Environmental Sustainability in Zanzibar

Chumbe Island

A guide to the environment and sustainable living for Zanzibar schools and communities

Learn how we can all help safeguard the natural resources we depend on for a sustainable future for Zanzibar

Nell Hamilton, Jokha Omar, Narriman Jiddawi, Anita Walther, Sophia Masuka, Elizabeth Godfrey & David Tanner. Edited by Nell Hamilton

Nell Hamilton and others

Go outside!

The environment is everywhere – all we have to do to learn about it is to go outside and look around us! Watch living things to learn about where they live, how they grow, what they eat, and how they breed. What resources do they use? How do they interact with other living things? How do they respond to each other, to you, and to their environment? How are people using the natural resources that surround them, and benefitting from them? Learn to love, watch and respect our natural neighbours and all they do for us!

Environmental Code Of Practice

ECO-Practice

Each time we visit a natural place or another person's property, we must take care that our visit causes no harm to our natural or human hosts, or to ourselves.

We should therefore follow this **Environmental Code of Practice (ECO-Practice)** wherever we go and whatever we do outside.

Mazoezi ya kimazingira

Be Safe: *Take care that you and your companions don't get lost or injured!*

Respect wildlife: *Never damage, disturb or kill any wild animals or plants!*

Respect people: *Be considerate to the other people who use the environment!*

Respect property: *Leave other people's property as you find it!*

Leave it clean and healthy: *Take litter home, be fire-aware, and keep water clean!*

*Take nothing but memories * Leave nothing but footprints * Kill nothing but time*

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This book is available online in English and Kiswahili, and can be downloaded free of charge at www.chumbeisland.com or email nell.chumbe@gmail.com.

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This book is dedicated to all young people who care about the environment, in loving memory of Lara Muller, who loved the sea.

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Mazingira Endelevu kwa Zanzibar

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1 Environment & sustainability

We spread out the earth and set upon it immovable mountains. We brought forth from it all kinds of delectable plants. A lesson and an admonition to penitent men. We send down blessed water from the sky with which we bring forth gardens and the harvest grain, and tall palm-trees laden with clusters of dates, a sustenance for men; thereby giving new life to a dead land. (Qur'an 50:7-11)

Once, there was an island

Many years ago, when your grandparents were young, there was an island between Pemba and the mainland called Maziwe. Maziwe was covered in lush mangrove and coral rag forest, and surrounded by a beautiful coral reef teeming with fish. It was famous for turtles: hundreds of green, hawksbill and Olive Ridley's turtles nested on Maziwe's sandy beaches every year. It was such a beautiful island and so rich in wildlife that it was made a Marine Protected Area in 1975.

Nobody lived there all the time, but, though it was a protected area, it was used by many fishers as a camp. They collected firewood from the forest to cook their food, and built shelters from mangrove poles and palm thatch. This continued for hundreds of years. But slowly, without anyone realising, the forest was disappearing. At first there were just a few fishers, but over the centuries more and more came. Each time they visited, each person would just burn a few branches and sticks. But day after day, year after year, this added up, and by the 1970s there were no trees left on the island. Maziwe was nothing but sand.

For a few years, fishers still used Maziwe, but they could no longer make fires and there was no shelter from bad weather. Then in 1978, disaster struck. During the monsoon, a big storm hit the island. Without trees to protect it, the strong waves washed over the top of the island and swept all the sand into the sea, and all over the coral reef. Now, all that remains of the island is a sandbank that can only be seen during the lowest tides. The turtles have nowhere to lay their eggs, and there is nothing left on the island for people. The whole island of Maziwe has been washed away.

Maziwe Island today: this small sandbank is covered by the sea at high tide © Luca Belis www.trekearth.com/members/Mistral/

Could this happen to islands in Zanzibar?

This is a true story of what happens when we don't take care of our environment. Each person probably thought they were only taking a few sticks – but if a lot of people each damage wildlife just a little bit, it adds up to a lot of destruction. As we will see, the natural environment supports our lives and livelihoods in hundreds of ways, and if we continue to allow it to be destroyed, we will struggle in the future. What would your family do without fish to eat, wood to cook on or water to drink?

How can we protect it?

We don't have to let this happen. We can change the way we interact with nature. It is not too late to protect Zanzibar's precious environment from destructive activities, and our coastline does not need to follow Maziwe into the sea. Firstly, we have to find out about our environment, and discover how the natural world provides us with everything we need. Secondly we must find out how our activities can harm the environment, threatening our way of life and our future. Thirdly, we must take action to change how we use natural resources so they are not destroyed by what we do.

This book will show you how we can achieve this. It will introduce you to the environment of Zanzibar and tell you about all the ways our environment provides us with the things we need to live healthy, happy, prosperous lives. It will also tell you about how our activities are damaging our environment. Finally, you will learn about ways to take action: there are many easy things we can all do to make sure our environment continues to support us into the future. Read on to find out how!

Environment

What is the environment?

The environment is all the living and non-living things around us – both natural and man-made things. It includes all the non-living things such as the air we breathe, the water we drink, roads and houses, oceans and beaches, even the sun, moon and stars! It also includes all the living things such as plants: the wild forests and plantations, baobabs, bushes and grasses, mangroves, seaweed, seagrass, coral reefs and crops, and animals including wild animals, fish, butterflies, birds, bees, livestock and people. Every single thing around you that you can see, touch, feel, smell or hear is part of the environment.

What does the environment provide for us?

Food and water – In Zanzibar, all our freshwater comes from rainwater that soaks into the ground. It filters through the limestone rock, and we dig wells to get water to drink, cook and wash with. All the fish we eat are wild animals caught in the sea, and our livestock also depend on food to eat and water to drink. Crops such as rice, fruits and vegetables need good fertile soils, plenty of rainfall, and bees, birds and bats to fertilise them. Without our environment, what would we eat and drink?

Good health – Vegetation (plants) slows down water flowing over the ground, so it soaks into the ground where it is filtered by rocks, making it safer to drink. The oxygen in the air we breathe that gives us life is produced by plants, and plants take up and use carbon dioxide from the air. We use many plants growing in Zanzibar to treat diseases from malaria to flu: they help keep us healthy.

A place to live – If you look out to sea on the east coast, you can see where the fringing coral reef is, because of the big waves beyond it. If those big waves hit the shore, they would wash the beach away. Coral reefs, seagrass and mangroves all protect the coast from erosion. On land, trees and grass do the same thing, stopping the soil from being washed into the sea when it rains. Without them, the land beneath our homes would be washed away and our houses could be damaged or even washed into the sea. Trees provide us with shade and protect our houses from strong winds. Our homes are built from palm thatch, coral rag, sand, cement and mangrove poles: these materials all come from the environment.

Livelihoods and financial prosperity – Most jobs in Zanzibar depend on the environment. 39% of people are employed in the service sector, (largely tourism), and 37% in agriculture, forestry and fisheries. The whole economy of Zanzibar depends on a healthy environment.

Natural resources

The environment provides us with everything we need to live. We call things we use and need '**resources**'. Resources can be physical things, like oxygen or water, or sources of energy such as sunlight or the wind. All man-made things are made using resources that ultimately come from the natural environment, known as '**natural resources**'. For example, cement is made by burning limestone, plastic is made from oil, and glass is made from sand.

But where do natural resources come from? Often, people behave as if all resources will last for ever, but as the number of people increases, some natural resources have become very scarce. We now need to be thoughtful when we use things: what are they made of? Where does the natural material come from? How much of it do people use? Could it run out?

Ulikua unajua...?

- During the 2011 Pacific Ocean tsunami, a whole beach ended up in a hotel dining room because they had cut down the mangrove protecting them from storms.
- Both people and wild animals find their way at night by using the stars!

Sustainability

What is sustainability?

Sustainability means the ability to continue to exist. We depend on natural resources, so we need them to still be around in the future for us and for our children. In the context of natural resources, sustainability means using resources no faster than they can naturally recover. We need to use natural resources sustainably now, or there won't be any left in the future.

Renewable and non-renewable resources

Renewal times for natural resources used in Zanzibar

Now	Sunlight Wind Air	Renewable
Months	Rice Cassava Fresh water Bananas	
Years	Palm thatch Clove tree Mangrove forest	
Decades	Coconut wood Grouper Mango tree Dolphin Shark Turtle	
Centuries	Baobab Whale Rainforest	
> 1000 years	Sand	
> 10,000 years	Coral reef	
> 100,000 years		→ Non-renewable
> Million years	Coral rag	
> 100 million years	Fossil fuels	

Different natural resources are made by natural processes at very different speeds and in different quantities. For example sunlight is made all day every day, but giant baobab trees take hundreds of years to grow so big. When we use resources, we need to consider how long natural processes will take to replace what we have taken. If we use resources more quickly than they can recover, then they may run out. This is not sustainable. To be sure of having the resources we need in the future, we must all live more sustainably, using resources no faster than they are being replaced.

We consider the rate of replacement of natural resources in the time frame of a human lifetime. If nature replaces things within a human lifetime we call them **renewable**. Renewable means that nature can replace the resources that we use. This includes freshwater, which is replaced when it rains, wood, replaced when new trees grow, fish, replaced by new baby fish, and energy from the sun or the wind. But things that take longer than a lifetime are called **non-renewable**.

Renewable resources – Some resources are effectively unlimited. So much is made that there will always be more than we can possibly use – for example, however much sunlight or wind energy we use today (e.g. by heating water in the sun or sailing a dhow), it won't stop the sun shining or the wind blowing tomorrow. This means we can use as much of these resources as we like and it will still be sustainable! Other resources take longer to be replaced naturally, taking months, years, or even decades before they are replaced naturally. This category includes many living resources – such as fish and wood – and also fresh water, replenished during the rainy season. We can use these resources, but to live sustainably, we must not use them up more quickly than they can recover. If we cut down trees, we must plant new ones. If we go fishing we must leave some behind to breed a new generation. But if we cut down *all* the trees and catch *all* the fish, or pump out *all* the freshwater from the ground, then there will not be any left for the future.

Non-renewable resources – Other resources that we use took thousands or millions of years to be made, often in environmental conditions different from those of today. So from a human perspective these resources are irreplaceable. Once we have used up what exists now, there will never be any more. Non-renewable resources include fossil fuels – coal, oil, gas, and things made from them, including plastic. Others are mineral resources – rocks, metals and precious stones. Quarrying or mining for these resources has other environmental costs. We need to find more sustainable alternatives to these resources so we don't need to use them so much.

Why is sustainability important?

We depend on the environment in countless ways for our livelihoods, but if we do not allow natural resources to recover from exploitation then the fish we eat will die out, we will have no wood to cook on, and no freshwater to drink. Just as we depend on the environment, it depends on us too – to look after it, and use it wisely.

But we are not using resources sustainably. Forest cover in Zanzibar is declining rapidly. Fish stocks are declining. The water table (level of water underground) is falling and coastal wells are becoming salty and undrinkable. Resources are being depleted, and if we do not take action – all of us – starting now – we will be in big trouble in future. This is the future the young people of Zanzibar will inherit.

So, what can we do? We are at a point in history where there are still natural resources left, we are aware of the impact we are having, and we still have time to take action. It is down to us to change the ways we use natural resources, and to use them sustainably, starting now. It is fine to catch fish, but not so many that there are none left for the future. Fish need time to grow up, find a mate and reproduce, just like people and domestic animals do. Trees, too, need time to grow – we must not cut forests down faster than they can grow back and recover.

Tembea ujionee!

- Take a walk outside and write down all the things you can see or feel that are part of the environment. Which are living and which non-living? How do they benefit us? Do this in different areas – urban, farmland, beach or forest – and compare.
- Which natural things do we use? Choose five things you use in your home. What are they made of? Are they made of renewable or non-renewable materials?
- How many different kinds of bird, insect, and plant can you find growing in your community?

What will we gain from living more sustainably?

Sustain our way of life – Protecting natural resources for the future will help us to preserve our social and cultural traditions. We will improve the standard of living for our families by ensuring they have enough food, clean water, a nice, safe place to live, and an income to live on.

Pride in Zanzibar and in our communities – Zanzibar is very special. It is world-famous for its beautiful beaches, lush forests, historical towns and villages, and its warm and friendly people. It is a beautiful place we are fortunate to call home – tourists can only come for a week or two! We have much to be proud of if we can look after it well.

Incredible natural neighbours – The natural world is amazing and it has been given to us to take care of. The variety of life around us is spectacular. Respect the wonder and beauty of nature for its own sake and revel in learning about the amazing creatures that live in our forests and oceans. It has so much to teach us, and enriches our lives in many ways we do not notice, but would miss so much if it were gone. Make a new effort to notice the different kinds of plants, birds and insects around you. Take time to sit and watch how they behave, and notice how they change as seasons pass. We are wealthy when our environment is healthy.

Who needs to act?

All of us can see places where the environment is being harmed, and feel as though 'someone' should do something about it? But who is someone? The answer of course, is you and me, and everyone around us. Whether you are a government minister, a parent, a teacher or a school child, we can, and must, all take action and work together to protect our environment for the future.

How can we live more sustainable lives?

Now, we understand that the environment benefits us in everything we do. We know how to think about the ways we depend on the ocean, forests, and other natural resources. We know how to ask ourselves if the things we use every day are made of renewable or non-renewable resources. The next step is to change our habits. Choose products made from renewable resources, such as baskets instead of plastic bags. Help the natural world replace the materials we use up, by planting trees, and choosing fish that breed quickly. To learn more about all these issues, and how we can all help make sure we keep the environmental benefits in the future: read on!

Kitunze kidumu!

- Choose products made from renewable resources.
- Replant mangroves and trees when you collect firewood and building poles.
- Get involved in cleaning up your community.
- Learn new things about the environment and share them with your friends and family.

2 Biodiversity

All the beasts that roam the earth, and all the birds that soar on high are but communities like your own. (Qur'an 6:38)

What is biodiversity?

Bio means life, and *diversity* means variety, so biodiversity means the variety of life. It includes all living things on the earth and in the ocean, from the biggest blue whales to the tiniest bacteria. Places where many different kinds, or 'species', of living thing grow together, such as a coral reef or forest, are said to have high biodiversity, while places where only a few species live, like ploughed fields or urban areas, have low biodiversity.

Endemic species – Having lots of species is not the only important thing. It also matters whether those species are found all over the place, or only live in a few sites. Species only found in one place in the world are 'endemic' to that area. Endemic species are very special. On islands, because populations of plants and animals are separated by the sea from other populations, they gradually change to adapt to local conditions. Over time, populations become so different from their relatives elsewhere that they become new species. Islands are therefore very important for biodiversity because they tend to have more endemic species than mainland areas of a similar size.

Biodiversity in Zanzibar: habitats and species

Marine habitats – There are many different marine habitats in Zanzibar – from the shore to the open ocean. Each habitat supports hundreds of species, and marine biodiversity in Zanzibar is famous all around the world. Many species spend part of their life in one habitat and the rest of it in another, so the diversity of habitats is very important.

Underwater habitats are hard to explore, but there is a huge amount to discover just by walking on beaches and intertidal areas at low tide. At first glance, **sandy shores** may not seem to support much life apart from coconut palms. But life here is hidden – you have to know where to look. Dig beneath the surface and you can find clams; ghost crabs live in burrows and scuttle across the beach so quickly you can hardly see them; hermit crabs are hidden too – in shells of other creatures. Sandy shores are essential nesting habitat for turtles, which come ashore at night to lay their eggs under the sand. Zanzibar has five species of marine turtle, the most common of which are the green turtle and the hawksbill. Sandy shores are also used by wading birds, that feed on fish and small shellfish: egrets, terns, plovers and many more. **Rocky shores** are great places to observe marine biodiversity. Rock pools hold crabs, sea urchins and young fish, and animals such as anemones and barnacles grow attached to rocks. These natural aquaria let you see a great diversity of amazing creatures without disturbing them. If you are very lucky you may even find an octopus. Many animals you can find are more bizarre than you could imagine! As the tide goes out, another ecosystem is exposed – **seagrass beds** grow in sand and mud. Seagrasses support a wealth of fascinating creatures – sea cucumbers, sea urchins, and many kinds of shellfish. On deeper seagrass beds, green turtles graze too.

Tembea ujionee!

- Turtle sanctuaries at Mnarani and Baraka Natural Aquariums in Nungwi
- Kizimkazi for dolphins
- Jozani forest for the endemic Colobus monkey
- Chumbe Island for coral
- Pemba for flying fox
- Menai Bay, Mnemba, Muyuni beach, Misali Island, and Vumawimbi for nesting turtles.

The most spectacular of our marine ecosystems are the **coral reefs**. Hidden beneath the waves are hundreds of species of brightly-coloured corals, sponges, crabs, lobsters, reef fishes, sharks, rays, and sometimes even the world's biggest fish – the whale shark! Beyond the reef in the **open ocean** there is still amazing wildlife to find – not least our native marine mammals: 8 species of dolphin, 3 whales, and the dugong. Spinner, Indo-Pacific bottlenose and Indo-Pacific humpback dolphins, sperm whales, pilot whales, and the huge humpback whale, are all found in Menai Bay.

Wild forest – Trees give forests a structure that provides a wide variety of places for different species to find a home. The more tree species growing in a forest, the more biodiversity it can support. The coastal forests of East Africa form one of the 25 most important forest areas in the world for biodiversity.

There are three main kinds of wild forest in Zanzibar. **Moist forest** is lush and green. The trees grow fast, big and tall, and when their leaves fall, they rot to form a deep fertile soil. Most of Zanzibar's moist forest is in Pemba, but in Unguja there is moist forest in the north and in Jozani. **Coral rag forest** grows in areas with lower rainfall, and its trees can survive drought. They grow in the coral rag, limestone which is very porous so rainwater drains away fast. The largest areas of coral rag forest in Zanzibar are on south-eastern Unguja. **Mangroves** grow along the coast and are salt tolerant. Mangroves are important because they are very productive (trees grow fast) and this growth provides lots of food for wildlife. Both main islands support large and important mangroves, which serve as nursery grounds for many coral reef fish.

Zanzibar is home to over 50 mammal species, including primates such as the endemic red Colobus monkey, blue Sykes' monkey, and 3 species of bush baby. We have two species of antelope, including the critically endangered Ader's duiker: there are fewer than 500 left in the world, almost all in Zanzibar. We also have 23 species of bat including the endemic Pemba flying fox. Small bats eat insects, while big ones eat fruit. One of the most incredible wildlife sights of Zanzibar is the migration of fruit bats at sunset from offshore islands where they sleep during the day, to the forests where they feed at night.

There are 177 species of bird, including brightly coloured sunbirds, majestic fish eagles, and songbirds which are hard to see but whose beautiful calls are easy to hear, especially before sunrise. Pemba is famous for its four endemic birds: the Pemba white-eye, Pemba green-pigeon, Pemba sunbird, and Pemba scops-owl.

There are several species of snake and lizard, most famously the chameleon, which can change colour to match its background! There are some very special invertebrates too, including the rare giant coconut crab, and thousands of insects: beautiful butterflies, dancing dragonflies, flickering fireflies and the ambush hunter, the praying mantis.

Ulikua unajua...?

- The Pemba flying fox is one of the biggest bats in the world! It weighs half a kilogram and has a wingspan a metre wide!
- Some people (known as birders) love birds so much they keep a list of all the different birds they have ever seen. Birders go on days out and even holidays especially to see more birds. Other people prefer to look for fish, orchids, trees, bats, butterflies or snakes! They never harm or kill the animals or plants, just admire them in their natural habitat. What kind of wildlife do you like best?

The human landscape – Much of the land on Zanzibar has been changed by humans – farmland, villages and towns. But there is still biodiversity here. Farmland is important for birds, bees and butterflies, and provides corridors that wildlife can use to move between natural forest areas. Even in villages, there is wildlife, as many woodland species can live around humans, as long as we leave some trees and bushes for them among our houses.

Why does biodiversity matter?

Biodiversity is important because living things depend on each other for food and a place to live and breed. As living things ourselves, we are part of the web of life, and we too depend on a diversity of living things for our food, for the air we breathe, and for our livelihoods. If we upset the balance of nature by causing species to die out, the system becomes unbalanced, and whole ecosystems can collapse. Sometimes this makes the areas uninhabitable for people, for example it may turn them into deserts: if all the trees are cut down, the soil blows away and little can grow.

Health – Plants provide the oxygen we need for life. Growing plants even absorb greenhouse gases, reducing climate change impacts. The natural world is beautiful; people who live or spend time in natural places are healthier than those who live in polluted areas. Hundreds of plants are used in traditional Zanzibar medicine. It is important to conserve forest diversity to protect these plants, and others too, as scientists are always searching for new and better cures.

Water **–** Forests stimulate rainfall by slowing clouds down as they move over the land. Vegetation filters water making ground water safe for us to drink. Areas rich in vegetation slow down surface water flow, so water soaks into the ground instead of flowing away and washing soil into the sea.

Food **–** Biodiversity provides us with the hundreds of fish we eat and the wood we need to make the traps and build the boats to catch them, and fires to cook them on. Insects, bats and birds all help pollinate the crops we grow. Creatures in the soil, too small to see, break down dead leaves, turning them into rich soils to grow crops; birds, snakes and predatory insects eat crop pests.

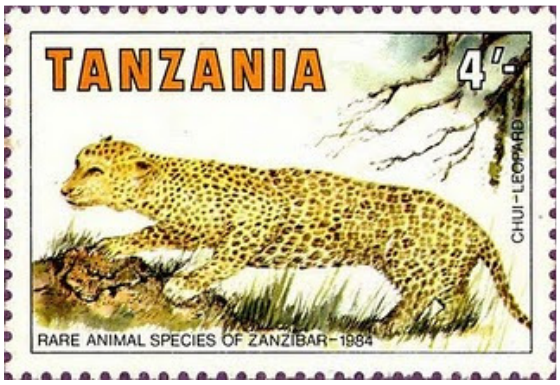
Shelter **–** Trees reduce the impact of wind in storms, and provide shade from the sun for our families, homes, livestock and crops. The raw materials we use to build our homes – the different kinds of timber, poles, thatch, and limestone – all come from the natural world.

Livelihoods **–** The richness of Zanzibar's wildlife attracts thousands of tourists every year – to visit Jozani forest, swim with dolphins, snorkel and scuba dive. All workers in fishing, farming, or tourism rely on a countless variety of animals and plants, big and small, for their livelihoods.

Why is Zanzibar's wildlife in danger?

When the population of a species is low and falling, the species is in danger of dying out, or '**endangered**'. This can be because of a threat to the plant or animal itself, or because its habitat – the place where it lives – is being damaged or disappearing. Humans compete with plants and animals in Zanzibar for resources and living space, and some species have already been lost – biodiversity in Zanzibar is declining.

Direct killing **–** Some species are killed deliberately. For food, we harvest huge quantities of fish every day, and some people hunt antelope too. We cut down trees for firewood, charcoal, timber for houses, fishing boats and furniture. Some species are harvested for commercial reasons – tritons, other shellfish and turtle shells are traded as ornaments, and shark fins are exported. We kill some animals – such as snakes – because we are afraid of them. Sometimes direct killing is not deliberate; marine mammals and turtles drown in fishing nets. Direct uncontrolled killing has a huge impact on populations and many of these species are endangered – including sharks, turtles, dolphins and tritons. For one species, which was unique to Zanzibar, it is too late: the Zanzibar leopard was hunted to extinction in the 1990s.



Already rare when this stamp was printed in 1984, Zanzibar leopards are now extinct

Habitat loss through degradation and destruction **–** In the sea, we are damaging coral reefs and seagrass beds with destructive fishing gear such as drag nets and dynamite. Coastal development and erosion means turtles can no longer find dry sand at the top of beaches to lay their eggs, and when their eggs hatch at night, the baby turtles get confused by bright lights from hotels, so they walk the wrong way and can't find their way to the sea! Quarrying for sand and limestone rock is a very serious problem both on beaches and inland. Forests are being cut down across Zanzibar, but especially along the coastline, to make way for farms, roads, houses and hotels. Shifting cultivation – cutting down or burning an area of forest in order to grow crops, then moving on to a new area after a few years – is still taking place, but the way it is being done now is unsustainable. Traditionally the old fields were left so the forest would re-grow, but now so many people need farmland that the forest is not given time to recover.

Invasive species **–** Sometimes, as people move around the world, they take animals and plants from one place and introduce them to another where they do not belong. Usually they do not survive, but if they have no natural predators in the new place, they may reproduce rapidly and devastate populations of local plants or animals, disrupting the natural balance of the ecosystem. Ships bring rats to islands, where they swiftly wipe out ground-nesting seabirds. Zanzibar's worst invasive species is the introduced Indian house crow. Crows are everywhere, feeding on food and

vegetable waste – and on native birds and their eggs, lizards, frogs, and other small animals. Populations of native species are declining throughout Zanzibar, but especially in Pemba where two of the four endemic bird species are now feared extinct. Domestic cats can cause problems if they go wild: they breed rapidly, have no predators, and feed on small mammals, birds and lizards.

Pollution – Waste management in Zanzibar is not adequate, and plastic, chemicals, sewage and many other materials are causing serious problems for biodiversity. Chemicals, especially pesticides, poison wildlife; plastic fragments escape into the environment where many animals mistake them for food so their stomachs fill up and they starve. Indirectly, pollution is encouraging the increase in the house crow population with serious knock-on effects for wildlife.

How can we protect biodiversity?

If we do not take action to protect Zanzibar's endangered species and their habitats, we will lose much of our precious biodiversity, more species will become extinct and much of what makes Zanzibar so special will disappear.

Protect endangered species – We depend on fish, so to ensure our fish will still be here in the future we must avoid catching or eating species which are endangered, and we must not use destructive methods to catch them: sharks, marine mammals and turtles are all worth far more to us alive. If you are lucky enough to encounter a nesting turtle, do not disturb it or its eggs; if the nest is in danger, turtle conservationists can collect the eggs to keep them safe until they hatch, then the newly-hatched babies can be released back into the sea. Hotels on beaches where turtles nest should not have any bright lights pointing at the beach which would confuse the babies. Instead of using timber from wild forests, choose faster growing species such as coconut and casuarina, grown in sustainable plantations where new trees are planted to replace those cut down.

Protect habitat – When we cut down forest, many wild plants and animals lose their homes, another reason to protect it. We must respect no-harvesting rules in our protected areas. There are 6 marine protected areas (p. 21), and six National Forest Protected Areas, three in Pemba (Ngezi-Vumawimbi Nature Forest Reserve, 2,900 hectares, Ras Kiuyu Forest Reserve, 270 ha, and Msitu Mkuu Forest Reserve, 180 ha) and three in Unguja (Jozani-Chwaka Bay National Park, 5,000 ha, Kiwengwa-Pongwe Forest Reserve, 3,325 ha and Masingini Catchment Forest, 285 ha). Biodiversity can generate sustainable jobs, for example through eco-tourism: tourists will pay more to visit areas with high biodiversity, enough to pay for its protection. Chumbe Island Coral Park employs nearly 50 people to staff the eco-lodge and protect the forest and coral reef habitat, paid for by tourist dollars. Places with lower biodiversity are still important – it is important to preserve patches of trees throughout the landscape to encourage birds, bats, bees and other pollinators.

Control invasive species – Eradicating invasive species is expensive and challenging, but can be achieved. Chumbe Island Coral Park successfully eradicated both rats and crows: rats were poisoned and crows have been trapped and shot. Eradicating crows from Zanzibar will be a much bigger job, and require collaboration between NGOs, government and local people. We can all help discourage invasive pests by covering compost heaps and rubbish bins. The government is planning a programme to trap and shoot crows. While complete eradication is unlikely, the work should reduce the number so native bird populations can flourish again. There are many domestic cats living wild in Zanzibar – responsible citizens should have their pet cats neutered to reduce the number of unwanted and abandoned kittens.

Reduce pollution – Avoid using pesticides on your crops – grow organic fruit and vegetables instead. Support community recycling schemes, and use toilets – don't help yourself in bushes or on the beach!

Kitunze kidumu!

- Support wildlife in your community by leaving areas of wild vegetation and planting trees, bushes and flowers, which are beautiful, reduce erosion, improve soil, provide shade and attract wildlife.
- Buy fruit that has been organically grown (without pesticides).
- Set up a wildlife-watching club in your school or community and explore wild Zanzibar together.
- Never drop litter.

3 Mangroves

If someone plants a tree he or she will be rewarded with the same amount of fruit which is produced by that tree. (Musnad Ahmad)

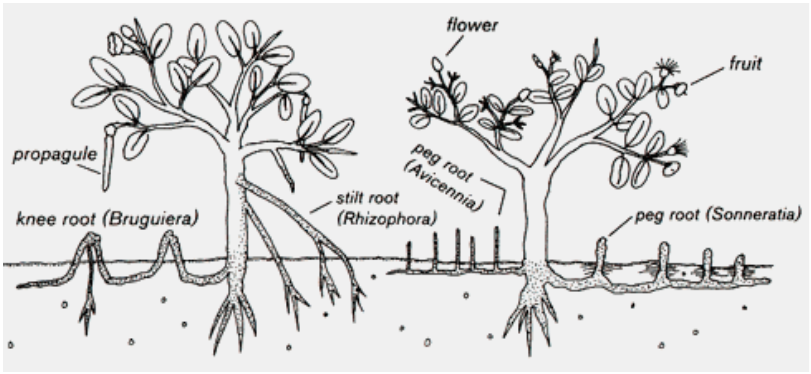
What are mangroves?

Mangroves are forests (and the trees that form them) found along coastlines in the tropics and subtropics, that are able to grow in the salty, very wet soil of the intertidal zone, where they can survive being partly covered by the sea twice a day at high tide. Mangroves also need some fresh water, so they grow best in sheltered estuaries, lagoons, bays, and inlets, where fresh and salt water mix. In the right conditions, mangrove forests can extend many kilometres inland, and some species of mangrove tree can grow up to 40 metres tall.

What is special about mangroves?

Most plants can't live in the intertidal zone, but mangroves have adapted special features to enable them to flourish in this challenging habitat. Because the water level changes by several metres with the tides, salinity levels and availability of oxygen change all the time. In addition, the variable amount of freshwater in the mangrove's favoured habitats – tidal lagoons which become diluted when it rains heavily, and concentrated during hot, dry spells – make living there impossible for less specialised plants, because fluctuating conditions are particularly difficult to adapt to.

High levels of salt are usually poisonous to plants, but mangroves cope with high salinity in the soil and water in three main ways. Firstly, they have special cells in their roots and trunk that minimise the entry of salt. Mangrove trees can also excrete salt through their leaf pores. Finally, they store excess salt in special sacrificial leaves. The tree then sheds these yellow leaves, which you may have noticed on mangrove trees in Zanzibar. Mangrove leaves are thick and waxy, with hairs on the underside, and these adaptations all help the tree conserve fresh water.



Some types of mangrove aerial roots (pneumatophores)
© www.shorecrest.org

Plant roots need air, so how do mangroves cope in the wet mud they grow in? Well, many mangrove species have special roots that grow in the air (called aerial roots, or pneumatophores) which rise above the mud, so they can absorb oxygen from the air. There are three types of aerial root: knee, stilt and peg. These specialised roots also help support the tree in the unstable soft, mud.

Different species of mangrove tree are adapted in different ways, and so they survive better in different conditions according to the amount of time their roots and trunks are covered by the sea on each tide or according to the amount of freshwater in their environment. As a result, if you walk through a mangrove from dry land to the seaward edge, you will see distinct zones where different mangrove species dominate.

Mangroves have other special adaptations too. Some mangrove species develop specialised seeds called propagules. These large green seeds vary in length from 10 – 40 cm. The seeds germinate into baby trees while still hanging on the tree, and then these seedlings drop into the mud or sea below and start growing straight away! Propagules can survive many months and travel long distances floating in the sea before settling on a suitable soil surface and growing roots.

Mangrove propagule
© Jonathan Bird

Mangroves in Zanzibar

Zanzibar has about 18,000 hectares of mangrove forest: 6,000 ha on Unguja Island and 12,000 ha on Pemba Island. The largest mangrove stands on Unguja Island are found in Chwaka Bay, and on Pemba Island at Ngezi / Michewени. Ten species of mangrove grow in Zanzibar, but red mangrove (*Rhizophora mucronata*), black mangrove (*Bruguiera gymnorriza*) and mangrove apple (*Sonneratia alba*) are the most common.

Why are mangroves important?

Mangroves play a number of vital natural roles in coastal systems throughout the tropics, including Zanzibar. Globally, mangroves are valued at US$ 200 - 900 per hectare for their natural services. Zanzibaris, especially those in coastal communities, have a very close relationship and dependency on mangroves for livelihoods and food.

Protecting the land – Mangroves create a natural barrier between land and sea. From the sea, they protect the shore from erosion and storm damage. They absorb energy from wind and waves, and reduce the impact of storms, cyclones and tsunamis. For example, after the 2004 Indian Ocean tsunami, there were fewer deaths and less damage to property in areas with healthy mangroves than in areas where mangrove had been destroyed. Some areas are protected by artificial barriers, however mangrove will recover on its own, and be beautiful, whereas man-made barriers are expensive to build and repair so are not as effective (or nice to look at).

Ujikua unajua...?

- All mangrove in Zanzibar is designated forest reserve!
- Red mangrove propagules can survive floating in the sea for up to a year until they wash up in a suitable place to grow!
- It isn't only people who find it hard to climb through the roots of a mangrove forest – predators do too! So mangrove roots provide a very important refuge for fish, crabs, prawns, and other marine animals to hide from underwater predators, while many birds nest in mangrove trees out of the reach of land predators.

Mangrove roots provide a refuge from predators for small fish © Wikimedia commons

Protecting the sea – Water flowing from land to the sea slows down when it reaches the mangrove. The sediment settles out. Without mangroves the sediments can smother corals and seagrass beds and make the water too cloudy so light can't reach the plants growing on the bottom. Along with the sediment that mangroves lay down and secure, any pollutants, such as sewage, carried in water runoff from the land will also settle out in mangrove mud instead of washing onto more sensitive seagrass and corals. The pollutants are not *good* for the mangrove, but mangroves can tolerate them better than other marine habitats such as seagrass beds and coral reefs.

Biodiversity and fisheries – The complex physical structure of mangrove roots, trunks, leaves and branches provides many places for animals and plants to live. They therefore support a high diversity of marine and terrestrial life. The fishing industry of Zanzibar depends on mangroves. One of mangroves' key services is to provide breeding, nursery and feeding habitat for fish and shellfish, which also find shelter from predators among the roots. This includes many commercially important species. Prawns, lobsters and mud-crabs spend their whole lives in mangrove, while young snappers and other commercially important fishes spend their first few months in this habitat before migrating to seagrass and coral reefs nearby as they mature. Reefs and seagrass beds near mangrove consequently yield higher fish catches than those without mangroves nearby. Mangroves also provide habitat for mammals such as the endemic red Colobus monkey, snakes, lizards and many birds, as well as sponges, worms and insects. These make mangroves a very attractive habitat for people interested in wildlife.

Climate Change – Like all plants, mangroves absorb carbon dioxide for photosynthesis, and turn it into carbohydrates which are stored in the wood (of course, if we cut the mangrove and burn it, the carbon dioxide is released into the atmosphere again). Replanting and restoring mangroves therefore helps reduce greenhouse gas emissions – but cutting them contributes to climate

change. Mangroves themselves are resilient to climate change, and by protecting against threats such as erosion, healthy mangroves will help Zanzibar combat the impacts of climate change such as sea level rise and more frequent storms.

Direct uses – We use mangrove products for many things, such as fuel wood and charcoal for cooking. Our homes are built using mangrove poles and with lime made using charcoal. Mangrove timbers make strong boats, and fishing traps and seaweed farms also use mangrove poles. Mangroves are also used for tanning leather and making dyes – this used to be a very major industry; fewer people are involved now, but it is still carried out on a small scale. The fruits of the cannonball mangrove (*Xylocarpus granatum* / mkomafi) are used as a traditional medicine to treat rashes and stomach pain.

Tembea ujionee!

- Visit your local mangroves
- Jozani-Chwaka Bay Conservation Project on Unguja Island
- Michewni on Pemba Island

What are the threats to Mangroves in Zanzibar?

Deforestation – Most loss of mangrove is deforestation due to unsustainable cutting of timber for construction of boats (dhows, masts, boats, paddles), buildings (roof poles, scaffolding, window and door frames), fishing traps and floats, and for firewood and charcoal. These traditional activities are threatening the survival of mangroves because coastal populations have increased, and demand for mangrove timber products has never been higher. The quality of timber remaining has declined to the extent that the construction poles available here are not good quality so many people now buy imported timber from the mainland.

Beach creation – Hotel developers want to provide tourists with white sandy beaches for which Zanzibar is famous. To create beaches, some people therefore cut down mangroves – which were protecting their property from erosion. After a few big storms, without the protection of the trees, the sand washes away, smothering nearby seagrass and coral, and leaving the property and buildings unprotected from the waves.

Fisheries and aquaculture – Mangrove poles are used in dema fish traps and seaweed farming. In some areas, people cut down mangrove to make space for ponds to raise fish and shellfish.

Pollution – Oil spills are very dangerous to mangroves, because the oil coats the aerial roots and suffocates the trees because they can't get oxygen from the air. Other kinds of pollution are not as threatening to mangrove trees as to other marine ecosystems because mangrove trees themselves can survive exposure to polluting chemicals and some levels of sewage. However the diverse wildlife they support, including fish and shellfish that we eat, is still seriously affected. Furthermore, fish and shellfish collected from polluted mangroves are dangerous for us to eat.

Salt making – producing salt damages mangrove in two ways. Some people boil salt water over mangrove-charcoal fires, which takes 7 kg wood to make 1 kg salt. The other way is to make a large flat pool in the mangrove in which salt water flows in and evaporates, by chopping down the trees.

Land reclamation – in some areas mangroves are filled in with soil, then deforested, to turn intertidal land into freshwater land for agriculture. But this land is poor quality as the soil is salty.

Population pressure – the population of Zanzibar is increasing rapidly, largely driven by the boom in the tourism industry. This means that demand for natural resources such as mangrove is increasing. Extraction has now increased beyond sustainability or replacement levels, and so mangrove forests are shrinking rapidly: in the past 50 years one third of Zanzibar's mangrove has been lost.

How can we protect mangroves?

Communities use local mangroves for many things. Some of these uses are very long-standing traditions and are sustainable uses of the habitat. Others, unfortunately, are either new or increasing uses and are causing serious problems to this important ecosystem.

Alternative livelihoods – we do not need to destroy mangroves to benefit from them economically. Some non-destructive mangrove-friendly livelihood options follow.

Ecotourism – Mangroves and the diversity they support are beautiful and attract tourists interested in wildlife. For example, at the Jozani-Chwaka Bay Conservation Area, they have built a walkway through the mangrove enabling guests to walk through the forest and see the trees, birds, crabs and other creatures living there.

Mud-crab fattening – Provided mangrove is not cut down, small cages can be built to protect juvenile mud-crabs from predators, and enable them to grow quickly to marketable size. Other kinds of fish and shellfish aquaculture are also able to provide sustainable income.

Mangrove nurseries – Mangrove seedlings cost little, and we can take surplus seedlings from healthy mangroves to replant and restore mangroves in other areas.

Bee keeping – Honey made from mangrove flowers commands high value in local and tourist markets. Bees are very important pollinators, so keeping bees is great for biodiversity too.

Bio-briquettes – Bio-briquette making is a sustainable technology that can be used as an alternative source of energy for cooking instead of charcoal or wood. It uses non-woody agricultural waste: dry leaves and other waste vegetation such as coconut husks. Bio-briquettes can be used for cooking by the community that makes them and also be sold to neighbouring communities, providing an alternative sustainable income.

Young mangrove trees replanted in Nyamanzi © Nell Hamilton

Sustainable forestry – Using timber from mangroves can certainly continue, but in order to preserve the industry, it is crucial that it be managed sustainably. Some healthy trees of the commercially important species must be left healthy to act as 'mothers' providing seedlings for repopulating harvested areas. In Chwaka Bay, this is already occurring. However it is unlikely that the mangroves on Zanzibar can continue to supply all the timber needs of the archipelago without significant mangrove restoration, so alternative sustainable building materials should be sought where possible, or timber should be bought only from well-managed forests which replant new seedlings for every tree cut. Rotation is important on a 10 year cycle. *Rhizophora mucronata* is a preferred species for restoration as it is a good habitat builder and grows quickly. Cut areas need time to recover before being recut. Stronger enforcement of legislation designed to prevent illegal cutting of mangrove, and greater involvement of communities in developing sustainable forest management programmes, would be the most effective strategies to protect our mangroves.

Kitunze kidumu!

- Dispose of rubbish in proper places, not into the sea or mangrove areas.
- Avoid buying lime which was made using mangrove as firewood.
- If available, use alternative fuels such as driftwood, dead or fallen wood, bio-briquettes and solar cookers instead of mangrove wood and charcoal.
- Report illegal mangrove cutting to the authorities.
- Set up a mangrove nursery in your community, or volunteer for a local programme to replant mangrove seedlings.
- Urge local and international NGOs and relevant government departments for greater protection of your mangroves through community-based mangrove management, to promote mangrove-friendly alternative incomes for people dependent on mangrove cutting for their livelihoods, and to pilot briquette making and efficient burners in your community.
- Let family and friends in your community know how important mangroves are.
- Work together with community to protect local mangroves by stopping damaging activities e.g., start or join community-led initiatives to patrol and protect the local mangroves.

4 Seagrass

Assuredly the creation of the heavens and the earth is a greater (matter) than the creation of men: yet most men understand not. (Qur'an 40:57)

What is seagrass?

Seagrasses are plants living in the sea. They are specialised marine flowering plants and closer relatives to a mango tree on land then seaweed, which is algae. Seagrasses grow in shallow seas close to the shore, and play a very important role in the marine ecosystem because they create a good area for animals to live. There are about 60 species of seagrasses in the world, 13 of which are found on the coasts of Zanzibar.

What does seagrass look like and how does it grow?

Seagrass got its name because many species have long narrow leaves like the grass that grows on land. The way seagrass grows is also similar, forming 'lawns' on flat sandy areas under the sea, like a grassy field. There are many different types of seagrass, and they are not all grass-like. Some species have leaves the shape of small paddles (oval), while others are shaped like ribbons, ferns, or even noodles. Below its leaves, a seagrass plant has a stem and roots. Like some true grasses, the stem of a seagrass plant grows horizontally underground. This well-developed, creeping stem is called a rhizome. Rhizomes are formed in segments, and at the joins between segments, or nodes, roots grow down into the sediment and absorb water and nutrients, and shoots and leaves – the part we can see – grow up.

Thalassodendron ciliatum | *Thalassia hemprichii* | *Cymodocea rotundata* | *Halodule sp.* | *Halophila ovalis*

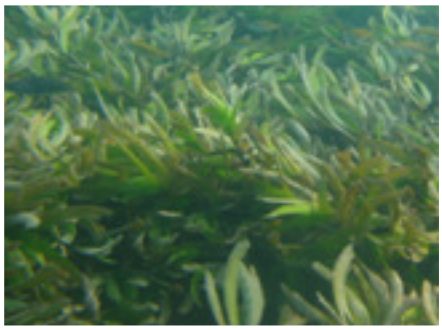
The most common seagrass species in Zanzibar, showing the different shapes of leaf © www.seagrasswatch.org

The entire life cycle of the plant takes place under water. Seagrasses can reproduce in two ways. Most seagrass reproduction is asexual: the rhizomes grow and branch out so the colony spreads, and if fragments of rhizome break off, they can develop into a new plant. If environmental conditions are right, some seagrass plants also reproduce sexually, where male flowers produce pollen which is transported by water currents to fertilise ovules (eggs) produced by female flowers on another plant to make seeds. The flowers are usually very small, so you have to look closely to find them. Seeds vary in shape and size, depending on the species. Seagrass flowering and pollination seasons vary between species and between plants in different places.

Where does seagrass grow?

Seagrass grows in shallow and intertidal mud and sand flats all around Zanzibar. Large beds can be found in coastal lagoons, sheltered from waves and strong currents. In some seagrass beds, many different species grow together, whereas others have just one species. In intertidal areas, the leaves trap water when the tide goes out, which protects the seagrass plants from overheating and drying out.

In general, seagrasses grow best in soft sediments like sand and mud, because the roots and rhizomes can easily anchor the plants to the sea floor and take up essential nutrients. There are a number of general environmental conditions that are critical to whether and where seagrasses grow. One important need is the availability of light. Like all green plants, seagrasses need light for photosynthesis, so seagrasses grow best in shallow water up to around 25 m in Zanzibar. Seagrass growth is also influenced by water temperature and salinity; different species have different needs.



***Thalassodendron ciliatum* at Chumbe Island Coral Park © Nell Hamilton**

Why does seagrass matter?

On first sight, a seagrass bed might not appear to support much life, but in fact seagrass communities are one of the most productive and diverse ecosystems in the world! They also have very close interactions with other marine ecosystems, especially coral reefs and mangroves.

Invertebrate harvester on a Zanzibar seagrass bed collecting shellfish for food © Lina Mtwana Nordlund

One of the most important roles of seagrass beds is to provide nursery habitat for many different kinds of fish and shellfish, such as snappers, rabbit fish and cockles, that are highly valuable to fishers and their families. The young fish grow up in the safe shelter of seagrass, protected from strong currents and large predators, and with plenty of food. Then, when they grow too big to hide in the seagrass, the adults move to coral reefs nearby. Other animals, such as sand-crabs, seahorses and shellfish, spend their whole life cycle in seagrass beds. However not just small, but also very large animals depend on seagrass. It is the main food source for big herbivores such as dugongs and turtles, which eat both seagrass itself and algae growing on its leaves.

Seagrass beds provide food for people too. Many women and children harvest shellfish such as cockles, oysters and gastropods from the seagrass meadows in Zanzibar. This is a good way to add protein to the diet.

Another very important thing seagrasses do is stabilise the sea floor with their roots and rhizomes. The tight network of seagrass leaves reduces water movement, and traps sediments floating in the water, so that they settle out on the bottom. This protects beaches and coastal properties from erosion, and makes the water clearer, which in turn benefits corals and other plants and animals that need light. This stabilising process also recycles nutrients, which are returned to the marine ecosystem through the seagrass plants. Seagrass photosynthesis produces oxygen, needed by fish and other animals in the sea, and reduces the amount of carbon dioxide. This is very important, because if carbon dioxide levels get too high, the sea becomes acidic and can dissolve coral!

Even after they die, seagrasses are beneficial. Seagrass leaves washed up on beaches stabilise the sand and help protect the coast from erosion. They also provide nutrients for intertidal organisms, and when they are blown up the beach they help plants grow there, further stabilising the coastline.

Ulikua unajua...?

- Seagrasses are not true grasses – in fact they are more closely related to lilies and the Zanzibar spice ginger!
- Seagrasses are the only flowering plants which live entirely under water!
- Different species grow at different tidal levels making different ecological zones!
- Some seagrass leaves can be as small as your fingernail, but others can grow over a metre long!
- An adult green turtle eats about 2 kg seagrass a day while an adult dugong can eat up to 40 kg a day!
- The world's biggest seagrass meadows can be seen from space!

What are the threats to seagrass?

Seagrass meadows are vulnerable to disturbance and climatic change, and are being destroyed globally at the high rate of 7% a year! This destruction, directly or indirectly, is largely caused by human activities.

Often, damage is accidental: people do not realise the seagrass is there or how they are harming it! Boats moored over seagrass beds shade them, and at low tide smother them. Anchors tear up seagrass, and when motor boats travel too fast in shallow water, the seagrass gets shredded by their propellers, leaving scars that take years to heal. The impacts affect a wide area of seagrass because they stir up the mud and a lot of sediment gets into the water. This blocks the light from reaching the seagrass so it cannot grow.

Dredging is even more damaging. To make water deep enough for larger ships, channels are dredged or dug out, and the sediment dumped elsewhere. This stirs up a huge amount of sediment which makes the water dark and settles out in a thick layer on top of the seagrass beds, which kills the seagrass, as well as any nearby coral.

Hotels that have removed seagrass end up building ugly walls to stop the beach from eroding their properties © Nell Hamilton

Seagrass is sometimes also deliberately destroyed. For example some beach hotels remove seagrass leaves from the beach, to expose the white sand they think tourists expect. This interrupts the natural nutrient cycle. Even worse, whole seagrass beds are sometimes uprooted. But hotel owners soon find that without the protection of the seagrass, the beach gets washed away, and erosion encroaches on the hotel buildings. This is why many beach-front hotels have ugly concrete walls in front of them now – they have destroyed the natural vegetation that would have protected their property. Worse still, the eroded sand gets washed out to sea and smothers corals on the reef!

Seagrass is sometimes damaged as a result of seaweed farming. To make space for seaweed farms, seagrass beds are removed, which also makes the sand less stable and increases erosion. Even if seagrass is not deliberately destroyed, the seaweed growing above the seabed shades the seagrass so it doesn't get enough sunlight to grow. 3% of the coastal population in Zanzibar is involved in seaweed farming, mostly women. Seaweed accounts for 20% of export earnings of Zanzibar! People use seagrass, especially in coastal villages, to stuff mattresses, as a fertiliser, or as fodder for cattle. It is also used for traditional medicine, crafts and paper production.

Sometimes the damage to seagrass beds comes from the land. Big problems are caused when polluted water flows into the sea after rain. This runoff, polluted by farms, industry or sewage, is full of sediment. It also contains very high nutrient levels, which lead to high growth of algae – an algal bloom. Together these factors make the water so cloudy that not enough light reaches the seagrass for it to photosynthesise or grow. Other pollutants, such as oil from outboard motors, jet skis or cars, are toxic to seagrass and the creatures which live in it. Litter is also washed into the sea if not disposed of properly. Once in the water, it can harm seagrass plants both physically, by smothering them, and chemically, by poisoning them and all the other animals and plants living among them. With an increasing numbers of people living along Zanzibar's coasts, the valuable

seagrass meadows are vanishing more and more. Thus, overdevelopment along the coast is a huge problem for both the marine environment and the people of Zanzibar who depend on it.

Seagrasses are also threatened globally by the impacts of climate change. As water gets warmer, disease activity and algal growth increase, putting pressure on marine creatures. Additionally, extreme weather events which damage the marine environment, such as cyclones, storms and heatwaves, are happening more often.

Tembea ujionee!

- You don't have to travel far to find seagrass in Zanzibar, whether you live in the north of Pemba or the south of Unguja! Just walk down to a local sandy beach at low tide, and you will probably find seagrass beds growing there.
- When you walk out to explore a seagrass bed, how many different kinds of seagrass can you find growing there? (Hint: look at the different kinds of leaves!)
- Feel under the mud or sand to see how the rhizomes grow, and how seagrass spreads. Can you find any flowers or seeds?
- How many different kinds of animals can you find living in the seagrass?
- How many people can you see collecting invertebrates in the seagrass bed? How many people do you think they are supporting? What would happen to those people if the seagrass were lost?

How can we protect seagrass meadows?

When motoring in seagrass areas, boat drivers should take care not to anchor over seagrass: anchor on sand, or install fixed mooring buoys instead. Also avoid motoring in shallow areas where the propeller can cut up the seagrass or stir up sediment.

Hotel owners should remember that seagrass prevents erosion of the sandy beaches that tourists come to enjoy and supports local livelihoods, and not remove seagrass from in front of their hotels.

Fishers should use techniques which do not damage seagrass, collecting on foot instead of using nets. It is better only to harvest bigger animals, and let the young ones grow up and reproduce, to ensure there will still be shellfish to eat in the future.

Seaweed farmers should remember that removing seagrass will lead to more sediment mixed in the water, so less light will get to seaweed crops and they will not grow well. It is better to place seaweed farming structures in patches with low seagrass density to avoid shading the seagrass.

Coastal communities can protect their seagrass meadows and the fisheries they support by protecting coastal vegetation such as mangrove, to avoid erosion and sediment smothering seagrass beds.

Communities should also take action to protect the seagrass beds on which they depend for food and protection from erosion. Respect existing protected areas, and if possible, local communities can also set up local no-take zones to protect populations of shellfish to repopulate neighbouring fished areas. To restore areas where seagrass has been destroyed, and encourage growth of shellfish, seagrass beds can be restored through transplantation.

Kitunze kidumu!

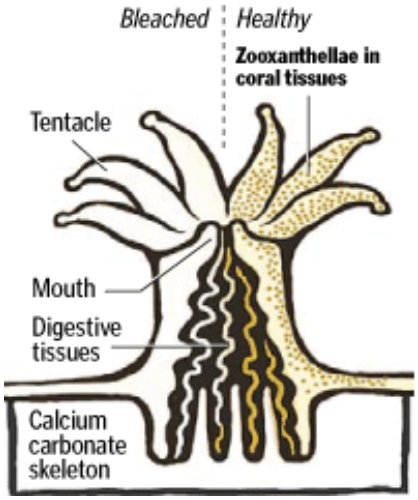
- Raise awareness by telling your friends and family how important seagrass is!
- Don't drop taka taka – recycle!
- Don't 'help yourself' on the beach!
- Buy fruit and vegetables grown organically without use of artificial pesticides and fertilizers which can pollute seagrass beds.
- Take care of seagrass beds while boating – go slowly, avoid shallow water, and don't anchor on seagrass!

5 Coral Reefs

He raised the heaven on high and set the balance of all things, that you might not transgress that balance. Give just weight and full measure. (Qur'an 55:1-9)

What is coral?

Coral reefs are one of the most spectacular sights in the natural world! In the past, some people thought corals were a kind of rock, but we now know that they are colonies of very tiny animals called polyps that have a hard, rock-like outer skeleton. Polyps are related to jellyfish and sea anemones, and like them, have stinging tentacles which they use to feed on plankton – tiny plants and animals drifting in the water currents. But corals mainly feed in another, unique way. Inside the cells of the polyp's body tissue, there are cells of a very specialised kind of algae, called zooxanthellae (pronounced '*zoozantheli*'). Like all plants, zooxanthellae use sunlight, water and dissolved carbon dioxide gas to produce food (a process called **photosynthesis**). These sugars are then shared with the coral polyp host. In return, polyps protect zooxanthellae from predators and provide nutrients and carbon dioxide. The pigments inside the algae cells that absorb sunlight are brightly coloured.



Coral polyp structure © Patterson Clark / The Washington Post

Most coral species grow best where the sea temperature is 23 - 29 °C, and cannot survive in water below 18 °C. They also need clean, clear water that gets a lot of sunlight and has a salt concentration of 3 - 4 %. These specific needs mean most coral species and reefs are found in tropical seas at depths of 2 - 30 metres.

What is a coral reef?

The rock-like skeleton of coral polyps is made from calcium carbonate (limestone), laid down by the polyps as they grow. When polyps die, their skeletons remain and new polyps grow on top of the old empty skeletons, so only the thin brightly-coloured top layer of the coral reef is alive. Over time, the collection of skeletons builds up to form a large rock-like structure called a coral colony. Corals colonies of different species grow in a range of shapes: branched like trees, in flat shelves, or round domes. Over centuries, many individual colonies of various sizes, shapes and ages grow together, and this becomes a coral reef. Zanzibar has about 90 km² of coral reef of three types. **Fringing reefs** border the shore with a small channel in-between, **barrier reefs** are separated from the shore by a deep lagoon, **and patch reefs** are small, isolated reefs in sandy lagoons.

Why are coral reefs important?

Chumbe Island Coral Park reef © Oskar Hendrikson

Biodiversity – Coral reefs are one of the most diverse ecosystems on our planet. Worldwide, there are around 845 species of reef-building corals, which provide habitat for thousands of reef fishes, shellfish, crabs, lobsters, sponges, and algae. Zanzibar's reefs are home to hundreds of coral and reef fish species: Chumbe Island Coral Park, a Marine Protected Area just 0.4 km², has over 200 coral and at least 432 reef fish species.

Food – Fish provide 60% of the animal protein eaten in Zanzibar, and are therefore a vital part of the islands' food source. Most of these fish need to spend at least part of their lives on a coral reef.

Income – Fishing is the main economic activity in coastal villages, with at least 34,000 artisanal fishers in Zanzibar. Zanzibar fishers land approximately 24,000 tones of fish each year.

Natural beauty – The amazing and diverse shapes and colours of the coral reef and reef fish are a powerful attraction for tourists to come to Zanzibar for snorkelling and diving. Tourism provides jobs for at least 100,000 Zanzibaris and generates 20% of Zanzibar's GDP.

Protection – Coral reefs provide a natural barrier in the sea that protects coastal communities and beaches in Zanzibar from erosion and flooding from wave action and storms.

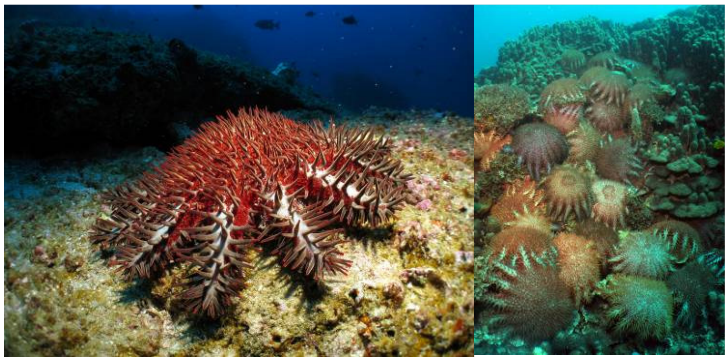
Carbon 'fixing' – Coral polyps make their limestone skeleton from calcium ions and carbon dioxide dissolved in seawater. This process, known as carbon fixing, helps reduce the amount of carbon dioxide in the atmosphere and thus helps slow down climate change.

Threats to the coral reefs of Zanzibar

Coral reefs face a variety of threats, mainly resulting from human activities.

Overfishing and destructive fishing methods – Demand for fish is rising due to both population growth and increasing tourist numbers. Overharvesting of fish, octopus, crabs and lobster is becoming a concern. In some areas of Zanzibar, populations of commercial fish and shellfish species are so low that fishers cannot find them any more. This creates further problems. For example, parrotfish eat corals, which they grind up in their teeth and release sand from their faeces which contributes to sand building. Also, some fishing methods are extremely damaging to coral, such as dynamite, poisoning, and 'kigumi' fishing where fishers use poles to break off coral colonies and drive out fish. These methods are illegal: they destroy large areas of reef and kill all the fish present, not just the fish targeted. Fishing nets dragged over the reef are very damaging, as they drag over the coral, catch on it, and break pieces off. Around Zanzibar, many large nets have got stuck on coral heads and been abandoned.

Scuba divers removing an abandoned net from a coral reef in Zanzibar. © Anne Tarvainen



Crown of thorns starfish, and a crown-of-thorns outbreak on a Pemba reef © Chris Bartlett

Crown-of-thorns starfish – These large, many-armed starfish eat coral polyps. Normally, predators, such as shellfish called tritons, eat them, and keep their numbers down, but triton shells are very popular with shell collectors, so they have been wiped out in many areas by the ornamental shell trade. Without predators, major outbreaks of crown-of-thorns starfish now occur, during which thousands cover reefs and cause extensive damage.

Snorkelling and diving – Coral polyps are very sensitive to touch, and if you touch a coral colony, even lightly, the polyps die after a few days. Careless snorkellers and divers kick up sand, smothering the polyps, and worse damage happens when they kick the coral or stand on it. It is also possible that peeing in the water and sunscreen have a negative impact on coral reefs that large numbers of tourists visit.

Boats – When boats run aground on reefs, they break and kill coral when the boat moves in the waves. Anchoring on a reef is also very damaging, because not only does the anchor itself break coral, but also the chain, when the boat swings around. Boaters walking on coral kill it too.

Coral mining and lime production – Live coral is mined, and turned into lime for construction. This is a very destructive activity, destroying vital reef habitat which take decades to recover. An

Ujikua unajua...?

- Most living coral reefs today are between 6,000 and 9,000 years old!
- Most corals feed on plankton at night, and keep their tentacles hidden during the day to stop them from being eaten by fish or shading the zooxanthellae from the sunlight they need for photosynthesis!
- Although coral reefs only occupy 1% of the world's surface, they provide a home for one quarter (25%) of all marine fish species!
- The global economic value of coral reefs is around US$ 30 billion!
- One third (33%) of coral species around the world are listed as threatened on the IUCN Red List of Threatened Species.

additional problem is that the kilns used to turn the coral into lime are typically heated by burning mangrove charcoal, causing further destruction of Zanzibar's coastal natural resources.

Siltation – As more and more land and mangrove is cleared to make way for housing, hotels and agriculture, more and more soil runs off the land into the ocean during heavy rains and smothers local coral reefs. Dredging also leads to siltation because it stirs up lots of soft sediment.

Pollution – As the population of Zanzibar and the number of tourists visiting increase, so does the amount of sewage, oil, chemical waste and rubbish entering the sea. These all damage coral and other marine life.

Coral bleaching and climate change – Climate change has many effects on coral reefs. Not only is seawater getting warmer, but extreme weather events are happening more often. For example, there are more big storms – which break off coral fragments, stir up mud and sand, and reduce salt levels. When the water gets too warm, coral polyps eject the algae in their cells. Living corals get their vivid colours from these algae, so after they are ejected the coral becomes bright white. This event is called bleaching. Bleaching is very bad for corals because they get 90% of their food from the algae. As long as the water cools down soon, they can take in algae again, but if the water stays warm, the polyps soon die. Coral bleaching events are becoming more frequent, and are affecting larger areas and deeper reefs each time. Coral disease also increases in some corals with warmer temperatures.

Ocean acidification – The increased carbon dioxide in the atmosphere that causes climate change is also absorbed by the ocean, where it reacts with dissolved salts and makes the sea acidic. It then dissolves the calcium carbonate (limestone) skeleton of corals and makes it harder for corals to build their skeletons at all. Reef breakdown due to acidification is very worrying.

How can we protect our coral reefs?

As we have seen, coral reefs are a critical part of our environment. We depend on them for many things: food, protection from storms, hundreds of thousands of jobs for Zanzibaris in fisheries and tourism. Corals are essential but also very fragile and vulnerable to destruction. We must therefore all do what we can and work together to protect them.

Tembea ujionee!

- Visit a Marine Protected Area in Zanzibar. Many have education programmes for schools, communities, tourists and others.
- Walk to a rocky seashore at low tide – you can see small corals growing in rock pools.
- Talk to local fishers about where the reefs are and how the fish catches have changed over time.

Swimmers, divers and snorkellers should be very careful not to touch coral, and never to stand on the reef! It is important to stay a safe distance from the coral, and be alert so fins don't kick the coral or stir up sand.

Boaters should stay in deep channels, not over shallow reefs, and should either anchor on sand, or use a fixed mooring buoy.

Fishers must avoid fishing methods which damage coral reefs: if they are destroyed, the fish will disappear. Fishers should work with others in the community to manage resources co-operatively, for example by establishing community-based protected areas to protect fish stocks.

Kitunze kidumu – Marine Protected Areas (MPAs) are zones where marine natural resources are protected from damaging activities. Measures taken to protect MPAs may include banning destructive fishing methods or even all fishing, or limiting the number of tourists allowed to snorkel or dive, in order to safeguard the fragile coral and other sensitive marine habitats. In turn, this gives fish a refuge where they can grow fast and breed. This actually benefits fishers because it also increases fish stocks in neighbouring fished areas up to 500 m from the MPA, because of migration! Coral and fish populations in MPAs are usually monitored, and crown-of-thorns starfish removed during outbreaks. There are currently six MPAs in Zanzibar: Chumbe Island Coral Park (established 1994, 0.4 km²), Mnemba-Chwaka Bay (which includes Mnemba Island Conservation Area) (1997, 0.15 km²), Menai Bay Conservation Area (1995; 467 km²), Changuu-Bawe Marine Conservation Area (2010), Tumbatu Island Conservation Area (2010), and Pemba Channel Conservation Area (which includes Misali Island Conservation Area) (1998, 23 km²). Good MPAs raise awareness within local communities that depend on coral reefs about the importance and benefits of coral reefs, and how we can protect them effectively.

We can also protect coral through activities onshore. Don't buy or sell coral or large shells as souvenirs – many large shell species are already endangered animals, and the triton shell has a crucial job in protecting the coral from crown-of-thorns starfish!

Marine Protected Areas in Zanzibar © Nell Hamilton

Forests, mangrove and seagrass all make sand, mud and soil more stable, so we should protect these habitats to stop sediment from washing on to the coral and smothering it, for example by replanting trees cut for firewood and not cutting down mangrove.

Kitunze kidumu!

- Never stand on coral reefs!
- Don't throw rubbish in the ocean or onto the beach, dispose of rubbish properly: reduce, reuse, recycle.
- Don't use damaging fishing methods or buy fish caught by dynamite or poison fishing, or other destructive methods.
- Avoid buying lime produced by burning live coral – use alternative constructive materials such as mud-bricks, sustainable wood, or lime made from fossilized coral collected inland.
- Tell family, friends and others in your local community how important coral reefs are, and let them know how they can avoid activities that damage your local coral reefs.
- Report illegal destructive fishing activities to the relevant authorities. Destroying coral destroys Zanzibari people's livelihoods, now and in the future.
- Lobby the authorities for greater protection of your local reef.

6 Fisheries

It is He who has subdued the oceans, so that you may eat of the fresh fish and bring up from its depths ornaments to wear. Behold the ships ploughing their course through it. All this that you may seek His bounty and render thanks. (Qur'an 16:14)

What are fisheries?

The term 'fishery' is used both to mean the operation or industry of harvesting a fish stock, and the sub-population or 'stock' of fish being exploited. Fisheries involve either catching wild fish and shellfish from seas, lakes or rivers, or raising captive fish in farms (aquaculture). They can be in freshwater, but Zanzibar fisheries are mostly marine. They are classified by the type of fish harvested, the fishing method and gear type used, and the location where the fishery operates. Some fisheries are exploited for subsistence, some for commercial gain, and some for recreation.

Traditional dema fish trap © Nell Hamilton

What kinds of fishing occur in Zanzibar?

There are many different fisheries in Zanzibar. Fishers target different kinds of fish in different locations and with different gear. Most Zanzibar fisheries are small-scale, taking place along coastal reefs where small traditional craft such as outrigger canoes (ngalawas) dhows (dau) dugout canoes (mtumbwi) and boats (mashua, boti) can reach. Several fishing methods are used, including traditional basket traps (madema), fence traps (uzio), gill nets (jarife), seine nets, handlines and longlines. Hand collection of shellfish and other invertebrates from intertidal waters and coastal lagoons is also very common, traditionally carried out by women and children for both subsistence and commercial purposes.

While most fish caught are used for subsistence or sold for local consumption, demand for fish is increasing as tourist hotels and restaurants seek high value species such as squid, octopus, crab, marlin and kingfish. Recent external investment is increasing fisheries' capacity. Outboard motors enable fishers to exploit more distant waters, and larger nets with smaller mesh sizes catch more fish than traditional techniques. These technologies also make Zanzibar more accessible to fishers from the mainland. Use of destructive, illegal methods such as harpoon, spear fishing, poison, dynamite, drag monofilament nets and beach seines has also increased.

Recreational fishing is not widespread in Zanzibar, but is gaining popularity among tourists. Game fishing is usually carried out from a purpose-built boat with a rod and line, aiming to catch large open-water species such as sailfish, marlin or sharks. These species and important reef fish are also illegally targeted by tourists spear fishing, who swim with a spear gun.

Why are fisheries important in Zanzibar?

People in coastal communities around Zanzibar depend heavily on marine resources for their livelihoods. Many people live very traditional lifestyles, collecting food as they need it: fish provide 98% of the protein in low-income diets in Zanzibar. For many families, fish provide the main income too; at least 34,000 fishers are employed in the industry. Fish caught are usually sold to local markets. Around 24,000 tonnes are caught per year, worth TSh 36 million to the Zanzibari economy.

Fishing is a culturally important activity for many, with fishing families going back many generations. Artisanal fisheries are therefore very important to coastal communities.

Much of Zanzibar's tourism is driven by the international reputation of its marine life, with tourists attracted by fresh seafood, and snorkelling or diving to see colourful fish, coral gardens and marine mammals. This brings more jobs to Zanzibar which also rely on healthy coastal resources.

What are the threats to fisheries?

Overfishing – Any fisher will tell you there are not as many fish now as there used to be, and they have to travel further now than they did in the past to catch the same amount of fish. There are several reasons for this: there are more fishers now, more fishing boats which are bigger, and fishers are using bigger nets (such as seine and gill nets) with smaller mesh size than before. Zanzibar waters also now attract fishers from other areas (migrating fishers, locally known as 'dago') because many local stocks in their areas have been overexploited. Worse still, huge drift nets up to 900 m long target open-water fishes like kingfish, swordfish, sailfish, tuna and marlin, and bottom-set nets up to 450 m long are set very close to the shore to catch sharks and rays.

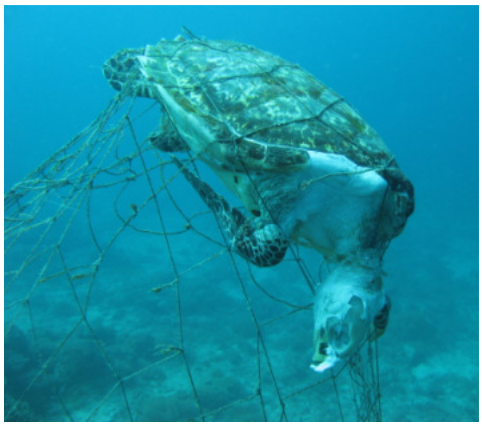
When these techniques were first introduced, a lot more fish were caught and populations declined. A few fish species breed quickly, and their stocks may recover quickly after high fishing pressure stops, but many others (including sharks and groupers) breed very slowly and may not be able to recover. It is therefore vital to understand the life cycle of the fish we depend on and monitor fishing impacts closely. Scientists monitoring fish stocks have confirmed what fishers know: the fish from Zanzibar's inshore waters that we eat are getting smaller and fewer every year. If this does not stop, then there will literally be no fish left!

Ulikua unajua...?

- Fishers in southern Unguja used to use dolphin meat as shark bait: it contains a lot of blood, which attracts them. But now they benefit so much from dolphin tourism they don't catch dolphins any more!
- Parrotfish produce sand! They graze on coral and excrete it in their poo as sand: one fish can make 90 kg sand in a year!
- Reef Balls are artificial reef modules placed in the ocean to form reef habitat, and are being used to preserve the reefs around Pemba!
- Biodiversity is much higher in Chumbe Island Coral Park (CHICOP) than outside: the 0.4 km² reserve is home to 200 coral and 400 fish species!
- Also, fish inside CHICOP are bigger and more numerous than in fished areas outside and the total weight of fish per km² was calculated to be more than three times higher!

Destructive fishing techniques – As well as catching more fish than traditional methods, new fishing methods are much more likely to destroy the fish habitat. Drag-nets break off and destroy coral, and dynamite fishers literally blow the reef to pieces killing everything, edible or not. Coral reefs and seagrass beds damaged in these ways take generations to recover. These activities are therefore not allowed in Zanzibari waters, nor is seine netting permitted on coral reefs – however it is hard to patrol the open seas and these illegal and destructive practices continue.

Bycatch – Bycatch is fish caught by accident in fishing gear set to target other species. In other countries, unwanted non-target species usually get thrown back dead, so nobody benefits, but in Zanzibar everything is eaten. Some fishing methods such as madema have low bycatch, however other techniques, especially trawl, drift and bottom-set nets, catch many more fish they don't want than fish they do. Most at risk from large nets are marine mammals such as whales, dolphins and dugongs, and also turtles, which get tangled in the nets and drown. Most marine mammal bycatch in Zanzibar occurs in nets off northern Unguja, and populations of many dolphin and sea turtle species are being reduced.



Critically endangered hawksbill turtle caught and killed by an abandoned net in Zanzibar © Nell Hamilton

Abandoned nets – If a fisher loses a madema because the marker buoy breaks off, then the trap, made from natural materials, will eventually disintegrate. However, modern nets are made from materials which do not break down, so if they are lost, the net continues to catch and kill marine life for centuries.

Pollution – Impacts of pollution on fisheries can be severe. Fish mistake plastic litter for food and eat it, where it blocks their guts and they starve. Untreated sewage contaminates seafood harvested from beaches and can spread deadly diseases such as cholera and typhoid. Toxic chemicals leach from rubbish dumps, farms using chemical fertilizers and pesticides, and burn sites into the sea, where they build up in the tissues of marine organisms through what they eat. They cause infertility, cancers and other diseases in both fish and humans, and can be fatal. Toxin levels build up the higher you go up the food chain, and so do their effects, including on people who eat contaminated fish. Children are particularly at risk.

Children collecting shellfish on a Zanzibar beach © Nell Hamilton

How can we protect Zanzibar's fisheries?

Zanzibar is not the first place to experience these challenges, and there are many solutions available that have been used successfully elsewhere. Whether children or adults, individuals or groups, we can help protect our fisheries and preserve livelihoods for future generations.

Marine Protected Areas (MPAs) – As with coral reefs, one of the best ways to protect fish stocks is to create Marine Protected Areas (MPAs). MPAs are zones where fishing is restricted. They protect coral, mangrove and seagrass habitat from destructive practices: this safeguards the areas where fish breed and nursery areas for young fish to grow. They provide food for many other species, and refuges for endangered species. In some MPAs, fishing is banned (no-take zones), others permit sustainable fishing but not destructive methods. They can combine both, with a central no-take zone surrounded by a buffer zone where sustainable fishing is permitted. Fishing restrictions may be seasonal, protecting valuable species in their breeding season but allowing fishing at other times. Currently in Tanzania, Community-Based Organisations (CBOs) have been established by groups of fishers themselves to enhance fishing now, and protect fish stocks for the future.

Although fishing is restricted in MPAs, overall, they benefit fishers. They give fish a refuge with plenty of food where they can grow to great size without being caught. They breed well, mature quickly, and produce too many offspring for the MPA. The young fish then migrate to the surrounding zone where fishing is permitted: fish close to MPAs are therefore bigger and more numerous than those further away! These effects extend up to 500 m from reserve boundaries, and are well known to fishers: for example many people fish in the waters just outside the no-take zone of Chumbe Island Coral Park. They know they can catch more fish there and make more money than if they fished elsewhere. Of course, MPAs must be managed well to be sure the rules are followed and communities benefit from these conservation areas, so they work best when established with community involvement. Coastal zone management planning should ensure coral reefs, seagrass beds and mangroves are all protected together. Regulations designed to protect fish stocks must be well enforced to be effective.

Tembea ujionee!

- Visit a fish landing site such as Malindi or Mkokotoni – or just your local beach.
- Visit fish markets at Chwaka, Matemwe, Uroa, Darajani, Nungwi or Pwani Mchangani.
- Talk to fishers in your family and community about how fishing catches and methods have changed.

Supporting sustainable fishery management – Fishers can help keep fisheries profitable by using sustainable techniques and helping educate their peers to do the same. For example:

- Avoid catching rare species that breed slowly (e.g. sharks, rays, groupers), and ecologically important species (e.g. parrotfish, triggerfish, wrasses and tritons).
- Use large-mesh nets to avoid catching young fish.
- Avoid damaging coral with anchors, boats, nets, traps, or by walking on it.
- Never catch fish that have aggregated to spawn.
- Use selective fishing techniques to avoid bycatch, especially of marine mammals and turtles.
- Be sure fishing gear does not get lost in the ocean, where it can continue to catch and kill fish.

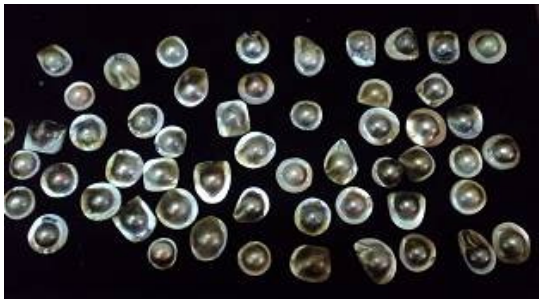
- Respect existing MPAs, and join efforts with other fishers and community members to create more MPAs and CBOs to protect our fish stocks for the future.

Alternative livelihoods – As the population of Zanzibar rises, people are seeking sustainable ways to earn a living without overexploiting declining fish stocks. Increasing options are becoming available.

Seaweed farming: Widespread throughout Zanzibar, seaweed farmers – usually women – grow seaweed on ropes (off-bottom culture techniques) in intertidal areas for export. It is an important livelihood activity, producing over 7000 tonnes a year.

Crab fattening: Some communities collect juvenile crabs and place them in net enclosures in mangroves where they are protected from predators. The crabs are fed a diet rich in carbohydrates so they reach marketable size quickly.

Zanzibar seaweed farmer
© Nila Uthayakumar



Pearls farmed in Fumba © Narriman Jiddawi

Pearl farming: Local communities in the Fumba peninsula farm oysters for pearls. The market for sustainably produced pearls in Zanzibar has great potential, through the thousands of tourist visitors annually, but it is essential that wild oyster populations are not depleted (this is currently done by ensuring all those with pearl farms have no-take zones in their areas).

Sustainable tourism: The most important way MPAs improve household income is by creating new jobs: for wildlife guides, boat captains, park rangers, snorkel guides, hotel staff and fishing guides. Indirectly, tourists provide a market for local crafts made from local materials.

Sport fishing: This is sustainable game fishing: after being photographed, fish caught are released – still alive – back into the sea.

Consumer action – To protect fisheries we must all work together to ensure fisheries are used and managed sustainably, so that people can continue to make a living from natural resources and support their families now and in future generations. If everyone raises awareness in their community and supports local fishers who catch fish sustainably, then rare species can survive, and enough fish will live long enough to breed. Always ask how fish were caught, and don't buy rare fish, juvenile fish, or fish caught in destructive ways – it puts local people out of business and denies children the chance to eat local fish in the future. Especially in local restaurants, raise awareness with staff and suggest sustainable alternatives to keep at-risk fish off the menu and in the ocean!

Kitunze kidumu!

- Help raise awareness: tell friends, family and co-workers how important sustainable fishing is!
- Don't drop litter (taka taka) – recycle!
- Don't 'help yourself' on the beach! Use a proper toilet away from food resources.
- Avoid dangerous diseases like cholera or typhoid: only collect shellfish from clean beaches away from sewage outfalls.
- Join community groups to lobby government to improve sewage treatment and provide proper toilets for your community so sewage doesn't get into the sea.
- Write to your Sheha or MP to let them know that sustainable fishing matters.

7 Pollution

Corruption (including pollution) has become rife on land and sea in consequence of mankind's misdeeds. He has ordained it thus so that they may taste the fruit of their own works and mend their ways. (Qur'an 30:41)

What is pollution?

Pollution is harmful waste materials released into the natural environment.

Polluting materials can be solids, liquids or gases, and they can harm all parts of the environment, land, freshwater, sea and air – the soil we grow things in, the water we drink and where we fish, and the air we breathe. In the past, waste products were natural and would soon rot away or disperse, but modern man-made materials may last thousands of years in the environment, where they harm wildlife – and us.

Solid waste – Solid waste pollution is the most visible – and most of it is litter: rubbish from households and businesses that has been thrown out in the environment. Sewage (sludge) is also solid waste and an environmental pollutant if not properly treated.

Liquid waste, soil and water pollution – When liquids such as chemicals, oil and untreated sewage are released into the environment, they wash into the soil, into the groundwater and into the sea. In addition, rotting rubbish at rubbish dumps and ash from burnt rubbish contain toxic chemicals which dissolve when it rains. Many of these substances are poisonous to wildlife. Rotting organic material from rubbish and agricultural run-off contain nitrates which make the soil and water unsuitable for important natural communities, especially coral reefs and seagrass, because nitrates promote growth of algae which make the water cloudy and block light from the sea floor.

Air Pollution – Most air pollution comes from burning things. Smoke contains carbon dioxide – a greenhouse gas that contributes to climate change, and solid particles – soot. Vehicle exhausts contain harmful gases such as sulphur and nitrogen dioxides and toxic hydrocarbons. Burning plastic releases toxic gases into the air. Another source of air pollution is rotting rubbish which produces methane, another greenhouse gas, more damaging than carbon dioxide.

Bio-accumulation – When animals eat polluting materials (solids or liquids) that do not break down, they are not digested, but accumulate (build up) inside the animal. When that animal is eaten in turn, the pollutants accumulate. This builds up as you go up the food chain, so that the top predators – fish, birds, marine mammals, and humans – may be seriously affected.

How does pollution affect Zanzibar and Zanzibaris?

***Solid* waste –** Most communities and businesses in Zanzibar have no formal solid waste collection, and our roadsides and communities are littered with plastic bags and bottles, metal cans, old clothes, batteries, tyres and diapers. This is very ugly; it repels tourists, who notice it immediately, and go home thinking we do not care about Zanzibar. It can also do serious damage to the environment. The damage is felt not only in the places where rubbish it is dumped, because it is blown about by wind, and washed away by rain into drains into the sea, then washes up on beaches, gets caught up on coral reefs or gets eaten by animals mistaking it for food.

Plastic: Plastic takes thousands of years to break down and is damaging whether on land or in the sea. Plastic litter gets eaten by cows, goats, and donkeys, bits of polystyrene and cigarette filters are eaten by birds and fish, and plastic bags are eaten by turtles which think they are jellyfish. The plastic blocks the animals' guts, and can kill them. Bags blow away and bottles get washed into drains and the sea. Plastic bags smother seagrass and can catch on coral and break it. Abandoned plastic fishing nets tangle on coral and continue to kill fish, turtles, and other marine life.

Rubber: Old car tyres collect water in which malarial mosquitoes breed. Burning tyres produces toxic fumes.

Glass: Glass can start fires in dry grass and broken glass can injure people and animals and damage vehicle tyres.

Metal: Metal litter such as cans or rusty nails can be dangerous, cutting children or animals. Metal takes a long time to break down and releases dangerous minerals into the environment, poisoning soil and water.

Wood: Wood is a natural material which does break down in time. However wooden products that have been painted or treated with fungicide or insecticide take a long time to rot, and the chemicals in them poison wildlife. Wooden things floating in the sea are also dangerous to boats. Wood comes from trees and so buying it leads to deforestation here and elsewhere.

Paper and card: Like wood, this will eventually break down, but until it does, it is ugly and can spread widely.

Appliances: All the materials from which appliances are made, such as batteries, glass and plastic, are potentially harmful to our environment. Abandoned appliances are also very ugly. Old fridges and freezers contain polluting gases, and children playing can get trapped inside them.

Batteries: Batteries contain poisonous chemicals such as mercury, lead and acids. Mobile phone batteries contain nickel and cadmium, which cause cancer. When batteries are put in landfill the pollutants are released slowly; if they are burned, they are released quickly in the smoke and ash from the fire. Heavy metals like mercury build up in shellfish, poisoning them – and these toxins are passed on to us when we eat the shellfish.

Sewage: Zanzibar has no sewage treatment to make sewage safe. In Stone Town and Marahubi, and other areas with sewers, the raw sewage washes straight into the sea. Where there are no sewers, people use pit toilets, but when they are emptied, the sewage is often dumped in wild places; otherwise, people have little choice but to go in the woods or on a beach. People also throw out dirty diapers on beaches all around Zanzibar. As well as it being unpleasant, it is also very dangerous. People walking, playing or collecting shellfish and farming seaweed on these beaches, or people who eat shellfish collected from them, are exposed to faecal matter that could make them very sick. Potentially deadly diseases such as cholera, typhoid, infectious hepatitis and infections caused by parasites can all be transmitted when we are exposed to untreated infected human waste. The germs also get into the groundwater and make our drinking water unsafe.

Animal dung: Animal dung smells bad and attracts pests such as flies. There are also some nasty parasites that can be caught from infected droppings.

Other solid organic waste: Organic waste such as meat, fish and vegetable waste does break down, but can still cause problems. When it is sent to landfill, it rots in big piles where there is no air (anaerobic) and the rotting process releases methane, a very bad greenhouse gas. If it rots in the open, it attracts pests such as rats, which carry disease, and Indian house crows, which kill hundreds of our native birds.

Liquid waste, soil and water pollution – Water is polluted by both households and industry. Rotting rubbish at rubbish dumps and ash from burnt rubbish contain toxic chemicals which dissolve when it rains. Household cleaning materials, the chemicals used in industrial processes, and pesticides used on farms, all wash into the soil, affecting plant growth, into the groundwater, polluting our drinking water, and into the sea, where they build up in organisms and cause health problems to animals and to people who eat them.

Oil: There are many types of oil and they are a special problem. Oil is used in cooking and

Ujikua unajua...?

- Taka taka is a top 3 complaint by tourists.
- Turtles eat plastic bags thinking they are jellyfish.
- Cigarette ends take more than 65 years to rot.
- A recent typhoid outbreak was caused by people helping themselves on the beach.
- recycling drinks and food cans uses 5% of the energy of making new ones.
- Two bird species that lived only on Pemba but nowhere else have probably become extinct because of crows that have invaded the island by eating rubbish.

thrown away. Other kinds of oil are spilled in people's homes and car mechanics' yards. If it is poured into drains, it gets into the groundwater and eventually to the sea, poisoning wildlife including the fish and shellfish that we eat. Engine oil, petrol and diesel are released from outboard motors and from ships flushing their fuel tanks. It smothers seagrass, coral, and seaweed being farmed. Seabirds get covered in it, and turtles and marine mammals can't breathe. If slicks wash up on beaches, shellfish are poisoned too, and the beach cannot be used any more by tourists or locals – it is very difficult and expensive to clean up. Oil spills from ships are rare but produce a lot of pollution when they happen.

Air pollution – Without proper rubbish collection, many people burn their household or business rubbish and most of us cook with wood or charcoal. It is not healthy to inhale smoke of any kind – it can cause lung disease and even cancer – but especially risky are fumes from burning plastic, rubber or batteries, and vehicle exhaust gases. Bad smells, especially sewage smells and burning rubbish, are horrible to live with and put off tourists.

What's wrong with the current solutions?

Dumping at sea – While the effects of dumping rubbish in the ocean are difficult to see, it has terrible impacts on marine life, which means also on the marine resources we depend on ourselves. It is also often a waste of time, because much of it washes back up on beaches during the next big storm. Untreated sewage carries disease and contaminates beaches and seafood.

Burning – Some waste products can be burnt safely, however burning plastic, appliances, rubber or batteries produces toxic smoke and ash. Open fires are also responsible for many fires that destroy homes and businesses, and kill people. The carbon dioxide produced is also a greenhouse gas.

Tembea ujionee!

- Jumbi dump
- Any street or beach
- Maruhubi
- Wesha and Mtoni
- Micheweni
- Malindi fish landing site
- Green house plastic recycling centre

Landfill – Rubbish collected in Stone Town is taken to municipal and community dumps such as Jumbi on Unguja, but there is not yet any municipal rubbish collection in the rest of Zanzibar. Harmful germs and chemicals from rubbish (including hospital waste) drain into the groundwater. The dumps are not covered so they attract rats and crows, and plastic blows away. There is no air in the rotting process because of the huge volume of waste piled up, so they release methane, which is four times more harmful a greenhouse gas than carbon dioxide. Landfill sites eventually fill up – so to make space for more rubbish they are burned which is very dangerous and unpleasant for local communities that have to breathe in the noxious and smelly smoke.

How can we clean up Zanzibar?

Pollution is damaging our health, destroying natural resources that we need, and damaging industries we depend on such as fisheries and tourism. So what can we do to change this?

Reduce – We need to reduce the amount of waste we produce. If we don't create it, then we won't have a waste problem to solve. Put simply, we should buy less. Ask yourself 'Do I really need this?' when you shop. Choose products that use less packaging, because all packaging turns into waste.

Reuse – Use products that you need as many times as you can. If something is broken, get it mended instead of buying a new one. Give away or sell things you no longer need. Hold a community 'yard sale': everyone brings old toys, clothes, furniture and other things they don't need any more, and neighbours can buy from and exchange with each other. You can save money too!

Recycle – With a little imagination, much of the rubbish littering our streets and beaches can be given a new life. This can be small-scale, when local people make beautiful crafts to sell to tourists. Many materials can now be recycled on an industrial scale here, including plastic and glass and collection centres for recyclable materials are being established in communities around Zanzibar. First, the materials are sorted by what they are made of. Then each kind of material is chopped up by a machine. The crushed material is exported overseas where it is used again to make new products. Ask your local recycling centre what materials they collect.

Until Zanzibar has universal recycling, there will be times you can't reduce, reuse, or recycle: in that case, what should you do?

Compost heap at Chumbe Island Coral Park – 80% of household waste produced in Zanzibar could be used to make compost © Nell Hamilton

droppings safely. Dog, cat and human faeces will rot too, but they can spread diseases, so do not put them on compost heaps.

Bonfire – While burning some things is bad, natural materials such as wood, plant, bones, food waste or animal droppings can be burnt. If you do burn waste, do it safely. Keep the fire small, never leave it unattended, choose a site a safe distance away from houses and trees or where the wind could blow smoke or sparks towards them, and don't make fires in extremely dry or windy weather. Never burn batteries, rubber, aerosols or plastic, as the smoke and ash they produce is toxic.

Landfill – Sometimes, as a last resort, we have to send things to landfill. But if you do, make sure waste is well packed in bags so it can't blow away, and that potentially dangerous substances such as engine oil or soiled diapers are safely contained. Dumps keep all the rubbish in one place, and in theory, the rubbish could be used for electricity generation in the future.

Compost – Waste made from natural materials that rot away, like food leftovers, garden waste, and even non-glossy paper, can be made into compost. Compost is a great soil improver which provides nutrients for growing plants and helps hold water. You can compost cooked food, but it should be buried deep inside the heap to avoid attracting pests like rats and crows. You can even compost cow, goat and donkey

Kitunze kidumu!

- Don't drop litter!
- Say no to plastic bags – take a basket or cloth bag shopping.
- Refill and reuse water bottles.
- Use cloth nappies that can be washed and used again, instead of plastic diapers that have to be thrown away.
- Get involved in community and beach clean-ups.
- Have vehicles serviced regularly to make sure they are burning fuel efficiently, not producing lots of harmful black smoke.
- Lobby government to improve waste collection and recycling.
- Reduce, reuse, recycle! The following table tells you the best thing to do with your household waste, acceptable alternatives, what you can do as a last resort if there is no alternative, and what you should never do because it is dangerous to your health!

What to do with waste	Reduce	Reuse	Recycle	Compost	Animal feed	Burn	Landfill	Dump at sea
✓ Best choice ✓ Acceptable ✗ Last resort ✗ Dangerous								
Plastic	✓	✓	✓	✗	✗	✗	✗	✗
Rubber	✓	✓	✓	✗	✗	✗	✗	✗
Glass	✓	✓	✓	✗	✗	✗	✗	✗
Metal	✓	✓	✓	✗	✗	✗	✗	✗
Wood	✓	✓	✓	✓	✗	✓	✗	✗
Paper / card	✓	✓	✓	✓	✗	✓	✗	✗
Old clothes	✓	✓	✓	✗	✗	✗	✗	✗
Appliances	✓	✓	✓	✗	✗	✗	✗	✗
Batteries	✓	✓	✓	✗	✗	✗	✗	✗
Plant waste	✓	✗	✓	✓	✓	✓	✗	✓
Meat / fish waste	✓	✗	✓	✓	✓	✓	✗	✓
Animal dung	✗	✗	✗	✓	✗	✓	✓	✗
Diapers (pampers) and sanitary pads	✓	✗	✗	✗	✗	✓	✓	✗
Oil and petrol	✓	✓	✓	✗	✗	✗	✗	✗

8 Climate Change

Then We made you heirs in the land after them, to see how ye would behave! (Qur'an 10:14)

Weather, seasons and climate: some definitions

Weather is the condition of the air around us at any one time: is it hot or cold, sunny or cloudy, dry or rainy, windy or calm? **Seasons** are regular changes in weather patterns (wind strength and direction, rainfall, etc) at different times of year. **Climate** is the typical weather experienced (calculated from measurements of rainfall, temperature etc), averaged over a very long time, in different seasons over many years. The **global climate** is the average across the world.

Climate, seasons and weather in Zanzibar – Zanzibar has a **tropical monsoon climate**; it is typically hot and humid. The seasons are driven by the 'monsoon' or 'trade' winds. From November to March, the wind blows from the north (kaskazi) bringing short rains (vuli) in November, followed by a hot dry season (kiangazi) from December to March. In April, the monsoon starts to blow from the south (kusi), triggering the long rains (masika) which last until May, followed by the cooler long dry season (kipupwe) until September.

The weather may change daily, but seasonal patterns are more predictable and do not vary much, while climate usually does not change noticeably within a lifetime.

What influences climate?

The sun – Almost all the energy that controls our climate comes originally from the sun.

The atmosphere – About half the energy from the sun that reaches the earth is absorbed by the land and sea, warming it up; the rest is reflected, mostly as heat. But the reflected heat does not all escape into space. Layers of naturally occurring gases in the atmosphere act like a blanket or glass roof to keep the heat in, and the earth warm. This insulating process is called the **greenhouse effect** and is essential to life on earth. The gases which cause it are known as '**greenhouse gases**' (GHGs). The most abundant GHG is carbon dioxide, produced by respiration, burning, and when plants and animals rot in air. Less abundant, but a stronger insulator, is methane which traps 20 times more heat than carbon dioxide. Methane is produced when plants decay without air, for example in waterlogged earth or in landfill sites. Another GHG is nitrous oxide released by soil when forests are cut down.

Latitude and altitude – In the tropics, near the equator (low latitudes), the sun is overhead and its rays shine straight down onto the earth, so more energy reaches the land. However, at the north and south poles (high latitudes), the sun's energy has to travel through more atmosphere, so the earth is much colder and covered in ice all year round. On very high ground such as the tops of mountains (high altitude) there are fewer layers of atmosphere to hold heat in, so the higher you are, the colder it gets. This is why there is snow on Mount Kilimanjaro, although it is in the tropics.

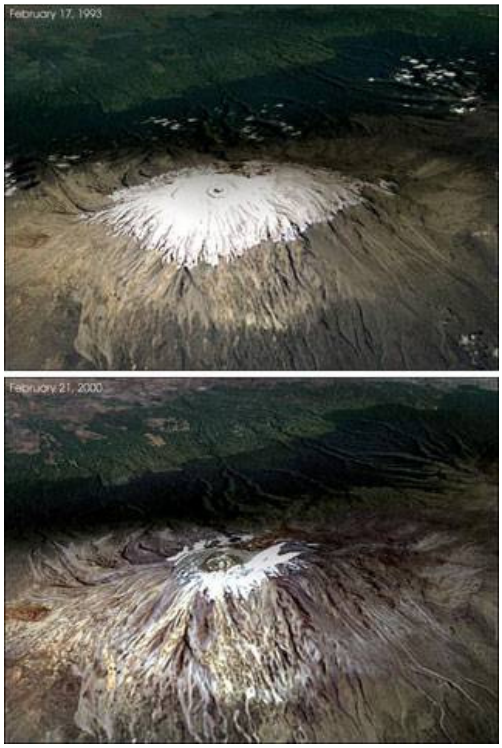
The oceans – The sea helps regulate temperature extremes by storing and moving heat. Coastal climates do not vary as much as areas inland. For example in Zanzibar the difference between daytime and nighttime temperatures is about 6 degrees, while in Dodoma it is 12 degrees cooler at night than in the day. Oceanic currents move warm water from the tropics to cooler parts of the world warming them up, and cold water flows back.

Life – Plants and animals influence climate. Plant tissues absorb carbon dioxide as they grow, and release it when they rot. So all living plants in the world's forests and oceans are carbon dioxide stores, keeping the GHG out of the atmosphere and reducing the greenhouse effect. Millions of years ago, many of the earth's forests were flooded, which slowed down decay. So as trees died, dead branches and leaves built up in layers in the swamps. Over time, the layers of plant tissue became compressed, and eventually fossilised to become coal, oil and natural gas. These 'fossil fuels' have therefore stored this carbon dioxide and kept it out of the atmosphere for millions of years. Animals produce carbon dioxide through respiration, and when cows and termites digest plant material they produce methane in their guts, which is released when they belch or fart!

What do we mean by climate change today?

Climate change occurs when there is a change in *average* weather conditions over a long period, as shown by measurements of weather conditions from several years, seasons and locations.

How do we know climate is changing? – In a human lifetime, climate seems constant, but scientists have found much evidence that during the past millions of years, the earth has been both much colder and much hotter than today. In cooler parts of the world, there are rocks with fossilised tropical animals such as corals (like coral rag) in places that are now too cold for corals to grow, so those areas must once have been much warmer. Glaciers today carve valleys in rocks, and we find similar valleys in areas now too warm for glaciers, so they must once have been colder.



The ice cap on Kilimanjaro in 1993 and 2000 – scientists estimate the ice will disappear by 2015 © NOAA

How do we measure climate change? – Scientists have been recording temperatures and rainfall around the world since 1850! There are now over 22,000 weather stations monitoring our climate across the earth and oceans. Satellites measure cloud cover and radiated heat over the whole planet, giving us very precise measurements of what has happened to the global climate over many decades. We can learn about the more distant past from permanent ice – in glaciers on mountains such as Kilimanjaro, or in the polar ice caps. Each year a new layer of ice is formed: a thick layer in cold years and a thin layer in warmer years. Scientists have counted ice layers back and measured their thickness to find out how climate has changed and how quickly over the past 800,000 years! We also measure the size of ice sheets and glaciers, and monitor sea levels, which rise and fall when polar ice melts and freezes: a tidal gauge outside Stone Town measures Indian Ocean sea levels.

What have we discovered? – All the different data and measurements tell us the same thing: our planet is getting warmer. In the past 25 years the planet has warmed by 0.5°C. In Tanzania, the annual average temperature has increased by 1°C since 1960 and is projected to increase another 1°C by 2060; reflected in an average rise in Tanzania of 0.02°C per year. This may not seem much – it is too small for us to feel – but this pattern is repeated around the world: little steps add up to big changes. The data show that permanent ice is melting – both polar ice caps and glaciers are disappearing rapidly due to rising temperatures. Sea levels are rising as water from the melting ice flows into the oceans. Temperatures are rising more rapidly, and changes are happening faster than they ever have before. The greenhouse effect is getting out of control.

Rotting takataka in dumps releases methane, a greenhouse gas © Nell Hamilton

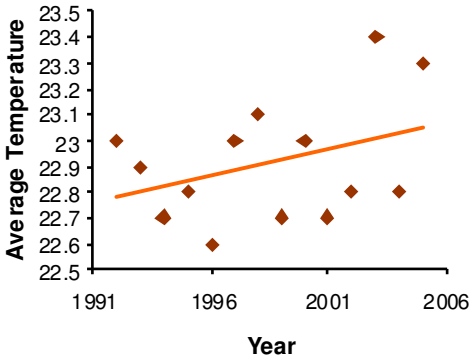
What is causing climate change now? – Natural forces will always influence climate, but they are not enough to explain the speed of climate change now. So what has changed?

Burning fossil fuels – When we burn fossil fuels (petrol, coal and natural gas) to cook, power vehicles or produce electricity for homes and businesses, the carbon dioxide that was stored by the plants millions of years ago is released. The global temperature started to rise 150 years ago: which is when humans first started burning fossil fuels.

Deforestation – As the human population of the earth increases, we need more and more wood, and land to grow crops on. Living trees absorb carbon dioxide during photosynthesis and store carbon in their tissues as they grow. When we cut forests down, they stop taking carbon dioxide out of the atmosphere, and when we burn the wood, we release the stored carbon back into the air. The population of Zanzibar is increasing at 3% per year, and deforestation is increasing – we cut down over 500 hectares of our forest every year.

Ulikua unajua...?

- A cow produces over 200 litres of methane every day!
- Tanzania is warming up by 0.2°C every 10 years



Agriculture – Removal of forest to cultivate land releases nitrous oxides into the atmosphere. People farm many cows and goats, which release methane, and when plants decay in rice paddies, and when food and plant waste rots in landfills, huge quantities of methane are produced.

Are humans really changing the climate of the whole earth? – Yes. Sadly, we are. Scientists are certain that the earth is warming, and this is largely the result of human activities, especially burning fossil fuels. Carbon dioxide levels in the atmosphere have increased by 40%, and methane levels have doubled since 1750 and could double again by 2050. Adding greenhouse gases to the atmosphere is like wearing more clothes – the gases trap more heat, the earth heats up, and the climate is changing.

How does climate change affect our environment – and us?

Extreme weather – Storms, droughts, floods and other extreme weather events, such as cyclones in the Indian Ocean, are becoming more frequent. Increasingly, forests, reefs, farms, towns and villages affected by them do not have time to recover between one storm and the next.

Higher temperatures and warmer oceans – Record high sea temperatures in recent decades have caused widespread bleaching of coral in the Indian Ocean, from which much has not recovered, with ongoing impacts on many socio-economically important reef-fish species.

Acidic oceans – Carbon dioxide from the air dissolves in the sea, making it more acidic, which can kill marine life (especially fish spawn), dissolve coral skeletons and stunt growth of shellfish.

Changing rainfall – In our grandparents' time, seasons were regular and predictable. But now the timing of seasons varies a lot, and in some years, in parts of East Africa, the rainy season has not come at all. When this happens, thousands, even millions, of people go hungry. In Zanzibar, all the water we drink comes from rainfall, which soaks into the ground. The coral rag acts like a big underground sponge, storing it. If we had a year without rain here, then large parts of Zanzibar would run out of fresh water to drink, and seawater would soak into the rock instead. Some coastal villages already have this problem. Those who can afford it buy in water from elsewhere, but most people can't afford to – and what if there were no fresh water anywhere?

Melting ice and snow – On Kilimanjaro, reduced snowfall due to climate change has resulted in 80% of the ice cap disappearing in the past 100 years. At this rate, by 2015 the ice will all be gone. The snow and glaciers of Mount Kilimanjaro act as a water tower, storing water that feeds several rivers as it melts during the dry season. As the ice disappears, the rivers are drying out, leaving nearby communities without water.

Rising sea levels – As polar and glacier ice melts into the sea, and the seawater itself expands as it gets warmer: the average sea level is rising. This will have significant impacts in low-lying coastal regions and islands such as Zanzibar. Sea level rise, on top of more frequent storms, increases coastal erosion: coastlines retreat and land becomes sea. Zanzibar is not yet affected, but other Indian Ocean islands are. Sea levels in Africa could rise by nearly 60 cm by 2100, which would seriously impact Zanzibar's coast.

Impact on biodiversity – Life on earth has survived climate change before, but historic changes were slow, and wildlife could adapt, by populations either spreading more to the north or south with each generation, or evolving to adapt to the new conditions. The change happening now is too fast for populations to adapt naturally, and if they could, farmland, roads and settlements create barriers preventing migration between wildlife-rich areas. Island populations of plants and animals cannot cross the sea, so if climate change brings too much or not enough water, or food species become scarce, many species will be unable to adapt and will disappear from Zanzibar; endemic species are likely to become extinct.

Tembea ujionee!

- Ask your grandparents if weather patterns have changed in their lifetimes.
- Visit hotels on beaches – are they leaving coastal vegetation to protect them from sea-level rise?

Impact on economic activities – We time sowing, planting and harvesting of crops according to the seasons. Heat-waves, droughts, or unseasonal rain can ruin our crops. Floods can devastate farmland and property, and widespread drought would cause terrible suffering. When coral reefs bleach and die, fish populations decline, and if Zanzibar runs short of water, it will not be able to support as many tourists. Many jobs will be lost.

How can we reduce the impact of climate change?

Reduce greenhouse gas emissions – Most greenhouse gases are produced by more developed countries, but we must still do our bit in Zanzibar. We can walk, or ride a bike or dala dala instead of driving, and take the ferry instead of flying. Those with a car or moped should make sure it is running well and burning fuel efficiently – no smelly black smoke! By buying products grown or made in Zanzibar, and made of local materials, we reduce fuel used to transport them. We can reduce methane emissions from rubbish dumps by making compost from plant and food waste (so it rots in air) instead of throwing it away – the compost will improve our soil and crops too! Plastic is made from fossil fuels, so making and burning it release harmful greenhouse gases. We must use less plastic, establish plastic recycling points in our communities, and use them! In the future, Zanzibar could generate all the electricity it needs from renewable sources such as solar, wind and tidal energy. Technology even exists to generate electricity from taka taka and sewage!

Reduce deforestation – Zanzibar's forests should be protected and restored. We can each use less firewood by using more fuel-efficient stoves instead of three-rock fires, and burning bio-briquettes instead of wood and charcoal. For building, we should choose timber from trees that grow quickly, harvested from plantations, not wild forests, and replant new trees to replace them.

Mangroves help protect coastal communities from rising sea levels, storms and erosion © Rachel Hamilton

And finally – Learn to Live with Climate Change – Of course we must all do our bit to reduce our contribution to climate change, but we have to accept that the climate is getting warmer and this will bring changes to the environment. So we must learn to live in a changing world. Coral reefs, seagrass beds, beaches, mangroves – all coastal vegetation – helps protect coastal property from the effects of storms and sea-level rise, so we need to treasure these habitats. New developments in coastal areas should be set back from the beach to allow for the encroaching sea, and sand must not be taken from beaches. Vegetation inland should be protected and restored, so that rainwater is absorbed into the ground, instead of washing into the sea, taking soil and nutrients with it. We must collect rainwater, and not use water excessively. Farmers can choose drought-resistant crop varieties that need less water and the tourism industry should reduce its water consumption. **Together we *can* protect our beautiful islands for the future.**

Kitunze kidumu!

- Switch off lights, fans and a/c when you're not using them.
- Use energy-saving lightbulbs
- Don't leave taps running when washing dishes clothes. or yourself – use a bucket.

Glossary

When learning, if you read a word you do not understand, look it up in a glossary, dictionary or encyclopaedia, or ask a teacher or friend. To learn more about any of the issues in this book, if you have access to the internet, search for the subject at www.google.com or www.wikipedia.org.

Adaptation – The process by which a population changes to suit a new environment

Appliance – Electrical household machine, e.g. cooker, washing machine, mobile phone

Atmosphere – Layers of gases around the earth

Bay – A curved area of sea surrounded by land on three sides

Compost – A fertiliser made from rotted plant and animal waste

Compost heap – A pile of plant and animal waste left to rot for several months to become compost

Coral bleaching – The process by which coral polyps eject the coloured zooxanthellae from their cells when water temperatures rise

Coral reef – An underwater structure made from limestone skeletons of thousands of living coral colonies and sponges

Creeping – A kind of plant growth: growing and spreading gradually where growing stems send out roots to cling to the ground

Dredging – Using a machine with a scoop or sucking device to make channels in the sea bed deeper, so bigger ships can use them

Dynamite – A powerful explosive used as an illegal fishing technique

Eco-lodge – A hotel with low environmental impact, which is built from renewable materials, uses sustainable technology and educates guests about the environment

Encroach – To gradually cover more and more of an area of land

Endemic – A species that only lives in a particular place

Excrete – Force out waste products from plant or animal cells

Extinction – The process where a species dies out and ceases to exist, or 'becomes extinct'

Fodder – Food for cows, horses and other livestock

Fossil fuel – A fuel formed underground from plant and animal remains millions of years ago, such as gas, coal and oil

Fungicide – A chemical substance used to kill fungi

Glacier – A vast frozen river of ice and compacted snow which moves very slowly

Greenhouse effect – Warming of the earth caused by gases in the atmosphere which trap heat from the sun

Greenhouse gas – A gas which contributes to the greenhouse effect, such as carbon dioxide and methane

Habitat – The place where an animal or plant lives

Mabadiliko / kujibadili – Mchakato ambao kwake mimea na wanyama hubadilika ili kuweza kukabiliana na mazingira mapya

Chombo – Mashine ya umeme ya nyumbani, k.m. mashine ya kufulia, simu za mikononi

Anga – Tabaka za gesi katika dunia

Ghuba – Eneo la bahari lililozungukwa na ardhi/nchi kavu pande tatu

Mbolea – Iliyofanywa kutokana na mimea iliyooza na uchafu wa wanyama

Chungu la mbolea – Chungu la uchafu wa mimea na wanyama ulioachwa uoze kwa miezi kadha ili iwe mbolea

Kupauka kwa matumbawe – Mchakato ambao kwake polipu wa matumbawe hutoa nje kutoka kwenye chembe chembe zao za maisha (seli) mwani mdogo zenye rangi joto linapozidi.

Mwamba wa matumbawe – Mwamba uliopo chini yamaji uiliofanywa kutokana na mifupa ya maelfu ya makoloni ya matumbawe hai na sponji

Tambaa – Ni aina ya ukuaji wa mimea,ambao hukuwa na kusambaa hatua kwa hatua ambapo huongezeka kwa kutoa mizizi nje na kushikamana na ardhi

Ondoa matope – Kutumia mashine yenye kijiko au kifaa cha kufyonza matope kwneye mito chini ya bahari ili iwe na kina kikubwa zaidi,na meli kubwa ziweze kuitumia

Baruti – Ulipukaji wenye nguvu; au uvuvi haramu wa kulipua

Hoteli inayojali mazingira – Hoteli yenye athari ndogo ya kimazingira, ambayo hujengwa kutokana na vitu vinavoweza kutumika tena, inayotumia teknolojia endelevu na inayofundisha wageni kuhusu mazingira

Mega pole pole – Kuingilia pole pole eneo la ardhi / nchi kavu na kilichukua

Spishi adimu – Spishi inyoishi mahali maalum tu

Kutoa uchafu – Nguvu za kusukuma uchafu nje ambao unatoka kwenye seli za mmea au mnyama

Toweka kabisa – Mchakato ambapo spishi hufa kabisa na haonekani tena

Malisho – Chakula cha ng'ombe, farasi na wanyama wengine wanaofugwa

Mabaki ya fueli – Mafuta tyaliyofanyika chini ya ardhi kutokana na mabaki ya mimea na wanyama mamilioni ya miaka iliyopita, mfano gesi, makaa ya mawe na mafuta ya petroli

Dawa ya fangasi – Dawa ya kemikali inachotumiwa kuuwa fangasi

Pande kubwa la barafu – Pande kubwa la barafu au theluji lililoganda na ambalo haliyeyuki

Athari ya gesi hatarishi / gesi zinazoathiri hali ya hewa – Kupata joto kwa dunia kunatokana na gesi katika hewa inaokusanya joto kutoka kwenye jua

Gesi hatarishi / gesi zinazoathiri hali ya hewa – Gesi inayochangia katika kupata joto dunia kutokana na gesi inaokusanya joto kutoka kwenye jua, kama dioksidi ya kaboni na mitheni

Makazi – Ni eneo ambalo mnyama au mmea unaishi

Harpoon – A long heavy spear (a weapon with a long handle and a sharp point) fixed to a rope, used as an illeagal fishing technique in Zanzibar
Ice cap – A permanent layer of thick ice and snow covering the north and south poles and high mountain peaks

Inlet – A narrow strip of water that goes inland from a sea or lake
Insecticide – A chemical substance used to kill insect pests

Juvenile – Young, not sexually mature

Lagoon – An area of the sea partly separated from the open ocean by a reef (= a line of shallower rock, sand or coral)

Landfill – Getting rid of large amounts of rubbish by burying it, or a place where rubbish is buried
Latitude – Distance south or north from the equator
Meadow – A field where grass grows
Moor – To tie a boat so it stays in the same place
Mooring buoy – A buoy anchored to the sea floor with a strong rope or chain, so boats can moor without needing an anchor

Neuter – To surgically remove a pet's testicles or ovaries to prevent it from having young

Node – A point on a plant's stem where leaves or roots grow from
Onshore – Moving from the sea towards land / on land rather than at sea
Open ocean – The waters of the ocean away from land

Pest – An insect, animal or fungus which damages crops or food
Pesticide – a chemical substance used to kill pests such as insects, weeds and fungi
Photosynthesis – The process by which a plant uses energy from sunlight to produce its own food
Pneumatophore – A root that grows in the air (aerial root), which enables a plant to absorb gases from the air even if it is growing in water
Polyp – A small simple tube-shaped water animal, like a tiny sea anemone, to which they are closely related
Polystyrene – A light plastic containing bubbles of air, used to protect fragile objects or keep things hot or cold

Propagule – A piece of a plant which will break off and grow into another plant, e.g. mangrove seedlings which germinate on the tree before falling off
Propeller – A revolving part of a motor with two or more blades which spins in water or air to make a boat or aircraft move

Quarrying – Extracting resources such as stones and metals from the ground
Resilient – Able to recover quickly to good condition after being damaged
Rhizome – A stem of some plants which grows horizontally along or under the ground and produces roots and leaves
Salinity – The amount or concentration of salt dissolved in a liquid (usually water)
Seagrass bed – An area of sand or mud where seagrass is growing

Mkukii aina ya hapuni – Mshale mzito mrefu (silaha yenye mpini mrefu na ncha kali) uliofungwa kwenye kamba, unaotumiwa kuvulia samaki; ni mtego haramu Zanzibar
Kofia ya barafu – Tabaka la kudumu la barafu nene na theluji inayofunika ncha ya Kaskazini na kusini ya dunia na vilele vya milima mirefu
Njia ndogo – Kishorobo chembamba cha maji kinachoingia ndani kutoka baharini au ziwani
Dawa ya wadudu – Dawa ya kemikali inayotumika kuulia wadudu waharibifu
Mdogo – Mchanga, mnyama ambaye hajakomaa kijinsia na kimaumbile
Rasi – Eneo la bahari ambalo limetenganishwa na bahari kuu kwa mwamba (= mstari wa mawe, mchanga au matumbawe ambao upo kwenye maji ya kina kidogo)
Shimo – Kuondoa takataka nyingi kwa kuzizika, au mahali ambazo takataka huzikwa
Latitude – Masafa kutoka Kaskazini au Kusini ya Ikweta
Bustani – Shamba ambalo majani (nyasi) huota
Tia nanga – Kuifunga mashua, ngalawa ili ibaki mahali pamoja
Boya la nanga – Boya lililotiwa nanga chini ya bahari kwa kutumia kamba imara au mnyororo, ili mashua ziweze kujifunga kwenye boya hilo na kutulia bila ya kuhitaji nanga.
Kuondosha kizazi – Kuondoa hasua au ovari (kifumbambegu) kutoka kwa mnyama dike au dume kwa kutumia upasuaji ili asizae
Vifundo – Mahali kwenye kigogo cha mti ambapo majani au mizizi huota
Nchi kavu – Kuelekea nchi kavu kutoka baharini / nchi kavu zaidi na sio baharini
Bahari kuu – Maji ya bahari amabyo yapo mbali na nchi kavu na ya kina kirefu
Mharibifu – Mdudu, mnyama au fangasi ambaye anaharibu mazao au chakula
Dawa ya wadudu waharibifu – Ni kemikali inayotumika kuuwa viumbe viharibifu mfano wadudu, magugu na fangasi
Usanidi mwanga – Mchakato ambao mmea hutumia nishati inayotoka kwenye mwanga wa jua kuzalisha chakula chake
Mzizi wa hewani – Mzizi unaoota kwenye hewa (mzizi wa hewani), unaouwezesha mmea kufyonza gesi kutoka hewani hata kama (mmea) unaota katika maji
Polipu – Mnyama mdogo sahili wa majini kama anemone, ambaye amehusiana naye kwa karibu (sana)
Polisterini – Plastiki nyepesi yenye mapovu ya hewa, inayotumika kuhifadhia na kulinda vitu dhaifu, au huwekea vitu moto au baridi
Mbegu za mikoko – Kipande cha mmea kinachovunjika na kuota mmea mwengine, kama miche ya mkoko inayochipua juu ya mti huo kabla ya kuanguka
Pangaboi – Sehemu ya mota inayozunguka yenye viwembe viwili au zaidi, ambayo inazunguka katika maji au hewa kuifanya mashua au ndege iende
Uchimbaji – Utoaji wa rasilimali kama mawe na metali kutoka ardhini
Yenye kumudiu / Imara – Inayoweza kurudi hali yake ya zamani nzuri haraka baada ya kuharibiwa
Rizomu – Kigogo cha baadhi ya mmea vinavyoota kulalo juu au chini ya ardhi na inayotoa mizizi na majani
Uchumvi chumvi – Wingi wa mkusanyiko wa chumvi iliyoyeyuka katika kitu cha majimaji (kwa kawaida maji)
Kitalu cha nyasi bahari – Eneo la mchanga au tope ambapo nyasi bahari zinaota

Shore – The strip of land along the edge of a sea, lake or wide river shores can be sandy, rocky or muddy

Snorkelling – Swimming underwater breathing air through a snorkel (breathing tube)

Souvenir – Something you buy or keep to help you remember a holiday or special event

Species – A group of living things (which may be a kind of animal, plant, fungus or bacteria) which are similar to each other, and can breed with each other but not with members of other groups

Subsistence – The state of having enough of the things you need in order to stay alive, but none to spare

Tanning – Converting animal skins and hides into leather using a dyeing / preserving agent such as mangrove bark

Tidal – Influenced by tides

Tides – Regular rise and fall in sea level (twice a day) caused by the gravitational pull of the moon (and sun)

Tsunami – An extremely large and destructive ocean wave caused by an underwater earthquake or earth movement

Yard sale – Selling unwanted household items from a stall outside your home, sometimes carried out by several neighbours on the same day

Zooxanthellae – Single-celled plants that live in the tissues of animals such as corals, which contain pigments that give them colour

Ufukwe – Kishorobo cha nchi kavu kwenye ukingo wa bahari, ziwa, au mto mpana; fukwe zinaweza kuwa za mchanga, mawe au tope

Kuogelea kwa kutumia kioo – Ni kuogelea kwa kutumia kioo na mrija wa kuvutia hewa

Zawadi ya ukumbusho – Kitu unachonunua au unachoweka kukusaidia kukumbuka tokeo maalum au nchi uliyotembelea

Spishi – Kundi la vitu vinavyoishi (ambavyo vinaweza kuwa aina ya mnyama, mmea, fangasi au bacteria) ambao wanafanana na wanaweza kuzaliana wenyewe kwa wenyewe lakini si pamoja na wengine wa makundi mengine

Kujikimu – Hali ya kuwa na vitu vya kutosha unavyohitaji ili kukuwezesha uishi, lakini huna cha kuweka

Tia rangi ya hudhurungi – Kubadilisha ngozi ya wanyama kuwa ngozi ya kutumiwa kwa kutumia dawa ya kuhifadhiwa / kupaka rangi ili isiharibike kama vile magome ya mikoko

Ya maji kujaa na kupwa – Inayosukumwa na maji kujaa na kupwa

Maji kujaa na kupwa – Kupanda na kushuka kwa kawaida kwa viwango vya bahari vinavyotokana (mara mbili kwa siku) na mvuto wa graviti wa mwezi (na jua)

Sunami – Wimbi kubwa sana la uharibifu linalosababishwa na mtetemeko wa chini ya ardhi au mwendo wa dunia

Biashara ya uwanjani – Kuuza vitu vya nyumbani katika genge nje ya nyumba yako, mara nyingine inafanywa na majirani wengi siku hiyo hiyo

Mwani mdogo – Mimea yenye seli moja ambayo inaishi katika tishu za wanyama kama matumbawe, ambayo ina kitu chenye rangi kinacho ipatia rangi mimea

English – Kiswahili dictionary

Some other English words that might be new:

abandon – tekeleza
admonition – onyo
aggregate – mkusanyiko
beast – mnyama, hayawani
bizarre – ya ajabu
bleaching – kupausha
boom – sitawi sana
bounty – ukarimu, karimu
cage – tundu
chop – kata
cope – mudu, weza
cyclone – kimbunga
deliberately – kwa makusudi
devastate – teketeza, angamiza
edible – inayolika
eradication – angamiza
field – shamba
flourish – stawi
fortunate – a bahati
fragile – rahisi kuvunjika
glossy paper – karatasi inyong'ara
grassy – yenye nyasi
hatch – angua
heal – maliza, ponya
heaven – pepo
insulator – kizio cha joto
irreplaceable – isiyorudishika mahali pake
kick – piga teke
kitten – paka mchanga
lawn – bustani
lobby – shawishi
lush – enye kustawi
mend – rekibisha
ordained – agiziwa, amrishwa
ornamental – a mapambo
outboard motor – mashine ya nje
pee – kojoa
pigment – rangi ya asili
pit toilet – choo cha shimo
porous – tundu tundu
precious – a thamani
predator – anayekula wanyama wengine
recreation – burudani, buni upya
refuge – kimbilio, hifahi
render – toa
revel – sherehe
rife – tapakaa
scaffolding – jukwaa
scar – kovu
seaward – kuelekea baharini
secure – hifadhi
seek – tafuta
soar – panda sana
soot – moshi
spectacular – kuvutia
spill – mwanga
storm – dhoruba
subdue – shinda
swiftly – kwa haraka sana
tangled – iliyosokotana
teeming – jaa
transgress – kuipa mpaka
trigger – anzisha
uninhabitable – isiyokalika
vanish – toweka
vivid – dhahiri, wazi
waxy – iliyopakwa nta

10 Take action

Quick and easy ways we can all help protect the environment, every day!

1 **Environment & sustainability** – Mazingira na uendelevu

- Follow ECO-Practice (Environmental Code of Practice) (see inside front cover of this book) all the time
- Whenever making a decision that might affect the environment, ask yourself if the environment would be better or worse if everybody made that decision, and choose the sustainable option
- Talk to your friends and family about the environment and why conserving it is important
- Support local co-ops such as women's groups by buying from them and promoting them

2 **Biodiversity** – Bioanuai

- Don't keep wild animals as pets, including parrots, wild-caught fish or monkeys
- Avoid cutting down trees and don't buy wood products from endangered hardwoods: choose sustainable coconut wood or fruit orchard waste instead
- Don't buy products made from endangered animals, e.g. ivory or coral
- Have your cat neutered
- Encourage wildlife by growing native trees
- Discourage crows: make sure you dispose of rubbish, especially food waste, where they can't access it
- On days out in Zanzibar, support local community businesses and visit conservation initiatives which are reducing their impact on the environment and helping protect wildlife

3 **Mangroves** – Mikoko

- Don't cut mangrove for firewood or charcoal: choose sustainable alternatives where available
- Buy wood and paper from sustainable sources
- Recycle paper and cardboard, and buy recycled paper products
- Use both sides of paper and reuse envelopes

4 **Seagrass** – Nyasi ya bahari

- Don't let your boat or anchor scrape the seagrass
- Don't collect pebbles or shells, or take rocks or sand from the beach for building materials

5 **Coral reefs** – Miyamba ya matumbawe

- Never drop litter, especially on a beach or near the sea
- Don't collect or buy shells or coral
- Ask how your fish was caught, and never buy fish caught with spear guns or dynamite

6 **Fisheries** – Uvuvi

- Observe closed seasons for invertebrate collection
- Choose sustainable seafood: eat line-caught or trapped local fish from sustainable stocks, avoid eating overfished species, and never eat endangered species such as sharks or parrotfish
- Don't collect, buy or sell marine creatures such as tritons as tourist souvenirs: they are illegal to export!

7 **Pollution** – Uchafuzi wa mazingira

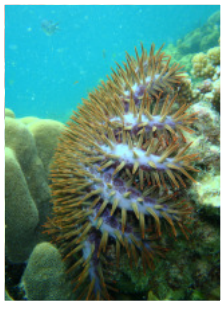
- Dispose of litter and household rubbish responsibly, especially plastic: reduce, reuse, recycle
- Get your car mended if the exhaust is smelly or black
- Reduce use of harsh household chemicals and keep them out of drains and the water supply
- Grow food organically i.e. natural compost for fertilizer and no pesticides
- Go to the toilet in a place that's safe for the environment – not on the beach!
- Avoid unnecessary packaging: take your own bag or basket when you go shopping
- Compost kitchen and garden waste such as vegetable peelings and leaves
- Don't leave broken glass around – someone might cut themselves and it can even start a fire
- Recycle dead batteries properly
- Don't drop litter on the beach, in the sea, or anywhere

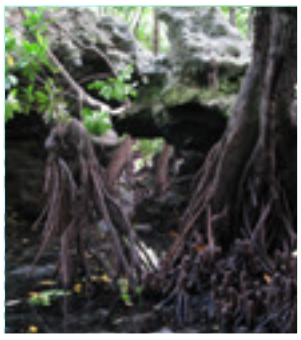
8 **Climate change** – Mabadiliko ya hali ya hewa

- Save energy: switch off lights and electrical appliances when not in use, and use energy-saving light bulbs
- Cook food faster, using less fuel, by cutting it smaller, and use a pan lid to keep the heat in
- Take public transport, walk or cycle, rather than drive, and take the ferry instead of flying
- Save water: only boil as much water as you need, and don't leave taps running – wash dishes and vegetables in a bowl, not under a running tap
- Choose plants and crops that grow well in dry conditions so do not need much water

Learn about:

+ The fascinating plants and animals that live around us – and why we need them!
+ How the natural environment helps to protect our homes, feed us, and keep us healthy.
+ How to benefit from nature without harming it.
+ Choosing seafood wisely to protect stocks and other wildlife.
+ How to make a living while protecting the environment for the future.
+ Turning waste into valuable raw materials.
+ How we all benefit when we clean up our beaches and communities.
+ How we can all act to protect our environment for the future!





The award-winning **Chumbe Island Coral Park** is a Marine Protected Area in Zanzibar that is self-funded through eco-accommodation located on Chumbe Island. Guest fees fund coral reef monitoring and research projects, and sponsor environmental education trips to Chumbe for 500-600 local students per year. The island's 7 exclusive eco-bungalows are constructed with innovative, environmentally friendly architecture, including rainwater catchment, photovoltaic energy, solar water heating, composting toilets and vegetative grey-water filtration.

CHUMBE ISLAND CORAL PARK
Zanzibar Tanzania

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