Coastal Geomorphology

A coast is a zone where the land and sea over lap and interact. A coast can either be gentle or steep, sandy or rocky. In east Africa, coasts are along the lakes and along the Indian Ocean.

Waves

These are defined as Undulations on the surface of the water caused by winds blowing across it. When the wind blows over the water, there is friction between the water and the wind. Energy is transferred from the wind to the water and forms the wave which normally moves along in the direction of the wind.

Waves can also be generated by tectonics movements such earth quakes that move under the sea, large whales, submarines, volcanic eruptions etc. Waves are the chief agents of marine erosion, transportation and deposition along the coast.

Each wave has a swash and back wash effect.

Illustration

The forward movement of a wave is known as the swash and it is usually more powerful when the wave breaks and retreats and then the back wash is formed.

Waves can be constructive or destructive. Waves which are constructive lead to deposition and its associated Landforms. Waves can also be destructive leading to erosion and its associated landforms or features.

Landforms resulting from wave erosion or formed by wave erosion.

Waves are very effective agents of erosion and wave erosion occurs through the following processes;

Hydraulic action, Abrasion, Attrition, Solution

- **Hydraulic action.** When a wave hits for cliff at the coast with great force, it compresses the air in the joints and cracks in the Cliff. When the wave retreats, this pressure is released explosively. When this pressure release action is repeated, the rock is stressed, cracks are then enlarged and pieces begin to fall off the cliff.
- **Abrasion**. It occurs when the rock particles that have been broken off by hydraulic action are thrown by the waves at the cliff. They erode it at the base leading to undercutting of the cliff.
- **Attrition.**

It occurs when the rock fragments and pebbles are knocked against each other in the water and become smaller and more easily removed.

- **Solution.**

it occurs in soluble rocks such as limestone is dissolved and washed away. However, no visible rock fragments are left. All these processes together produce landforms which include cliffs, caves, good etc. as explained below.

1. **A Cliff**

It's a steep slope or rock face along the sea or coast. It might be 400m in height or quite below. Cliffs may either be vertical or slanting. The formation of cliffs depends on the nature of rocks, their stratification and jointedness, their resistance to erosion and their homogeneity or heterogeneity. Cliffs are formed by waves that attack a gently sloping land towards the sea or lake resulting into the formation of notches.

These notches or cuts are created by waves through the processes of wave erosion like hydraulic action or abrasion. These notches are very common on rocks which have well developed gorges. continuous wave erosion, weathering and mass wasting results into the collapse and retreat of gently sloping rock leaving behind a steep rock surface along the sea or lake. Best examples of cliffs in east Africa include fort Jesus near Mombasa, port Garaza near Tiwa and at kasenyi on the shores of Lake Victoria.

Illustration

2. **Wave cut platforms.**

This refers to a gently sloping bend like rock sloping seaward below the Cliff. They form between low and high water tides. It's formed as a result of water attack on the cliff. These waves force the cliff to collapse and slowly retreat. This results unit the creation of wave cut benches through the grinding action of materials swept back and forth by the breaking waves. These benches are finally enlarged into wave cut platforms e.g. at Tiwi beech in Kenya and the oceanic hotel at Mombasa was built on wave cut platforms.

Illustration

3. **Bays and headlands.**

Bays and Headlands are indented coasts where water either projects into the adjacent land or land projects towards the sea. They are formed where there are alternating hard and soft rocks which lie at right angles to the coast.

Bays are wide indentions where the sea or lake projects towards the land. They are as a result of differential erosion of the soft rocks where the eroded soft rocks are forced to curve in into which the sea or lake water flows or follows. Best examples can be found at Sango bay, Murchison bay, the Napoleon Gluff, Barckley Gluff and Speke gluff on Lake Victoria and Watamu and Malindi bays in Kenya.

Headlands on the other hand are projection of land and resistant rocks protruding towards the sea. When the soft rocks are eroded to form bays and resistant rocks remain and stand out as headlands.

Illustration

4. **Caves**

Caves are holes or tunnels that are dug into the cliff. They develop from waves that enlarge an initial line of weakness in the rock especially along joints, faults and bedding plains. The breaking waves through the processes of abrasion and hydraulic action compress the air the crevices, joints and holes within the cliff face. When the water retreats, the air expands rapidly. This expansion and compression loosens the rocks and enlarges the cracks which later results into the formation of cylindrical tunnels called caves.

In some cases, the force of waves spurting into the air may weaken the roof of the cave so much that the roof collapses. The resulting landform is a vertical shaft or tunnel connecting the cave to the cliff top. This landform is called a blow hole or gloup.

When the entire roof of the cave collapses due to wave erosion along the major joints or faults, the resultant landform is called a geo.

5. **Arch, stack and stump.**

An arch is a bridge like feature found above the cave. It's formed when a cave is curved into the side of the headlands or where the caves develop on either side if a headland and they alternately join.

With continued wave erosion on the headland, the arch may collapse leaving behind an isolated rock mass separated from the main land called a stack. Best examples can be found at the rock pillar Stack near Entebbe airport at Kasenyi fish landing site. An arch is found at Vasco da Gama pillar in Malindi.

Illustration

Continued wave erosion of the stack may lower it below water level or maybe submerged at high tide to form a stump.

Landforms formed from wave deposition

For wave deposition to take place, the materials have to be moved along the shores by longshore drift i.e. a mechanism in which waves transport eroded materials before they are deposited to form various landforms.

The major wave deposition features include beaches, spits, bars, mudflats etc.

1. Beach

A beach is an accumulation of materials deposited by waves mostly consisting of sand, shingle or both along the coast. They are gently sloping coastlines of sane and shingle which are transported and deposited along the coast by longshore drift. It's formed when constructive waves remove materials from the bottom of the sea and deposit them at the shores where they accumulate. Beaches maybe submerged at high tide or may be exposed at low tide e.g. Nyaki beach in Kenya near Mombasa. Others include Nabugabo, Butembe, Gaba, Lido etc. along the shores of Lake Victoria.

Illustration

Types of beaches

1.1. Barrier beach

These are long Sandy ridges of islands lying parallel to the coast and separated by a lagoon. They are formed on gently sloping coastlines by longshore drift and waves breaking off shore materials are deposited under water as off shore sand bars and appear above high tides. Wave action gradually moves the deposits on the main land as barrier beaches. They are referred to as barrier islands when they are not joining the Coast.

Illustration

1.2. Beach cusps

These are projections of Sand and shingle that are cone shaped with an apex facing sea wards formed by eddies or head currents of a powerful swash.

or these are series of small horn shaped projections separated by shallow indentations that face sea wards giving the beach a pointed appearance. Cusps are formed mostly where waves break parallel to the shore and most cusps develop on exposed beaches where large waves are frequent.

1.3. Bay head beach.

It is a crescent of sand and shingle lying between headlands. Examples include Lutembe beach, lido beach, and Bugonza on the shores of Lake Victoria.

1.4. Spits

A spit is along narrow accumulation of shingle and sand in a linear form with one end attached to the land and the other projecting into the sea or across the estuary. A spit may link two headlands to form a bay bar. Spits develop from the movement of materials by longshore drift.

When the long shore drift operates across a river mouth, a zone of slack water develops between the long shore drift and river and any material carried by longshore drift is deposited.

The deposited material forms a spit. The main condition for the formation of spits is the presence of an ample longshore drift materials together with an irregular coastline. Examples include Kaiso and Tonya spits along the shores of Lake Albert.

Illustration

2. Tombolo

This refers to a spit that grows out from the coast and links an island to the mainland. The ideal condition for the formation of a Tombolo is an ample supply of debris for wave deposition to form connecting ridges and a low tidal range such that the deposited materials are not carried away. Best examples are found at Lambu Island which is joined to the mainland at Masaka

Illustration

3. Sand bar

This refers to a ridge of sand, mud, gravel and shingle deposited off shore and parallel to the coast. It's formed on gently sloping coasts and shorelines with an irregular shape. Its formation is attributed to waves that move or drift the materials along the shore or as a result of backwash combining the materials directly behind the beach.

Similarly, long breaking waves cause the sand grains to move seaward resulting into accumulation of materials on the submerged line known as break point bar. The repeated process leads to the formation of a bar behind which develops a lagoon, mud floods and mashed.

4. Bay bars

Bay bars form where spits continue to grow in length and link the two headlands which later enclose a lagoon and mashed. Examples are on lake Nabugabo in Masaka which is enclosed by Rwamunda swamp and lake Nabugabo was cut from Lake Victoria as a bay bar.

Illustration

5. Coastal dunes

these develop on coasts where winds are predominantly onshore and are sufficiently strong enough to move a large supply of sand inland from a wide beach area. They are Common along arid and semi-arid coasts.

6. Mud flats

Mud flats form when tides and waves deposit fine materials such as silt along gently sloping and sheltered coasts. The deposition of large quantities of Alluvium results into the building of a plat form of mud mixed with water called a mud flat e.g. the mud flats along the east African coast which are occupied by mangrove swamps and forests.

SEA LEVEL CHANGES

sea level changes refer to relative movements in the level of water in the sea, Ocean, lakes relative to the adjacent land. When the sea level changes on a worldwide, it's known as eustatism or an eustatic change. water in the sea is never constant.

Sometimes the level or water in the sea or ocean can rise relative to the land and this is referred to as submergence or positive change.
At times, the level of water in the sea or ocean Lowers or reduces relative to the land and this is known as emergence or negative sea level changes.

Therefore, sea level changes or base level changes involve two processes i.e.

- ✓ submergence or positive base level changes
- ✓ Emergence or negative base level changes

Sometimes the change in sea level is Worldwide and uniform which indicates an actual movement of the sea itself. This is known as eustatic sea level changes.

EMERGENCE

Emergence refers to where the land has risen relative to the sea or where the sea level has fallen relative to the adjacent land. This results into exposure of features that are formally under water and can be seen.

Causes of emergence

- ✓ Rise in the level of the adjacent land due to isostatic uplift.
- ✓ Fall in the level of the sea level due to drought, glaciation, global warming, widening of the sea floor etc.

SUBMERGENCE

Submergence refers to a situation where coastlines fall relative to the adjacent land or where the sea has risen relative to the adjacent land or Coast.
This therefore leads to formally exposed land / features being covered by water (indulated)

CAUSES OF SUBMERGENCE

- ✓ fall in the level of the adjacent land due to relative sinking (Down warping)
- ✓ Rise in the level of the sea because of illuviation, deglaciation, narrowing of the ocean floor etc.

CAUSES OF SEA LEVEL CHANGES

1. **climactic factors**

Temperature changes can also lead to sea level changes. High temperatures result into prolonged droughts hence high rates or excessive evaporation leading to a fall in the sea level relative to the land adjacent.

Temperature changes leads to expansion and contraction of the sea water. A rise in temperatures of the water will cause its expansion which later brings about submergence while a fall in temperatures results into contraction of sea water which later brings about emergence.

Pluviation i.e. increased precipitation or rainfall leads to a rise in sea level relative to the adjacent land while desiccation i.e. decrease in rainfall totals leads to a fall in sea level relative to the land. E.g. in 1997 - 1998 Uganda experienced el-Mino rains which led to an increase in water in lakes causing submergence. In 2010, there was a prolonged drought period which resulted into emergence due to reduced water in lakes as a result of excessive evaporation.

2. **Glaciation and deglaciation**

Deglaciation involves the melting of Ice due to a rise in temperatures. The melt waters lead to the release of large quantities of water which flow into the Sea leading to a rise in the sea level.

On the other hand, during periods of major glaciation, there is a drop in global temperatures. Water is frozen off into large ice masses in the Polar regions and mountains which cause a universal fall in the sea level.

3. **Tectonic movements**

These are related to processes of warping, faulting, volcanicity and seismic activity. Up warping of coastal areas and down warping of ocean basins leads to a fall in the sea level resulting into emergence while down warping of coastal areas and down warping of the ocean basins results into the rise of the sea level (submergence).

Enlargement or expansion of the ocean basins due to plate divergence leads to a fall in sea level (emergence) e.g. the Atlantic Ocean is experiencing emergence of its coastlines since it's getting larger as plate movements cause north and South America to drift away from Europe and Africa respectively.
On the other hand, contraction it ocean basins due to plate convergence leads to a rise in sea level.

4. **Volcanism:**

volcanoes at constructive plate boundaries and subduction zones displace water causing rise of sea level relative to the land.

5. **Isostatic re-adjustments**

The word isostasy is a Greek word meaning equal standing. The structure of the earth is in such a way that lighter rocks (sial) are sitting on denser rocks (sima). Due to isostatic re-adjustments, large amounts of weight e.g. glaciers, buildings, deposited debris etc. may be loaded or unloaded onto a region which may cause the land to sink or to rise and consequently cause emergence or submergence.

The addition of materials on continental areas increases weight causing continents to sink slowly hence a rise in the sea level e.g. ice accumulation during the Ice Age. After the melting of the ice sheets, the isostatic uplift of land masses occurred leading to a fall in sea level.

6. **Sedimentation.**

Deposited sediments in the sea or ocean basins by in flowing rivers reduce the size and depth of the ocean basins leading to a rise in the sea level hence submergence.

7. **Human activities**

The pumping of water or oil for the ground can lead to the gradual sinking of the ground which results into emergence.

Man can also carryout dredging or desilting of coastlines which results into emergence. Sometimes sand mining at the coast can also bring about emergence. this is because the size of the lake basin is enlarged therefore bringing about lowering or drop or decrease in the water level.

Pouring of sewage and other sediments in the lake brings about submergence since the sediments try to fill the ocean basin and causes the rising of water.
in some countries, there is pouring of expired food, items like wheat, rice etc. in the ocean and this brings about submergence.

8. **Global warming**

The world's temperatures have been increasing over the years by at least 0.6 degrees Celsius or 1 degree

This increase in global temperatures has been due to man's misuse of the environment involving deforestation, burning of fossil fuels e.g. coal, oil and natural gas etc. which reduces

gases that trap heat in the atmosphere e.g. carbon-dioxide and carbon-monoxide which makes the climate to become warmer. This has resulted into melting of snow and ice e.g. at the poles resulting into submergence.

In the tropics, global warming has led to the reduction of glaciers which are potential sources of water to rivers that flow into oceans. This has resulted into reduction in the volume of water flowing into the seas and oceans hence bringing about emergence.

FEATURES OR LANDFORMS RESULTING FROM SEA LEVEL CHANGES

LANDFORMS RESULTING FROM SUBMERGENCE (RISE IN SEA LEVEL)

when the water level in the sea or oceans rises, areas or features which were not formerly in water become submerged.

Submerged features fall into two categories i.e.

- ✓ Highland features
- ✓ Lowland features

Submerged highland features

1. **Rias**

It's defined as a long narrow water inlet at the coast. Before the sea level rises, a river flows into the ocean through a Valley. When sea level rises, the valley is flooded or submerged by the rising water levels to form a ria. It's formed with a shape of a funnel and decreases in width and depth inland. Examples can be found along the coast of east Africa at the mouth of the Mwachi river which forms the Kilindi harbor at Mombasa, the drowned river mouth of the Kombeni river which forms the Mombasa harbor.

Illustration

2. **Dalmation coastline / longitudinal coastline.**

These are submerged tops of hills or highlands. They are formed in areas where hills and valleys lie parallel to the coast before submergence.

When the sea level rises, the valleys become flooded with water and the hills remain as chains of islands within the ocean and run parallel to the coastline. The water within the drowned valleys that separates the chains of islands from the main land is known as a sound.

Examples include the Smith sound west of Mwanza on Lake Victoria, the Pemba and Zanzibar coasts etc.

Illustration

3. **Fiords**

These are submerged or drowned U-shaped glacial troughs or valleys formed along glaciated coasts. They have steep walls often rising straight from the sea. When the sea level rises, the coast is submerged and the lower parts of the U-shaped valleys or glacial troughs are and filled with water hence forming fiords. They are usually steep sided and very deep. There are no examples in east Africa but there are many at the coast of Norway, British Columbian coast, at the Coast of Chile etc.

llustration

SUBMERGED LOWLAND FEATURES

4. **Estuaries**

These are submerged or drowned river valleys with a V-shaped cross profile pointing landwards. It is formed when the sea level rises along a low lying Coast causing the sea to penetrate Inland along river valleys eg the rufigi and kibanga estuaries. They are similar to Rias only that Rias form in highland coasts while estuaries form in lowland coasts.

5. **Creeks**

These are narrow inlets formed by submergence of small streams. They are similar to estuaries only that they are smaller. Best examples of creeks are mfwapa, Tudor, reitz and kilifi all formed due to sinking of small rivers and streams along the East African coast.

6. **Mudflats and lagoons.**

Mudflats are deposits of fine silt and alluvium of rivers to form plat forms of mud. Sediments are deposited in shallow water either behind shingle, bars, sand spits, or sheltered parts of estuaries and bays. At the Coast, such deposits enclose water and separate it from the rest of the sea to form a lagoon.

LANDFORMS FORMED DUE TO EMERGENCE

GENERAL ILLUSTRATION SHOWING THE DIFFERENCE LANDFORMS.

1. **Raised cliff**

Initially a Cliff is formed where the sea is in contact with the land. Through the phases of hydraulic action and abrasion, a notch is created and it becomes deeper due to continued wave erosion. When the above land loses support it collapses and a cliff is formed. when the sea level falls, the cliff is left isolated and it's no longer in contact with the water and therefore it's left behind at high tide to form a landform known as a raised cliff.

2. **Raised terraces**

Initially a wave cut platform develops at the coast as a cliff retreats. When the sea level falls, the Former wave cut platform is no longer in contact with the water and is now known as a raised terrace. An example of a terrace is at Lutembe beach where it was formed when the water level of Lake Victoria fell at one time.

3. **Raised beach**

This is formed when sea level falls such that the former beach is now left above the new water level which is above the present zone of deposition. This beach which is left suspended above the present water level is referred to as a raised beach. Best examples are found at Bagamyoyo in Tanzania where three layers of raised beaches can be found and at the Mamangina in Mombasa-Kenya.

4. **Raised caves**

Initially a hole develops in the cliff face where there is a joint in the cliff. Through continued hydraulic action and abrasion, the hole becomes larger and finally the cave forms. When the sea level falls, the cave is left high above the high tide level and with no anymore contact with the sea which is now known as a raised cave. 8

5. **A raised geo**

It's formed where the entire roof of a cave collapses through erosion to form a narrow water inlet called a geo. When the sea level falls, it will not be in contact with the sea level and therefore it will have no water in it. It's now called a raised geo.

Economic importance of features resulting from sea level changes

- Rias and fiords are used in the construction of natural harbours e.g. kilindini and Dar-es-salaam harbors.
- The landforms formed due to rise and fall in sea level are important tourist attractions and this brings in both local and foreign income in the respective countries
- The landforms are important sites for education and research.
- Mudflats are reclaimed for agriculture purposes and this improves on the food security in the country.
- Rias form natural route ways inland
- The raised beaches are used for sand mining.

Negative

Settlement is difficult along the sides of a fiord because of lack of level land.

the mudflats, swamps and marshes are breeding places for disease causing vectors eg mosquitoes etc.

there is a problem of occasional flooding especially in areas covered by Mudflats and this leads to destruction of property.

CORAL REEFS

Coral reefs are rock Platforms formed from the continued deposition and accumulation of shells or skeletons of marine organisms known as coral polyps.

Coral is a limestone rock made up of the skeletons of the tiny marine organisms ie coral polyps. The polyps usually live in closely peached colonies of thousands and their skeletons are made up of calcium carbonate.

When the polyps die, their skeletons and shells accumulate at the bottom of the sea and they are eventually compressed together with time by their own weight, consolidated and cemented together to build a coral reef. other organisms such as echinoderms and calcareous algae help to cement the space between the skeletons.

After a long time, hard rocks known as coral reefs are formed. Example are found at the east African coast along Kenya and Tanzania

CONDITIONS NECESSARY FOR THE FORMATION OF CORAL REEFS

Requires hot temperatures if the tropical climate ranging between 20-30^0 C which are ideal for the growth of coral polyps. They are found manly in the tropical and in the near tropical seas and oceans within 30^{0}N and S of the equator. They are mostly found on the Eastern side of land masses where warm ocean currents increase the sea temperatures hence allowing the growth of corals.

On the western side of landmasses, there are cold ocean currents which lower the temperatures hence preventing coral growth.

It requires salty, oxygenated sea water of between 27-40 parts per 1000 for calcium carbonate to precipitate hence enabling the growth of coral polyps. Salinity encourages coral growth since coral polyps take up calcium carbonate from sea water to build their shells.

It requires a shallow continental shelf with a depth of between 20-60m to allow the penetration of sunlight which is ideal for the growth of coral polyps.

There should be presence of clear silt free water and calm or stable water. The clear water allows light to penetrate to lower levels while the calm water allows the accumulation of coral polyps to form coral reefs. Coral reefs grow away from River mouths where silt laden water pours into the sea and dilute the salt concentration and destabilize coral formation.

There is need for a solid rock bed along the coast upon which coral reefs form or accumulate.

Availability of planktons which act as food for the coral polyps. Food supplies are usually most plentiful on the sea ward of a growing reef so that corals tend to grow more rapidly outwards.

Sea level changes caused by submergence of the coast which encourage coral deposition. A fall in the sea level exposes the coral polyps and they eventually die.

Presence of Minute sea organisms (very tiny) called polyps which die and their skeletons pile and accumulate to form Coral reefs.

TYPES OF CORAL REEFS

There are three types of coral reefs namely
Fringing reefs
Barrier reefs
atoll reefs

FRINGING REEFS

This consists of a platform of coral which is joined to the coast and extending sea wards for about 1km. It's separated from the coast by shallow and narrow lagoon of about 500 -2000m. Best examples can be found at kilifi and Tiwi at the coast of the Indian Ocean.
Illustration

BARRIER REEFS

These are coral platforms which are separated from the coast by a wide and deep lagoon. Barrier reefs are found several kilometers off the coast.
Illustration

ATOLL REEF

This is a circular shaped coral platform enclosing a mass of water to form an atoll. It has a fairly deep lagoon but it's generally broken in places by a narrow channel. Eg the Gilbert and Ellie islands on the Pacific Ocean and chumbe Island South of Zanzibar.
Illustration

NOTE

The process of coral formation involves:

- Coral landforms or reefs form when coral polyps die
- Skeletons of dead polyps drop and accumulate on the continental shelf.

- With continued accumulation of skeletons of polyps over time, there follows compression, compaction, cementation and consolidation of fossils thus corals are transformed into coral reefs.
- Living organisms e.g. algae help in cementation to turn limestone rocks into Coral reefs.

THEORIES FOR THE FORMATION OF CORAL REEFS

The formation of barrier reefs and atolls have created a lot of controversy as they have been found at far greater depth, in some cases exceeding 1000m a level where polyps cannot survive. As a result, relevant theories have been formulated to account for the origin of coral reefs.

These theories include the following;

Darwin's theory
John Murray's antecedent theory
Daly's theory of deglaciation

DARWIN'S THEORY OF SUBSIDENCE / SUBSIDENCE THEORY.

Darwin proposed his subsidence theory in 1842 when he was trying to account for the formation of coral reefs. According to this theory, it's states that originally there was presence of a volcano or volcanic island on the sea floor. The coral polyps colonized the edges of the volcano and later formed a fringing reef.

The volcanic island together with its fringing reef that had formed subsided or sunk as a result of isostatic re-adjustments that followed subsequent eruptions. Such subsidence increased the water depth beyond the level at which coral polyps can survive. The coral polyps subsequently died while some tried to grow to keep pace with changes in water depth.

The fringing reefs on the flanks of volcanic islands grow upwards and eventually grow into barrier reefs and finally into atolls When the volcano has completely submerged or sunk.

Illustration

RELEVANCE OF DARWIN'S THEORY

The theory is relevant because there was actual submergence of the east African coastline evidenced by the presence of Rias and Mudflats in the submerged coastal areas.

There is presence of volcanic islands off the East African coast in the Indian Ocean.
However, critics of Darwin's theory down Play its relevance by arguing that some coral reefs have also been found in areas where there is no evidence at all of submergence and also that

some coral reefs have also been found at a great depth denying the assumption that when sea level increases or rises, coral reefs grow to keep pace with increase in the water level.

JOHN MURRAY'S ANTECEDENT THEORY

This theory assumes that coral reefs developed on a platform of pelagic deposits. Murray assumed that there were uneven growth rates of coral reefs grew up on the banks of their own debris and there was more rapid growth on the sea ward than on the land ward sides.

The platform provided a base for atoll formation. Corals first grew as fringing reefs then into barrier reefs then finally as atolls.

As the reefs grew upwards and outwards, those on the inner or landward were deprived of food causing them to die. The skeletons of sea organisms dissolved into water such that a feel lagoon formed or developed inside the reefs. According to Murray, there was no subsidence in it.

Illustration

RELEVANCE OF MURRAY'S ANTECEDENT THEORY

The proposers of this theory identified the barrier and fringing reef at Maryote between Madagascar and Mozambique. Atoll were formed around Aldabara as evidence to support this theory.

More pronounced coral polyps grow on the sea ward side than the Land Ward Side.

fragments of coral do exist in lagoons between reefs proving the idea of dissolving dead corals to form lagoons.

The steepness of the coral reefs is greater on the seaward side than on the landward side.

DALY'S THEORY OF DEGLACIATION

According to this theory, there existed submarine platforms or hills from which peri-glacial coral reefs were eroded and planed to the sea level. Barrier reefs and atolls started formation on the flanks or foot hills of these hills as fringing reefs.

Deglaciation emptied vast quantities of melt waters into the sea such that there was a rise in sea level.

As sea level rose, the coral reefs which had started growing on the platforms or hills as fringing reefs gradually transformed into barrier reefs and finally into atolls when the hills were completely submerged. This took place because the upward and outward growth of corals was able to keep pace with the rate of rise in sea level and be maintained at the water surface.

Illustration

ECONOMIC IMPORTANCE OF CORAL REEFS

- Some corals are precious e.g. this with a hard core are used by craft men to curve out jewelry materials.
- The lagoons cut off from the ocean are good for water sporting and swimming since they are normally free from dangerous fish e.g. sharks and whales.
- Reefs especially the fringing type shelter the coast from strong waves. The water above the reef is shallow which helps to check the speed of the approaching waves leading to the development of sheltered harbors.
- Research shows that the existence of corals is an indication of the possible presence of petroleum at the east African coast. The polyps which die have fats which accumulate into oil wells in sedimentary rocks. Therefore, the east African coast has some deposits of oil which when exploitation begins, they may help in economic development.
- The variety of shapes in which they appear e.g. sea fan corals, dwarf corals, reef building corals, mushroom corals, soft corals are a tourist attraction. Tourists to the east African coast normally carry them as souvenirs.
- Corals are important sources of calcium carbonate which is limestone which when processed into cement is an important raw material in the building and construction industry of both Kenya and Tanzania e.g. Bamburi cement industry in Mombasa and Waze cement works in Tanga Tanzania both use coral limestone.

- Coral reefs are also used for research purposes by scholars and for education purposes.
- Some corals weather into good soils making the coastal soils rich in nutrients and can support agriculture e.g. cloves at the east African coast.
- The corals have also supported aquaculture (tilapia), a crocodile farm and Agro forestry where by Bananas, vegetables and trees are planted on the Tanzanian coast and also farms e.g. at Bamburi quarry in Kenya.

Negative

- Where the coral reefs are found, the water is shallow and so they can cause damage on large ships in the ocean.
- The sharp reefs also tear fishing nets and may interfere with the fishing**.**