmlands were damaged by the tsunami of 2004. The rubber plantation started by the Forest Corporation on Katchal Island brought in many Tamil-speaking people from Sri Lanka for work, of whom many have now moved to Sri Vijaya Puram. Car Nicobar Island is the district headquarters, and the entire region is administered from three locations: Car Nicobar Island, Kamorta Island, and Great Nicobar Island.


ANDAMAN
ISLANDS
Ten degree channel


Ten degree channel
Indigenous communities
Jarawa
Andamanese
Onge
Sentinelese
Shompen
Car Nicobarese
Central Nicobarese
Little Nicobarese
Great Nicobarese
Chonera
Settler communities
Karen
Bengali
Ranchi
Telugu
Mixed
Tamil
Malabar
Bhanru
NICOBAR
ISLANDS

ACTIVITY 7.1 ORIGINAL ISLANDERS

CLASS	LOCATION	GROUPING	TIME
6	indoor	groups of four	60 minutes

Objective

To gain awareness that indigenous knowledge is a valuable collection of learning, passed down through generations that has exceptional local relevance.

Learning outcomes

This activity will enable students to:

- recognise the validity of indigenous knowledge systems
- outline the importance of indigenous knowledge in the context of changing climate
- demonstrate respectful representation of indigenous people

Materials

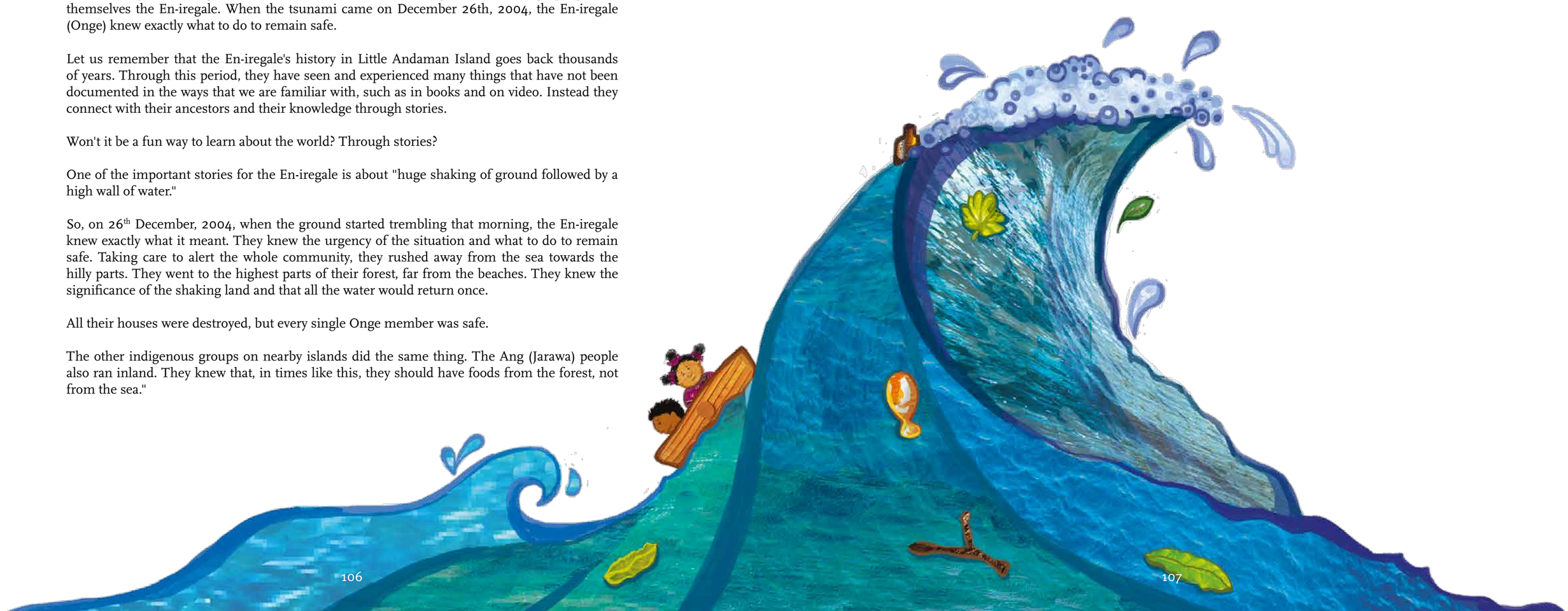
- Chart papers
- Sketch pens, crayons
- Sheets of paper
- Glue

Learning procedure

- Read out the following text to students:

> "We may refer to the indigenous islanders by certain names, but they have names for themselves and all the places, things, and events they observe and are a part of. The Onge people call themselves the En-iregale. When the tsunami came on December 26th, 2004, the En-iregale (Onge) knew exactly what to do to remain safe.
>
> Let us remember that the En-iregale's history in Little Andaman Island goes back thousands of years. Through this period, they have seen and experienced many things that have not been documented in the ways that we are familiar with, such as in books and on video. Instead they connect with their ancestors and their knowledge through stories.
>
> Won't it be a fun way to learn about the world? Through stories?
>
> One of the important stories for the En-iregale is about "huge shaking of ground followed by a high wall of water."
>
> So, on 26th December, 2004, when the ground started trembling that morning, the En-iregale knew exactly what it meant. They knew the urgency of the situation and what to do to remain safe. Taking care to alert the whole community, they rushed away from the sea towards the hilly parts. They went to the highest parts of their forest, far from the beaches. They knew the significance of the shaking land and that all the water would return once.
>
> All their houses were destroyed, but every single Onge member was safe.
>
> The other indigenous groups on nearby islands did the same thing. The Ang (Jarawa) people also ran inland. They knew that, in times like this, they should have foods from the forest, not from the sea."

- Divide the class into groups of four. Instruct the groups that they will be drawing scenes of what the Onge saw on 26th December. They will not be drawing the Onge themselves.
- Ask students, from the story, what do you think they saw when the ground shook? What would happen to trees? What would fall to the ground? What do you think they saw at the shore? Think about the intertidal zones and coral reefs. How would the shoreline look if all the water were to rush away from the shore and expose submerged parts of the reef?
- Have you taken a walk up through the forest at Munda Pahad/Chidiyatapu? What would it look like to watch the water come rushing back from the top of a tall hill?
- Draw a poster with many panels like a graphic novel (comic book) of what the Onge could see. Only draw the natural world. Do not draw the people.
- Display the posters in the class and, if time permits, encourage students to describe their own group's poster or even ask questions about other groups' posters.



ACTIVITY 7.2 TELL US YOUR STORY

CLASS	LOCATION	GROUPING	TIME
7	indoor	individual work	60 minutes

Objective

To explore their own family history by using their family member(s) as sources of information.

Learning outcomes

This activity will enable students to:

- Discover one's family history related to migration to the islands
- Use a questionnaire to gather and organise information about their family
- Explain the range of reasons why families may have moved to the islands

Materials

- Map of the Andaman and Nicobar Islands and physical map of India
- Sticky notes
- Pencils, sketch pens
- Thread and pins or masking tape
- Print of the accompanying map for each student

Learning procedure

- The two sessions for this activity should be spaced approximately one week to ten days apart from each other.

- In the first session, ask students whether they are familiar with the diversity of linguistic and ethnic communities who live in the Andaman and Nicobar Islands. Ask students how often they visit the mainland and where they go when they visit. Including your own experiences with your community and connections to the mainland could help students understand the frame of reference for their discussion.

- Once the discussion is done, divide students into small groups only for the classroom discussion. Instruct each group to prepare a list of no more than 20 questions by which they can learn more about their families' migration history.

- After about ten minutes, for this part of the activity, ask students to read their questions out loud to the class and choose questions which are respectfully worded and cover the following areas:

    - First people to move to the islands from within the family, when and why
    - The locations of members of the extended family
    - Connections maintained with the mainland through visits and shared festivals and so on
    - New festivals or observances, customs or practices since moving to the islands followed as a part of the larger island community
    - The facilities or sights and sounds of the islands in the earlier days
    - The changes that have taken place in the islands since then
    - Any fond memories of the old days in the islands and how far back they were
    - Professions and changes to professions since migration

- Encourage students to interview as many family members as possible and make a separate record of each person's responses. Record the age, gender, and family relation (grandmother, uncle, cousin) when interviewing. Allow the respondents to decline answering any question. Try to ask questions for more details if the answers are only "yes," "no", or other similar short answers. Encourage conversation and take notes as much as possible. After the interview, sit down and recall as many details as possible from the conversation. Note all these down. Collate all the responses into a story of maximum of 1000 words or two to four foolscap pages.

- Instruct students to fill in the accompanying map with as much detail as they can, covering:

    - The region from where their ancestors migrated
    - The regions in the islands where their families are currently settled

- During the second session, invite any students who are comfortable sharing to share their story with the whole class. In case the students are not comfortable sharing with the whole class, divide the class into groups based on differing ethnic and linguistic communities in each group.

- Mark the journeys of various communities to the islands on the map using tape and string or sticky notes or even pins and string.

- Once complete, discuss the reasons for migration, anonymously, if the students are not comfortable. Summarise the similarities and differences between the migration stories of different communities. Cover topics like professional choices, access to resources, government schemes, and so on.

- As the students are discussing their stories, make a list of all the communities that are represented within the class on the board along with the year in which they first moved to the islands.

Further work

Conduct the same interviews with someone else in your neighbourhood. How different or similar is their story?

Activity Sheet 7.2(1) - Questionnaire

Date: Name:

- Interview a family member (or more, if required) to collect information about your family history. Use the questionnaire to collect information on significant moves. Collect information on dates of these movements and reasons behind them.
- Make up at least three more of your own questions to ask. Each question should help you gain more information about your family's background. Make sure you do not ask questions with yes/no answers.
- If some of the questions listed cannot be answered by your family members, go ahead and replace the question with one that is more appropriate. Make sure to note these changes in your notebook.
- The questionnaire is only to be used to gather information. Use this information to write a short, one page story about your family's story, in your notebook.

Questionnaire

Name of the person being interviewed: .....

Your relationship with that person (father, grandmother, etc.): .....

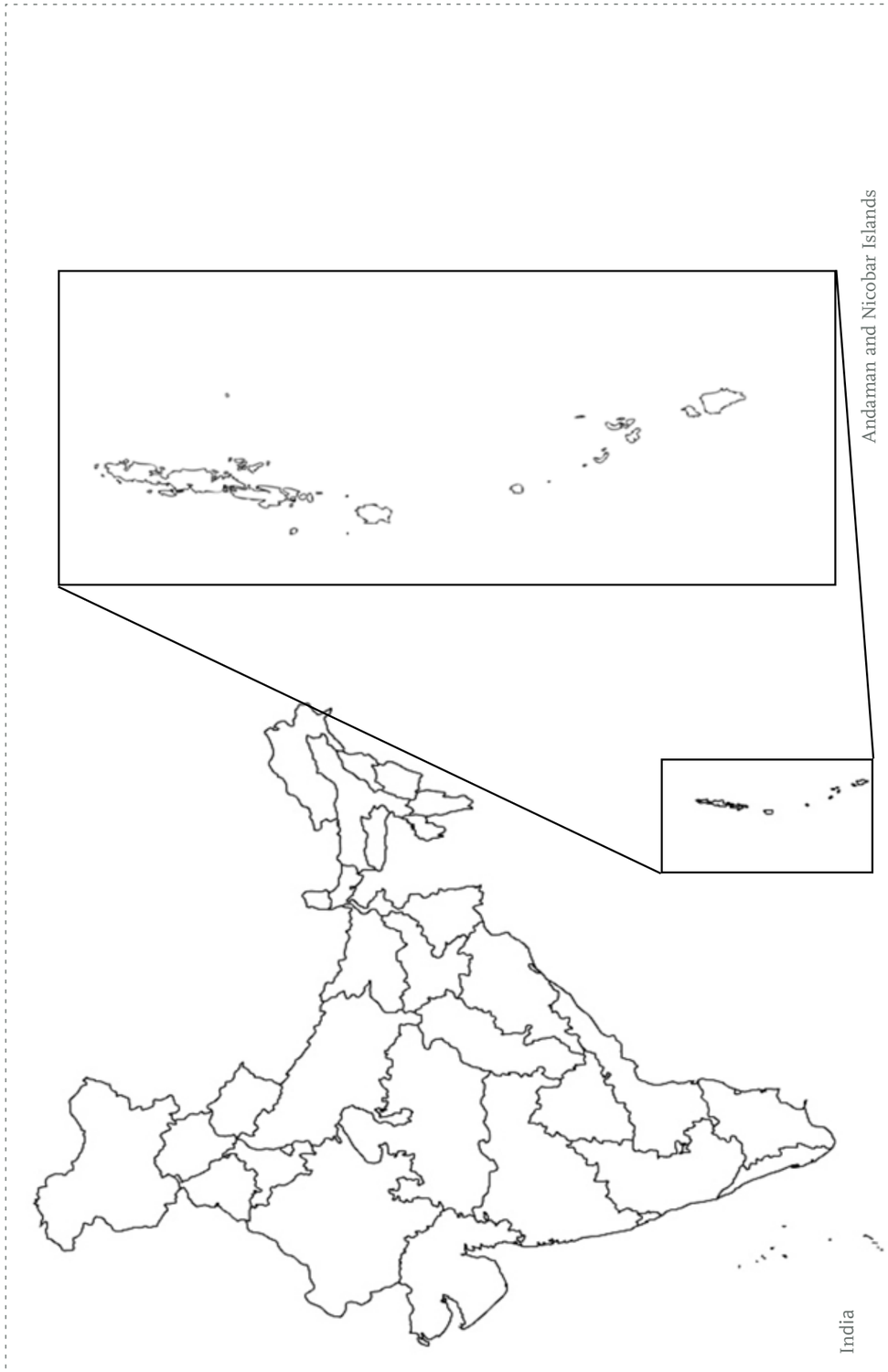
His/her date of birth: .....

His/her current location (which should be the same as yours): .....

Questions to ask:

1. Who was the first member of our family to move to Andaman and Nicobar Islands?
2. How many generations of our family have lived here?
3. When did they move?
4. Where did they come from and where did they move to?
5. Why did they come?
6. What did they do?
7. Do they still continue the same profession? If not, why?
8. Is it a family profession? Do you work in the same profession?
9. Did many other people from the family or the community move here as well? Did they all move at the same time?
10. What has changed since the family has moved here?
11. Are there any interesting stories or events that have occurred in the family in the last 100 years?

What are some other questions that you are going to ask?



Use this map to mark where your family came from, where they moved to and where the currently reside.

ACTIVITY 7.3 HOW CAN THE FLOATING POPULATION BE LESS HEAVY?

CLASS	LOCATION	GROUPING	TIME
8	indoor	pairs	60 minutes

Objective

To raise awareness of responsible tourism through a knowledgeable assessment of the risks and opportunities.

Learning outcomes

This activity will enable students to:

- explain how the average annual load of tourism on certain islands can be calculated
- determine some necessities for a successful tourism industry
- outline advice to visitors to the islands to have a responsible impact on local resources

Materials

- Map of theAndaman and Nicobar Islands
- Sticky notes
- Sheets of paper or a notebook, and writing material

Learning procedure

- Display a map of the Andaman and Nicobar Islands in the class. Ask students which islands are known for their tourism. Mark these islands with sticky notes beside them.
- Next, instruct students to use the scale of the map to share an estimate of the areas of the islands where tourism takes place. Write these on the sticky notes next to the islands.
- Draw the following table on the board:

	Area	Estimated tourists per day	Tourists per kilometre per year
Shaheed Dweep (Neil Island)	18.9 km²	300	
Swaraj Dweep (Havelock Island)	113.93 km²	1000	

- Next, instruct each pair to come up with a list of the top 10 necessities for tourists visiting the islands. For example drinking water, water for bathing, electricity for small personal electronics, electricity for air conditioners, electricity for washing machines at the hotel, water at the hotel for washing clothes, favourite foods, etc. Share the list of examples with students only if they are stuck.
- Next, bring together three pairs of students. In the new, larger group, ask the students to reduce their list of necessities to five main necessities.
- Invite all the groups to share their lists. If another group has listed the same point, they should check or cross it off their list. Each group only shares the unique values on their lists.
- By the end of the class, reach a consensus about the most vital things required for a tourist experience.
- Ask learners how these can be provided for tourists and what tourists travelling to the Andaman and Nicobar Islands should be aware of when they visit the islands.
- Students can make a poster to depict their advice to tourists to encourage responsible and fair tourism for all, including the residents of the islands.

Further work

Create a list of local businesses that are responsible with their tourism activities.

CHAPTER 8

RESOURCES AND SUSTAINABILITY

As an archipelago, resources in the Andaman and Nicobar Islands have natural limitations. The requirements of non-human and human migrants and settlers are difficult to meet using only the resources naturally available here, unlike those of the endemic organisms and the original islanders (indigenous tribes).

Resources on the Islands

Forests

Outsiders sailing past the islands were attracted to the tropical forests. In addition to timber, tropical forests contain resources ranging from medicinal plants, fruits and other non-timber forest products to animals that have traditionally been hunted by the original islanders. Also, the other functions of forests help keep us alive. We refer to them as ecosystem services: habitat and shelter for biodiversity, prevention of soil erosion and the sequestering of carbon (holding it in a state that is not harmful for human beings and other living organisms). .

Oceans

Seawater may not be fit for domestic, agricultural, and industrial use. However, the ocean surrounding us supports livelihoods: fishing, tourism, and even transport and communication. Marine life is fished for consumption and used in various industries, including agriculture. Coral reefs support a diversity of life, attract tourists to snorkel and SCUBA dive, and its products are used in pharmaceutical industries. Most importantly, oceans support the phytoplankton which are responsible for producing most of the oxygen available for living things. Ocean temperatures and health determine the quality of the monsoons which provide freshwater.

Freshwater

The very limited freshwater we depend on for drinking, cooking, cleaning, irrigation, and other day-to-day activities comes from surface water and groundwater, which are replenished by the rains.

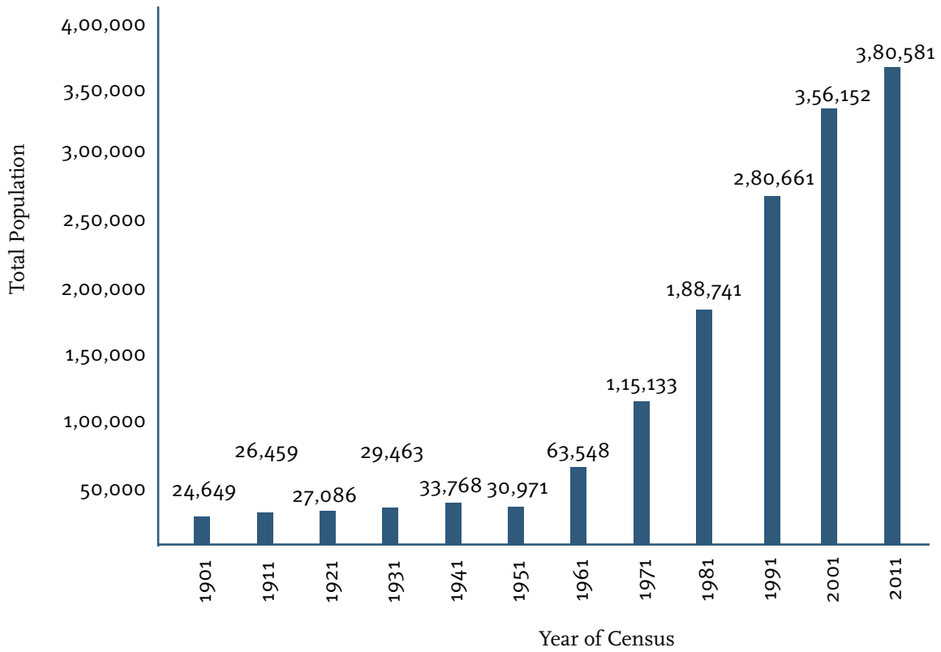
Soil

Soil health is important for cultivation. The migrant and settler communities who depend on agriculture and horticulture as a source of food and income, rely heavily on the good health of the soil. The original islander communities were more reliant on whatever grows easily in their local ecosystems.

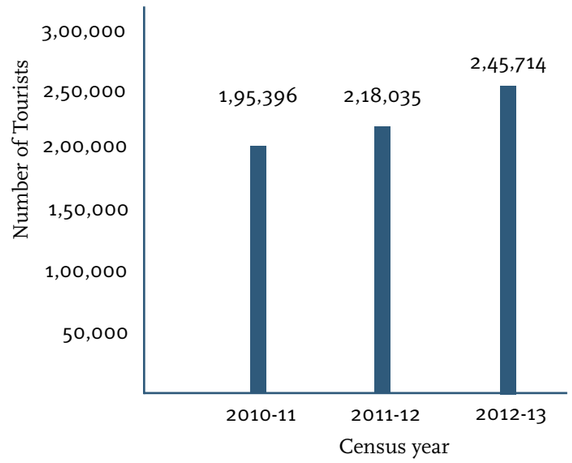
The problem

The limitations on our island resources range from the area of land to the geological limitations of the islands' formation. Therefore, the islands are capable of optimally supporting only a certain number of people, with very little margin for expansion. As our lifestyles rely on certain very specific products that the island ecosystems are not equipped to produce, the increasing population becomes a pressing issue.

This results in a pattern of consumption based on products brought to the islands for the growing local population and the floating population too. Tourists are a large component of this floating population.



As the tourism industry grows, natural resources are consumed at a rate that makes them impossible to replace in the islands. While the resources reduce, the population dependent on them increases.



Does that mean we should shut down the profitable tourism industry? The answers lie in the way in which we imagine our businesses, problems, and their solutions.

Some vegetables can be grown on the islands. However, the optimal scale of such cultivation would be limited to personal consumption. To support the growing population, the rest need to be transported to the islands from the mainland. An increasing variety and volume of vegetables are today brought in from the mainland.

Additionally, consumer goods ranging from paper to clothes, from pipes and wires to cars and buses are transported to the islands and then distributed to places that need them.

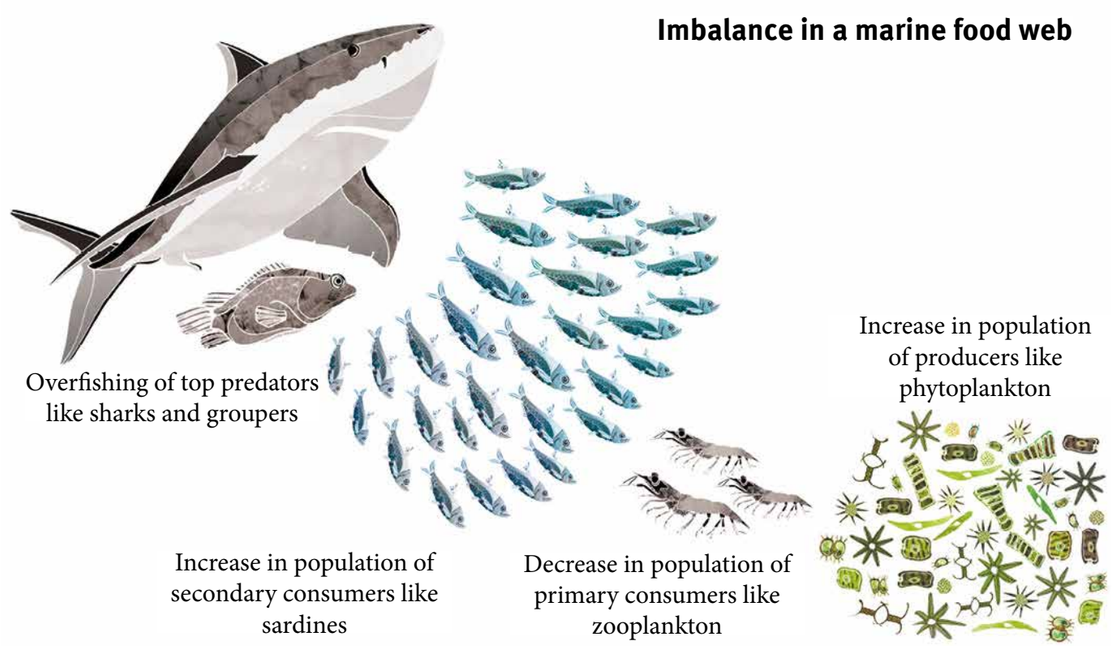
Certain products such as coconuts, arecanut, tropical fruits like mango and pineapple, spices, and various handicrafts made from shells, bamboo, cane, and wood are exported from the islands, but these cannot keep the entire island economy afloat.

Resources from the mainland

It becomes easier to understand the dependence of our small island economy on the mainland when we understand the key resources transported here from the mainland.

Diesel and other fossil fuels

Diesel, petrol, LPG (liquefied petroleum gas) and kerosene are non-renewable resources that are shipped to the islands from the mainland. Diesel, in particular, is used as a fuel to power cars, buses, boats, power generators and other machinery. More than 150 power stations across the islands use diesel to generate almost 85% of the total power supply. Highly populated islands are economically important and receive high-priority diesel-fuel-based power supply; these include South Andaman, Middle Andaman, North Andaman, Long Island, Neil, Havelock, Little Andaman, Car Nicobar, Katchal, Kamorta, and Great Nicobar. Everything ranging from the cell-phone reception towers and internet management and distribution systems to domestic lights, fans, ACs, refrigerators, water pumps, televisions and other electrical appliances relies, in a large part, on the electricity generated using fossil fuels.



Drinking water

In order to cope with the demands of the tourism industry, large amounts of packaged drinking water are transported to the islands. Without this import, the strain on the rainwater-fed resources would make it impossible for the locals to access clean drinking water during the fair season.

Rapid degradation of natural ecosystems

Deforestation

Once the settlement of the islands by outsiders began, the rate at which forests were cleared to create space for human habitation and agriculture became impossible to naturally replenish. Forested land continues to be cleared to meet the growing needs for land and infrastructure. Deforestation not only contributes to habitat loss and soil erosion but also the destruction of coral reef ecosystems due to sediment run-off.

Overfishing

Marine resources were a key attraction for people settling in the islands. However, the intensity and type of fishing do not allow reduced populations to recover. When these populations decline to a point where organisms can no longer sustain their numbers, marine food webs are disrupted and, in some cases, irreversibly damaged. Sharks and dollar grouper fish, both predators in the marine food web, have been fished excessively in the islands due to their high market value. Today, some populations are in a decline, which poses a challenge to the health of marine ecosystems. Overfishing of even one species can lead to the disturbance and eventual decline of the entire ecosystem, leaving it unproductive and economically and ecologically damaged.

Accumulation of waste

The Andaman and Nicobar Islands generate around 75,000 kg of solid waste every day. At that rate, in the limited land area, there are natural problems with collection and disposal of solid and liquid waste materials.

Since the increased influx of products only mirrors the increased demand, the only solution is to shipping the waste back to the mainland. The earlier method of collection and dumping of solid waste in a landfill in Brookshabad, South Andaman Island is now no longer sustainable.

At many places in our islands, waste is still dumped on land or in nearby *nalas* (creeks) or even burnt. Burning leads to air pollution and the leaching of chemicals into the soil. Litter thrown on streets, drains, streams, and creeks ultimately end up in the ocean. Plastic waste breaks down into microplastics which are often mistaken for food and consumed by countless sea animals and birds leading to their death.

Waste is not simply a leftover of consumption. It is often that part of a product which has no planned and independent use for the consumer.

Linked impacts

All of our ecosystems are interlinked with no clear boundaries between them.

01. Waste in landfills releases harmful chemicals into the soil and groundwater.
02. Liquid waste from industries contaminates water bodies.
03. Pesticides and fertilisers from agricultural fields enter ponds, rivers and the ocean.
04. Deforestation causes sediment runoff into rivers and over coral reefs.
05. Garbage dumped from ships and motor boats contributes to pollution in the sea.
06. Sediment and agricultural runoff damage coral reefs.
07. Burning waste adds to air pollution.
08. Sewage from drain pipes also enters the groundwater as well as the sea.
09. Pollutants in groundwater end up in our household water supply.
10. Burning of fossil fuels leads to build-up of greenhouse gases such as carbon dioxide.

Pollution

Air, soil, and water have some ideal or best states in which they exist. Certain components may be present naturally in our environment, but when the concentration of these increases, they start to contaminate the air, soil, and water. Contaminating components are added by natural events (such as volcanic eruptions) and human actions and activities. A contaminating substance is often a pollutant.

Carbon dioxide, a gas that is naturally present in the atmosphere in small quantities, becomes an air pollutant when it is present in excessive quantities. Even though natural phenomena such as breathing and plant decay add carbon dioxide to the air, it is human actions such as the burning of fossil fuels (petrol, diesel, coal) and the cutting down of forests that release much higher concentrations of carbon dioxide into the air. When carbon dioxide is added to water, it turns into carbonic acid and pollutes the ocean too.

Air pollution

Air pollution occurs when gases (carbon dioxide, carbon monoxide, sulphur oxides), as well as other very light particles (soot, cement, dust) enter the atmosphere. Our diesel generators, vehicle exhaust, fumes from factories, burning of waste, and smoke from firewood are all sources of this pollution.

Allergies, breathing difficulties, asthma, bronchitis, irritations of the eye and skin, and other extremely severe health problems are all the direct results of air pollution. Average global temperatures and other changes in climatic systems are the direct result of high concentrations of greenhouse gases (carbon dioxide, methane) that trap the radiated heat of the sun within the earth's atmosphere.

Freshwater pollution

Freshwater in the islands is mostly polluted by chemicals, microbes, and contaminants that seep into it from waste and sewage. Once these contaminants enter nearby ponds, streams, and larger water bodies, they contaminate the soil along the way.

Freshwater is also polluted when the chemicals used in agriculture (chemical fertilisers and pesticides) run off with irrigation, and rainwater runs into ponds, streams, and into groundwater aquifers.

When too many nutrients enter the water, certain types of organisms get a boost while others die out. This is called eutrophication. For example, excessive phosphates from detergents feed algal populations in a water body. The algae consume and deplete the dissolved oxygen available for other aquatic organisms, and there is mass death of these oxygen-starved organisms.

Birds, reptiles, and mammals, including both wild animals and our livestock and pets, also consume this water. Dysentery, typhoid, cholera, and a range of other diseases in humans are a direct result of consuming polluted water.

Ocean pollution

Ultimately, polluted water from drains and *nalas* reaches the sea, polluting the oceans. Eutrophication occurs in the ocean, too. Other chemicals entering the ocean also affect marine organisms. Ships that ply the oceans are known to dump their trash and sewage waste into the oceans. Many times, ships also dump ballast water containing other organisms into regions where they do not belong. Ballast water is filled in tanks to make up for the weight of cargo before or after a ship is loaded and is pumped into tanks directly from the ocean. Plastics, broken, damaged, and discarded fishing nets, and a range of other consumer products such as plastic straws and carry bags, choke or drown turtles, dugongs, fish, birds, and many other marine organisms.

Soil pollution

Soil pollution occurs through the release of harmful chemicals into the soil. These mostly come from solid waste (including household and industrial waste) and agricultural fertilisers and pesticides. These pollutants can enter food chains (getting more concentrated as they go up a food chain), leach out into our freshwater resources and finally, the ocean, while reducing the overall fertility of the soil and negatively impacting the health of crops that are grown in contaminated soil.

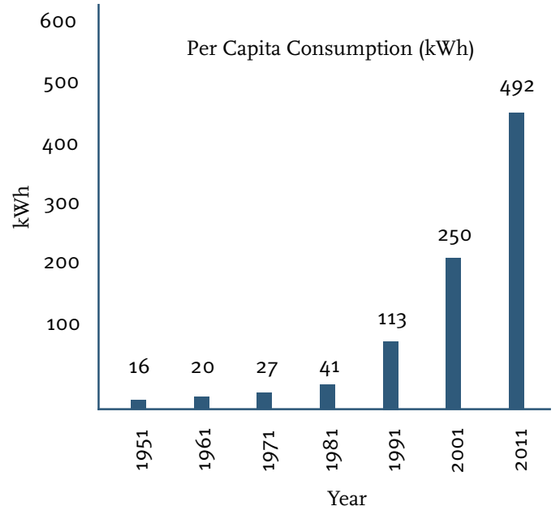
Solutions and suggestions

Being an island ecosystem, the Andaman and Nicobar Islands require a mindful and careful management of the natural resources. Working with the local self-government systems (Panchayati Raj Institutions), the elected national representative and at household and personal levels, are all necessary to protect our islands against advancing climate change and the rapid depletion of natural resources. Investing in and updating practices regarding waste management, sewage treatment, and the management of agricultural land, tourism, fisheries, and the consumption of energy and water are the ways to achieve sustainability.

Reducing our dependence on diesel

Solar Energy – Apart from the monsoon months, solar energy can help reduce—if not eliminate—the reliance on expensive diesel fuel-based energy during the rest of the year. The administration has developed a 32 MW plant on South Andaman in Port Blair. The telephone and internet networks are slowly being added to this solar energy supply grid in an effort to reduce reliance on the expensive diesel-based energy supply.

Hydro Energy – The hydroelectric project at Kalpong River in North Andaman was initially used for irrigation purposes, and later for power generation. Since 2002, this hydroelectric project provides 5.25 MW of additional capacity in the power system of the North and Middle Andaman region. While hydroelectricity is a cheap and clean source of energy, there is a fair bit of environmental damage that occurs along with its set-up, including the change in the natural flow of a river; the disruption of



movement of aquatic life along the river; displacement of communities; and more. In cases such as these, it is essential to weigh the benefits of a project versus the negative impacts that it might have.

The hydro potential of the Andaman and Nicobar Islands is now being analysed for establishing mini-micro hydroelectric power-generating units. Tides and waves can also be used to produce electricity.

Soil conservation

It is important to remember that soil pollution affects us all. A community's collective action will help to change patterns in agriculture so that a shift can be made to organic fertilisers, the establishment of sewage treatment facilities, and thorough and effective waste management strategies.

Soil erosion can be prevented by controlling the number of trees that are cleared and covering already exposed soil by planting local varieties of trees. These saplings are available at Forest Department nurseries.

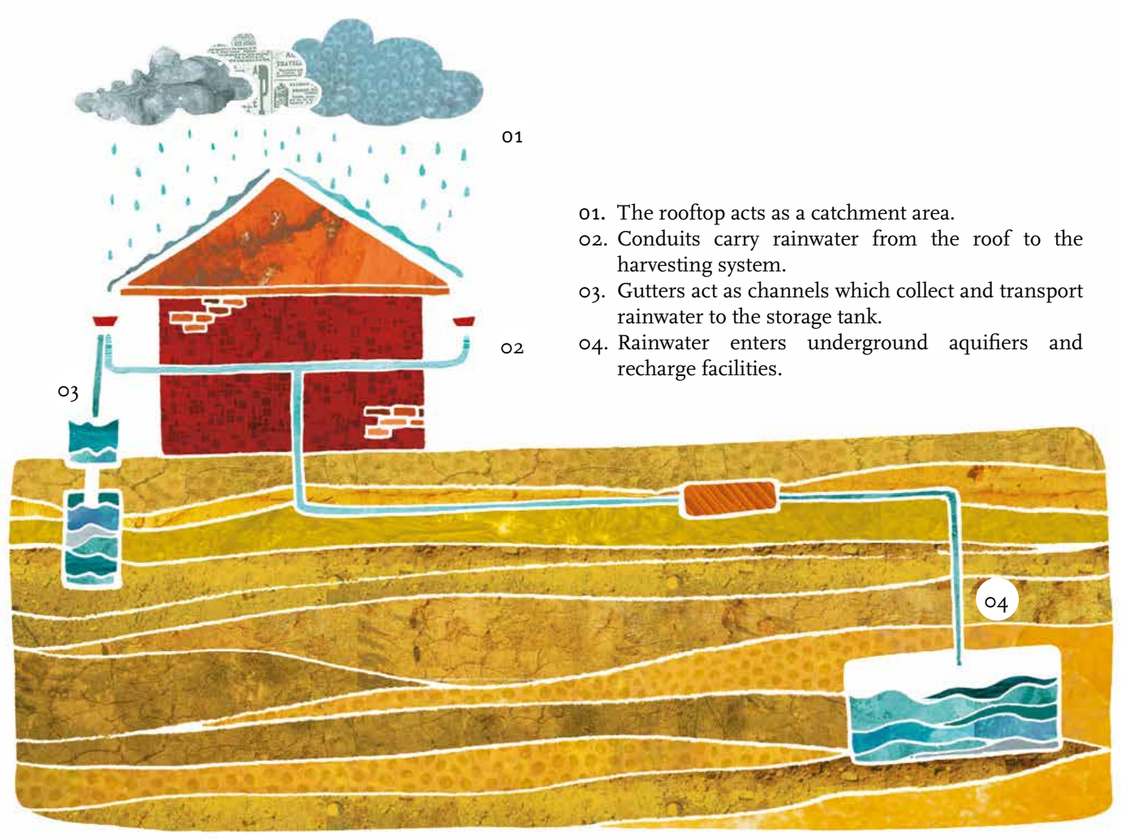
Waste management

Segregation of waste based on whether it is biodegradable or not should be done effectively at the source (households, schools, hospitals, shops, and restaurants) so that the sanitation workers of the Municipal Council and Gram Panchayats can swiftly transfer it to material recovery facilities (MRFs). Segregation of garbage at the source removes the added cost incurred to segregate waste. It also helps give sanitation workers a chance at more dignified work. In the MRFs, non-biodegradable waste is further segregated based on the materials (metal, glass, plastic based on quality, fibres, and so on). Once the classified waste is compressed and baled, it can be sent to the mainland for recycling. If this system works well, it will reduce the amount of waste going into landfills and the ocean.

However, systems in the mainland are themselves facing challenges to recycle and properly dispose of the large volumes of waste generated locally. Therefore, reducing the consumption of products that create such waste, like single-use plastics, is the most sustainable option. The islands should adopt a policy of allowing only products and materials that generate the minimum amount of waste.

Sewage treatment

Investment in sewage treatment processes can ensure that liquid waste does not cause any harm to the ecosystem it enters. Treated sewage water is used for flushing public restrooms, gardens and a range of other purposes in some places on the mainland.



01. The rooftop acts as a catchment area.
02. Conduits carry rainwater from the roof to the harvesting system.
03. Gutters act as channels which collect and transport rainwater to the storage tank.
04. Rainwater enters underground aquifiers and recharge facilities.

Sustainable fishing

There are over 400 commercially important marine species in the waters of the Andaman and Nicobar Islands. Small-scale and artisanal fishing is sustainable to a large extent. Small-scale fishing practices like hook and line fishing can provide a continuous income for the present and future generations. Practices such as trawling, catching juvenile and protected species of fish and destructive fishing methods can cause irreparable damage to fishing grounds and populations. Fishing restrictions in certain areas and during particular breeding seasons, as well as the marine national parks and protected areas, help manage fish populations.

Freshwater conservation

Our islands get around 3,000 mm of rainfall every year. Wetlands serve as important catchment areas for water to enter groundwater aquifers. Many houses and hotels in the islands have borewells and normal wells to reach this water. It is important to ensure that the ponds and wetlands are maintained and not filled in.

Surface water or rainfall run-off is collected by check-dams when it is discharged into a stream. The Dhanikhari dam, situated in South Andaman, and Rutland Island, supplies much of the freshwater to Sri Vijaya Puram.

Renewable resources, such as energy from the wind and the sun, are continuously available in nature and can have very low impacts while being harnessed. On the other hand, non-renewable resources will not form again in our lifetime. It has taken millions of years and extraordinary circumstances for such a thing to happen again. They are being used faster than they can be replenished. In addition, non-renewable resources have to go through many industrial processes such as mining of ores, logging of forests, combustion of fossil fuels, etc., before they can be used, leading to a lot of damage to the environment.

ACTIVITY 8.1 OUR WATER

CLASS	LOCATION	GROUPING	TIME
6	indoor	whole class	20 minutes

Objective

To contextualise current economic activities and systems against their impacts on natural ecosystems and the mindsets of growth and gain.

Learning outcomes

This activity will enable students to:

- outline the ways in which commons—natural resources which belong to all the people living in a locality—are contaminated
- describe how people are affected by such contamination
- observe and record data about water sources around their home

Materials

- Clear tub of drinking water
- Dry clay soil (construction)
- Baking soda (agriculture)
- Small shreds of paper, plastic bags (litter)
- Shredded nylon rope or string (fishing)
- Soil (erosion)
- Floor cleaner (factories)
- Oil (transportation)
- Detergent (washing)

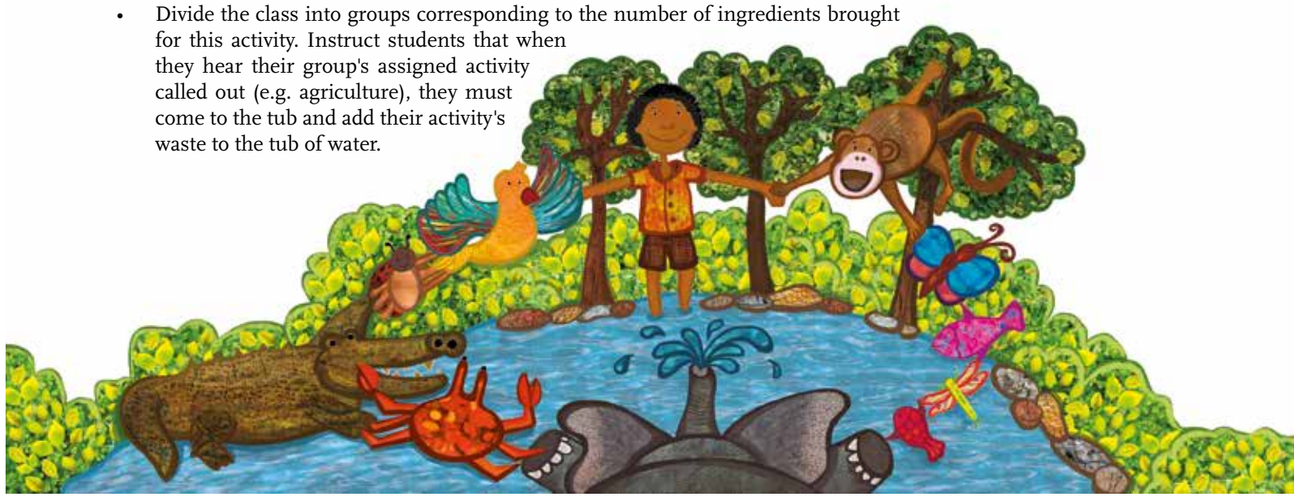
Learning procedure

- Ask students where they get the water they use from. Who is responsible for the collection or preparation of the water to make it suitable for drinking? Which activities are prioritised for access to water? Which activities are reduced when there is a water shortage? Who takes care to manage the usage of water?

- Ask students if there are bodies of water around their living space which they would not drink nor draw water from for any use. What makes the water unusable? List students' responses on the board. Elicit the following responses if the students do not immediately think of the following: construction, agriculture, litter, fishing, erosion, factories, transportation, washing. Ask them whether any other organic waste such as human waste also makes its way into the freshwater bodies around. How?

- Place the tub of water where it is visible to all students. Ask them to describe the colour and smell of the water. Ask them if they would taste this water. Why or why not?

- Divide the class into groups corresponding to the number of ingredients brought for this activity. Instruct students that when they hear their group's assigned activity called out (e.g. agriculture), they must come to the tub and add their activity's waste to the tub of water.



- Narrate the story of the pond and pause to ask questions (e.g. would you drink the water now? Would you swim in the water now?) during the narration:

  This is the story of a pond surrounded by a town that did not understand it. The pond had been used by people who had spent years and years and years learning, carefully developing many ways of living that treated the pond and the land and trees and the mountains and the sea and the rivers like their own family, their own community. The pond was used to being watched and listened to and observed in all seasons, day and night. The healthy pond was good for drinking from, swimming in, and sitting beside and thinking.

  As time passed by, a different kind of town grew around the pond. The people living in the town had very different ideas. They watched different things. They listened to very different things and they were carefully observant of many different things but just not the pond.

  The work that these people did around the pond slowly changed its colour, its smell and, if anyone dared, even its taste. A new idea was brought into the area around the pond with the new kinds of activities: "waste." Waste is a part of an activity which has no use for anyone. Waste is easy to forget about but waste also never leaves our world! The town became a city and more and more people came. People drained swamps and cut down large forests to build houses, schools, stores, roads, hospitals, and many other buildings. Rains washed loose soil from all this **CONSTRUCTION** into the pond.

  More people needed more food. The forest did not have the foods that the townspeople were used to. They needed food to fill the stomachs of many, many, many more people than before. The food needed to be planted and cared for and protected from other hungry things like insects. In **AGRICULTURE**, the stronger the chemicals, the less effort it takes to protect the delicate food. Chemicals washed from the farms into the pond.

  The townspeople had a range of clothes made of a range of materials that could be used over and over again. The only thing is that the material needed to be washed clean. From all the **WASHING** and washing, soapy water flowed into the pond.

  The townspeople on the island had different jobs that had to be done in the town and they had different needs and wants. They wanted things to be built and made a certain way. **FACTORIES** were built and people worked hard there. But they were careless about the waste because it cost money to pay attention to the waste. It cost money to make the waste harmless. So the harmful waste gushed into the pond.

  As people move about in their busy days, they often drive from place to place. The townspeople's jobs and their new work made it necessary to do everything fast. No more walking. Engines were needed in boats, cars, buses, and other **TRANSPORTATION**. Engines were needed in generators for electricity. Engines were everywhere. Engines need oil, and the oil leaks sometimes. But even if it leaks only sometimes, the damage it causes lasts for a long, long time. The oil slides into the pond.

  Young and old people love to fish, but they don't make their nets and lines from the fibres of trees and plants. They use a much stronger material, but even that material breaks sometimes. The difference is, unlike the leaves and plant fibres, it doesn't get eaten up by animals or the earth. The nylon strings from the **FISHING** lines remain in the pond for years and years and years, breaking down into tinier and tinier pieces. The townspeople are hungry all the time. Their food comes from the farms, but their food also comes from far, far away. They carry the food in plastic bags. The plastic bags get thrown away the moment they carry the food home. The **LITTER** of plastic bags washes into the pond.

  Time passed by, and the pond even gathered soil that was **ERODED** far, far away but came to rest in the pond. Today, the pond is not like it used to be. Even ponds get old, but this ageing was so fast! Would you swim in this water now? Would you drink it?

- Ask students who polluted the river.
- Encourage them to think about the pollution in their containers. Have them reflect upon what they could do to make sure that such pollutants don't get into the river in the first place.
- End the class by asking students if they think it is easier to prevent pollution, or to clean it up later.

Further work

Look around your home for signs of polluted water bodies.

Activity Sheet 8.1 - My Pond

Date: Name:

Location:

1. Name of the pond/river: .....
2. Describe what the pond/river looks like: .....
3. Describe the area surrounding the pond/river: .....
4. Would you feel comfortable drinking out of this pond/river or swimming in it? Explain why. .....
5. What are some birds or animals near the pond? Name some of them: .....
6. Is this where you get the water for your home from? .....

ACTIVITY 8.2 OUR CHANGING ISLANDS

CLASS	LOCATION	GROUPING	TIME
7	indoor	whole class	80 minutes

Objective

To demonstrate the limited nature of physical resources in our islands.

Learning outcomes

This activity will enable students to:

- evaluate data related to population growth
- conclude that ecosystem resources are finite
- understand associated problems with rapid population growth
- analyse practices that affect the use, availability, and management of natural resources
- outline the ways in which commons—natural resources which belong to all the people living in the surroundings—are contaminated
- describe how people are affected by such contamination
- observe and record data about water sources around their home

Materials

- Chalk or rope to mark the square, measuring tape/ruler

Learning procedure

- Ask the students to recall some of the natural resources available on the island.
- Divide the class into two equal groups.
- Draw a 6x6 foot square and explain to the students that within this, the 3x2 foot square represents the space available to them while the rest represents existing natural resources such as forests, mangroves, and oceans.
- Ask one group to stand in the space in the front of the square.
- Ask the other students to form groups of two or three.
- Ask each smaller group to enter the islands, one at a time, representing migrants moving to the islands. As they enter the islands, people who have already been there need to move to the back of the square.
- As the people move to the back of the square, they also have to call out resources that they will use and for what purpose. For example, as they move into the back area, they can say they are going to use forests to extract wood for making houses.
- As the entire square begins to get filled, including the area that was initially demarcated for natural resources, initiate a discussion about their actions. Ask them questions such as:
    - What are the resources that they are relying on for their needs called?
    - What does increased population growth mean for the resources?
    - What are the impacts that increased usage of natural resources has on the environment?
- Help students understand that a growing population contributes to increased forest land clearing, increased demand in fisheries, reclaiming of mangroves, and impacts many other resources which are diminishing at a much faster rate than can be replenished naturally. This leads to the depletion of the resources that impact the ecosystem and the biodiversity that is dependent on it.
- Introduce to them the fact that since the island have limited resources, an increase in population is accompanied by an increase in the transport of goods from the mainland. This causes an increase in pollution through transport and an increase in the collection of waste.

ACTIVITY 8.3 ENERGY AUDIT

CLASS	LOCATION	GROUPING	TIME
8	indoor	groups of five	80 minutes

Objective

To conduct a systematic audit of electricity consumption at the household level.

Learning outcomes

This activity will enable students to:

- conduct an energy audit
- read and understand an electricity usage table
- comprehend the amount of energy at their home in one day
- recognise where energy comes from and the impacts its usage has on the environment
- brainstorm ways in which to reduce consumption of energy
- list alternate sources of energy

Materials

- A copy of the audit sheet per student
- Dictionary per student
- Resources for calculation: https://urjapay.andaman.gov.in/Tariff

Learning procedure

- Start by conducting a personal energy audit to become familiar with the process. Show students how to read an electricity bill.
- Ask students if they know what the term audit means. Ask them to look up the word in their dictionary. Inform them that they will be carrying out an energy audit for their home in order to make their energy consumption more efficient.
- Ask if they know how the fans that they use are run. Initiate a discussion to help students understand that the fans run on electricity which is generated by diesel-generating sets present on the island.
- Inform the students that in preparation for their next class, they will calculate the amount of energy they are using at home on average on a daily basis. Distribute the audit sheet for students to fill in independently.
- In order to prepare them for the next class, do a mock inventory of the school, filling in spaces for only the appliances that they use in their classroom. Ensure that the student's don't fill in their Activity Sheets but only discuss it as a reference.
- Ask students to start thinking about the different appliances they use at home and for how many hours a day. Tell them to take this Activity Sheet home and complete an audit of the energy usage there.
- Urge students to make observations, like if the lights were on when nobody was in the room, or if the windows were shut and air conditioners were on even though it was cool outside.
- Ask students to share how they will calculate the total units that are used/month. Allow them to share their ideas before informing them that they will have to list the number of hours that an appliance is used on average/day. For instance, the lights and fans are on for eight hours a day whereas the computer is only used for two hours a day. They will have to multiply the number of hours with the units/month and finally, with the number of appliances.
- Ask them to guesstimate the number of hours or average the number of hours that appliances are being used at their home. They can cross out the appliances that are not in their homes. Alternatively, if some appliances they regularly use are not on the list, ask them to add them on.
- Once back in class, recap their activity by engaging in a discussion again about how electricity is generated. Recall that diesel brought in from the mainland is used to generate electricity. Have a small discussion about the impacts of transporting and burning diesel on the environment.

Appliance	Wattage	Units/month (for average usage 1 hr/day)	No. of Appliances	Usage (Hours)	Total Units/month
Lamp	60	1.8			
Tube light	50	1.5			
Table fan/Ceiling fan	60	1.8			
Music system	100	3			
Television	90	2.7			
Mixer/Grinder	375	11.25			
Iron	750	22.5			
Refrigerator	150	4.5			
Cooler	250	7.5			
Heater	1000	30			
Washing machine	750	22.5			
Geyser	2000	60			
Microwave oven	2000	60			
Air conditioner (1 ton)	1500	45			
Air conditioner (1.5 ton)	2250	67.5			
Computer	100	3			
Printer	150	4.5			
Toaster	750	22.5			
Pump motor	375	11.25			
TOTAL					

Ecology vocabulary

Abiotic	Detritivores
Abyssal zone	Detritus
Aerial roots	Disphotic zone
Adaptations	Dispersal
Apex predator	Ecosystem
Aphotic zone	Eggs
Archipelago	Endemic species
Asexual reproduction	Eutrophication
Benthic zone	Evaporation
Biotic	Evolution
Biodegradable waste	Exotic species
Bioluminescent	Extinct
Bivalves	Flora
Bleaching	Food web
Brackish	Fossil fuels
Budding	Gastropods
Camouflage	Germinate
Carnivore	Global warming
Climate change	Groundwater
Commensalism	Hard corals
Competition	Herbivores
Condensation	High tide line
Conservation	Indigenous
Consumer	Intertidal area/ Intertidal zone
Continental margin	Introduced species
Continental rise	Invasive species
Continental shelf	Knee roots
Continental slope	Larva
Coral polyp	Last glacial maximum
Countershading	Lenticels
Currents	Littoral forest
Decomposer	Low tide line

Lower intertidal	Propagule
Marine debris	Reclaimed
Marine protected area	Renewable resources
Middle intertidal	Reproductive adaptations
Molluscs	Reverse osmosis
Mutualism	Rocky shore
Native species	Salinity
Natural resources	Sandy beach
Nematocyst	Sapling
Neritic zone	Scavenger
Non-biodegradable waste	Sea level
Non-renewable resources	Secondary consumer
Oceanic zone	Sexual reproduction
Organic debris	Species
Parasitism	Sperm
Peg roots	Stilt roots
Pelagic zone	Structural adaptations
Pencil roots	Surface water
Photic zone	Sustainable development
Photosynthesis	Symbiosis
Physiological adaptations	Tentacles
Phytoplankton	Threatened species
Plankton	Tide pool
Planula	Tides
Pneumatophores	Transpiration
Pollutants	Upper intertidal
Precipitation	Vivipary
Predation	Water cycle
Predator	Waves
Prey	Zonation
Primary producer	Zooplankton
Producer	Zooxanthellae
Prop roots	

Checklist of endemic fauna

	Common name	Scientific name	Endemic to
	Mammals		
01	Andaman horse shoe bat	*Rhinolophus cognatus*	A & N
02	Dusky round leaf-nosed/Nicobar leaf-nosed bat	*Hipposideros nicobarulae*	Nicobar
03	Nicobar flying fox	*Pteropus faunulus*	Nicobar
04	Miller's long-footed/Andaman Archipelago rat	*Rattus stoicus*	Andaman
05	Miller's Nicobar/Miller's Nicobar rat	*Rattus burrus*	Nicobar
06	Zelebor's Nicobar rat	*Rattus palmarum*	Nicobar
07	Andaman spiny/Thomas ground shrew	*Crocidura hispida*	Middle Andaman
08	Jenkin's shrew	*Crocidura jenkinsi*	Andaman
09	Nicobar spiny/Nicobar white-tailed shrew	*Crocidura nicobarica*	Great Nicobar
10	Nicobar tree shrew	*Tupaia nicobarica*	Great Nicobar
	Birds		
11	Andaman bulbul	*Microtarsus fuscoflavescens*	Andaman
12	Nicobar bulbul	*Hypsipetes nicobariensis*	Nicobar
13	Andaman crake	*Rallina canningi*	Andaman
14	Andaman coucal	*Centropus andamanensis*	A & N
15	Andaman cuckoo-dove	*Macropygia rufipennis*	A & N
16	Andaman cuckooshrike	*Coracina dobsoni*	Andaman
17	Andaman drongo	*Dicrurus andamanensis*	Andaman
18	Andaman serpent eagle	*Spilornis elgini*	Andaman
19	Nicobar serpent eagle	*Spilornis klossi*	Great Nicobar
20	Andaman flowerpecker	*Dicaeum virescens*	Andaman
21	Nicobar jungle flycatcher	*Cyornis nicobaricus*	A & N
22	Narcondam hornbill	*Rhyticeros narcondami*	Narcondam
23	Nicobar megapode	*Megapodius nicobariensis*	Nicobar
24	Andaman nightjar	*Caprimulgus andamanicus*	Andaman
25	Andaman barn/Andaman masked owl	*Tyto deroepstorfii*	Andaman
26	Andaman hawk/boobook, Andaman owl	*Ninox affinis*	Andaman
27	Andaman scops owl	*Otus balli*	Andaman
28	Hume's hawk/Boobook, Hume's owl	*Ninox obscura*	Andaman
29	Nicobar scops owl	*Otus alius*	Nicobar
30	Nicobar parakeet	*Psittacula caniceps*	Nicobar
31	Andaman green pigeon	*Treron chloropterus*	A & N
32	Andaman wood-pigeon	*Columba palumboides*	A & N
33	Nicobar pigeon	*Caloenas nicobarica*	A & N
34	Nicobar imperial-pigeon	*Ducula nicobarica*	Nicobar
35	Nicobar hooded pitta	*Pitta abbotti*	Nicobar
36	Andaman shama	*Copsychus albiventris*	Andaman
37	Nicobar sparrowhawk	*Tachyspiza butleri*	Car Nicobar
38	Andaman teal	*Anas albogularis*	Andaman
39	Andaman treepie	*Dendrocitta bayleii*	Andaman
40	Andaman woodpecker	*Dryocopus hodgei*	Andaman

	Common name	Scientific name	Endemic to
	Reptiles		
41	Andaman bronzeback tree snake	*Dendrelaphis andamanensis*	Andaman
42	Nicobar/Tiwari's bronzeback tree snake	*Dendrelaphis humayuni*	Nicobar
43	Andaman cobra	*Naja sagittifera*	Andaman
44	Andaman day gecko	*Phelsuma andamanense*	Andaman
45	Andaman giant gecko	*Gekko verreauxi*	Andaman
46	Adler's bow-fingered gecko	*Cyrtodactylus adleri*	Nicobar
47	Andamans bent-toed gecko	*Cyrtodactylus rubidus*	Andaman
48	Nicobar gliding gecko	*Ptychozoon nicobarensis*	Nicobar
49	Andaman krait	*Bungarus andamanensis*	Andaman
50	Big-eared lipinia	*Lipinia macrotympanum*	A & N
51	Andaman garden lizard	*Pseudocalotes andamanensis*	Andaman
52	Bay Islands forest lizard	*Coryphophylax subcristatus*	A & N
53	Daniel's forest lizard	*Bronchocela danieli*	Nicobar
54	Nicobar blind lizard	*Dibamus nicobaricum*	Nicobar
55	Tytler's mabuya	*Eutropis tytleri*	Andaman
56	Andaman pit viper	*Trimeresurus andersonii*	Andaman
57	Cantor's pit viper	*Trimeresurus cantori*	Nicobar
58	Nicobar bamboo pit viper	*Trimeresurus labialis*	Nicobar
59	Andaman skink	*Eutropis andamanensis*	Andaman
60	Nicobar tree skink	*Dasia nicobarensis*	Nicobar
61	Yellow-striped kukri snake	*Oligodon woodmasoni*	Nicobar
62	Camorta Island stripe-necked snake	*Gongylosoma nicobariensis*	Nicobar
63	Nicobar keelback snake	*Hebius nicobarensis*	Nicobar
64	Paradise tree snake	*Chrysopelea paradisi*	Andaman
65	Andaman wolf snake	*Lycodon tiwarii*	Andaman
66	Andaman cat snake	*Boiga andamanensis*	Andaman
67	Nicobar cat snake	*Boiga wallachi*	Nicobar
68	Nicobar racer snake	*Liopeltis nicobariensis*	Nicobar
69	Andaman Island worm snake	*Argyrophis oatesii*	Andaman
70	Red-tailed trinket snake	*Gonyosoma oxycephalum*	Andaman
	Amphibians		
73	Bilateral banded frog	*Microhyla chakrapanii*	Andaman
72	Charles Darwin's frog	*Minervarya charlesdarwini*	Andaman
73	Andaman wart frog	*Limnonectes andamanensis*	Andaman
74	Shompen frog	*Lymnonectus shompenorum*	Nicobar
75	Nicobarese tree frog	*Polypedates insularis*	Nicobar
76	Camorta Island toad	*Bufo camortensis*	Nicobar

	Common name	Scientific name	Endemic to
	Marine fishes		
77	Anglerfish sp.	*Himantolophus kalami*	Andaman
78	Leaf blenny	*Alloblennius frondiculus*	Andaman
79	Andaman threadfin bream	*Nemipterus andamanensis*	Andaman
80	Combtooth blenny sp.	*Andamia expansa*	Andaman
81	Combtooth blenny sp.	*Praealticus dayi*	Andaman
82	Silolona damselfish	*Amblyglyphidodon silolona*	Andaman
83	Bluemargin dartfish	*Ptereleotris caeruleomarginata*	Andaman
84	Tiger dottyback	*Pseudochromis tigrinus*	Andaman
85	Black-tipped Andaman snake eel	*Ophichthus mccoskeri*	Andaman
86	Obscure garden eel	*Heteroconger obscurus*	A & N
87	Andaman goatfish	*Upeneus andamanensis*	Andaman
88	Andaman goby	*Callogobius andamanensis*	Andaman
89	Dasi's goby	*Oligolepis dasi*	Andaman
90	Goby sp.	*Callogobius trifasciatus*	Andaman
91	Goby sp.	*Lentipes andamanicus*	Andaman
92	Goby sp.	*Oxyurichthys talwari*	Andaman
93	Goby (mudskipper) sp.	*Scartelaos cantoris*	Andaman
94	Whitetail jawfish	*Opistognathus albicaudatus*	Andaman
95	Andaman brown moray	*Gymnothorax andamanensis*	Andaman
96	Blemished razorfish	*Iniistius naevus*	Andaman
	Freshwater fishes		
97	Andaman sleeper goby	*Eleotris andamensis*	Andaman
98	Andaman pipefish	*Microphis insularis*	Andaman
99	Andaman emerald snakehead	*Channa royi*	Andaman

Checklist of endemic flora

No.	Common name	Scientific name	Plant type
	Flora		
100	Unknown	*Plecospermum andamanicum*	Climber
101	Andaman malpighia-vine	*Aspidiopterys andamanica*	Climber
102	Wild areca palm/*Jungli supari*	*Areca triandra*	Shrub
103	Andaman spurge	*Euphorbia epiphylloides*	Shrub
104	Andaman wendlandia	*Wendlandia andamanica*	Small Tree
105	Andaman padauk	*Pterocarpus dalbergioides*	Tree
106	Andaman bulletwood tree/*Mowha*	*Manilkara littoralis*	Tree
107	Andaman marblewood/*Kala lakri*	*Diospyros marmorata*	Tree
108	Andaman elephant apple	*Dillenia andamanica*	Tree
109	Andaman crepe myrtle/Pyinma	*Lagerstroemia hypoleuca*	Tree
110	Andaman fig tree	*Ficus andamanica*	Tree
111	Andaman mango	*Mangifera andamanica*	Tree
112	Andaman incense tree/*Dhoop* tree	*Canarium manii*	Tree
113	Andaman screw pine/*Ketaki*	*Pandanus andamanensis*	Tree / Shrub
114	Andaman canoe tree/*Jungli dungi*/*Thitpok*	*Tetrameles nudiflora*	Tree
115	Andaman false diplospora	*Pseudodiplospora andamanica*	Tree
116	Andaman osage orange	*Maclura andamanica*	Tree
117	*Bada jaiphal*	*Myristica andamanica*	Tree
118	Lephew	*Xanthophyllum andamanicum*	Tree/ Shrub
119	Red bombway	*Planchonia andamanica*	Tree
120	Thinkala	*Neonauclea gageana*	Tree
	Cane		
121	*Malai beth*	*Calamus baratangensis*	Tree
122	*Mota beth*	*Calamus andamanicus*	Tree
123	*Pathi beth*	*Daemonorops kurzianus*	Tree
124	*Safed beth*	*Calamus basui*	Tree
	Orchids		
125	Emeric's air blossom	*Aerides emericii*	Epiphyte
126	Unknown	*Eria andamanica*	Epiphyte
127	Unknown	*Pomatocalpa andamanicum*	Epiphyte
	Zingiberaceae		
128	Unknown	*Etlingera fenzlii*	Herb
129	Unknown	*Alpinia zerumbet*	Herb
130	Unknown	*Amomum andamanicum*	Herb
131	Wild turmeric	*Curcuma codonalta*	Herb