Czech University of Life Sciences Prague

Faculty of agrobiology, food and natural resources

Department of agroecology and crop production

The role of mangrove swamps and their importance for a sustainability of coastal ecosystems in Uzi Island, Zanzibar

Bachelor Thesis

Šárka Zděnovcová

Agriculture and Food (ATA)

Ing. Michaela Kolářová, Ph.D.

(1) Honest declaration

I declare that I have elaborated my bachelor thesis “The role of mangrove swamps and their importance for a sustainability of coastal ecosystems in Uzi Island, Zanzibar” independently under the supervision of the bachelor thesis supervisor and using literature and other information sources cited in the thesis and listed in the bibliography at the end of the thesis. Furthermore, as author of this bachelor thesis, I declare that in connection with its creation I have not infringed the copyrights of third parties.

In Prague 18.04.2019 ______________________________

(2) Acknowledgement

I would like to take this opportunity to thank my wonderful supervisor Ing. Michaela Kolářová, Ph.D. and Ing. Josef Holec Ph.D. for their patience and guidance throughout the process of this Bachelor Thesis. Alongside great thanks to my local Uzi Island mentor Abdulah for first-hand inventory of the distinctive mangrove species and contribution to my thesis, personal experience and knowledge obtained from integration into a small local community which has direct influence on the status of mangrove forests on the island.

Summary

The aim of this thesis ′The role of mangrove swamps and their importance for a sustainability of coastal ecosystems in Uzi Island, Zanzibar′ is to give a structured overview of the topic of mangroves on a worldwide scale and on a local scale regarding a small Island which is called Uzi.

It is essential to explain the importance of mangroves, the main definitions, the main conditions, properties, the main issues and propositions for solutions. This thesis is composed of chapters which explain the basic vital information there is to know to truly understand the special significance of mangrove swamps.

The first chapter is the introductory and describes the definition of mangroves and how they are different from other plants. Shining small light on their significant value to the coastal environments, what are their dominant properties and the important relationships towards the inter-conneted ecosystems. Stating that the decrease of mangroves doesn't only effect animals involved but the negative effects go deep beyong many obvious and effect coastal communities. The second chapter is a brief description of the objectives for this paper which gives a clear structure to the thesis. Chapter three is the main source of information and constitutes the vast majority of the thesis. A large part is decribing mangrove distribution patterns, definitons, environment description, chararacteristics and properties of mangroves, interactions and mangrove adaptatios on a global scale. On local scale there is more detail towards a specific area in this case Uzi Island including detailed mangrove inventory and tackled issues such as problems, threats and danger. This section also includes existing case studies of succesfull establishment of restoration and conservation strategies.

Conclusions are drawn in chapter four, where the subject of self evaluation takes place. Most important and significant facts where stated and previously set objectives have been evaluated if succefully reached its purpose or not. Overall a brief summary of the thesis was given to have a nice finish.

Key words: global ecosystems, mangrove forests, developing countries, restoration

Obsah

Summary **4**

1 Introduction **1**

2 Objectives **2**

3 Literature review **3**

3.1 Global scale **3**

3.1.1 Mangrove definition 4

3.1.2 Environment 4

3.1.3 Mangrove interactions & characteristics 7

3.1.4 Functions and properties of mangrove environments 8

3.1.5 Mangrove adaptations 10

3.1.5.1 Roots 11

3.1.5.2 Inquisitive features of fruits, seeds and leaves 14

3.2 Local scale **15**

3.2.1 East African Mangrove species distribution summary 19

3.3 Mangrove inventory **20**

3.3.1 Bruguiera gymnorhiza 20

3.3.2 Rhizophora mucronata 21

3.3.3 Ceriops tagal 22

3.3.4 Avicennia marina 23

3.3.5 Sonneratia alba 24

3.3.6 Lumnitzera racemosa 25

3.3.7 Pemphis acidula 25

3.3.8 Heritiera littorali 26

3.3.9 Xylocarpus granatum 26

3.4 Storage and propagation **27**

3.5 Conclusion of mangrove uses **27**

3.6 Problems and benefits of mangroves **30**

3.7 Danger and threats **31**

3.7.1 Threats and vulnerability 32

3.8 Socio-economic exploitation statement **32**

3.9 Conservation actions **33**

3.9.1 Restoration 33

3.9.1.1 Natural regeneration (Kairo et al. 2001) 34

3.9.1.2 Types of benefits of mangrove restoration 34

3.9.1.3 Existing Successful Case Study 35

4 Conclusion **36**

5 Bibliography 37

6 APPENDIX 44

6.1 Uzi Island community – Own experience 44

6.2 Extra representative tables 50

1 Introduction

Mangroves are special plants categorized as salt-tolerant that inhibit the intertidal margins of low-energy coastlines, mudflats and river banks in tropical and sub-tropical areas (Mchenga & Ali 2015). These plants have special adapted roots such as aerial roots and salt filtering tap roots that enable them to profit from brackish water (salty water but not as salty as sea water).

Mangrove swamps and forests carry numerous positive properties and functions to its surroundings, for example when speaking about the maintenance of a functioning environment regarding flora, fauna and us humans. Mangroves have crucial roles in the existence of either the diversity of life forms, the human dependence on them and in the case of Uzi, the stability of the island itself. With no doubt the mangrove environment is fragile and is decreasing in number with a shocking rate of 2 % a year (Duke 2007).

All of these plants play an essential role in this inter-connected and complex structure of not only marine ecosystems but also coral reefs, sea grasses, algae and sandy beaches. Where specific ecosystems are supporting each-others existence and creating a balanced and functional environment for all life.

It is essential to understand the dynamics of mangrove environments, what goes in and out, to understand how knowledge in this case is important, which possibilitie have been already set to improve the situation in long-term. The conservation and restoration strategies have been very innovative and successful so far.

The dependence of coastal residents on raw materials that originate from mangroves is not questionable, increasing rapidly every single day, endangering the island. But is there a way how to merge all of the crucial aspects together and create harmony? In other words, the declination of mangrove swamps does not only affect only coastal residents, the expanse of the shoreline but also directly harming the economy coming through the loss in fishing industries, algae farming and other marketing tactics.

2 Objectives

This thesis is dedicated to give a slight and structured understanding about what the term mangrove represents, what is the main purpose of this environment, why is it important to know about this topic, what has been done or can be done to minimize the already drastic consequences.

This research will identify locations where mangroves are located on a global and local scale, further stating particular physiological and characteristic features owned specially by mangroves. The major part of the report concentrates on emphasizing how essential it is to understand the basic description, adaptations, features, habitats, environments and conditions that are the main necessity for a nourishing mangrove population. It is also crucial to understand WHY is this information useful and HOW all of this information can be used to optimize the necessities of human needs and environmental needs, thus creating a fitting and balanced relationship.

Furthermore, it is absolutely vital to state and describe the different species of mangroves present on Uzi Island to have a clear idea of the environment and relation dynamics between mangrove plants, its ecosystems and humans. In attempt to simplify the imagination process, clear tables with representative figures of plants and seeds have been created to demonstrate the visual looks of each plant.

Another major part of this report is to address the social, health and ecological aspects and consequences of these issues. Not only does this report address the impacts of loss, it also informs about already existing strategies or potential strategies that will positively influence the existing situation and in a long run maybe make a difference.

To finalize the objectives of this thesis, it will be enriched by my own experience and knowledge obtained from my stay in Uzi Island, regarding mangrove populations, mangrove uses, mangrove significance, connected agricultural practices and the mutual relationships and reliance between humans and plants.

3 Literature review

3.1 Global scale

Mangroves cover an estimated surface area of 15.9 million hectares (159000 km) (FAO,2007). The prevailing amount of their biomass is in this range, between 30 ° north and 30 ° south of the equator. They exist on the boarders of land and water, along the coastlines of many tropical and sub-tropical peninsulas and islands. It is estimated that mangrove forests account for 75 % of coastal vegetation (NOAA, 2014) . Due to the fact that they can only exist along the shorelines of land and salty water, their biomass range is very limited as shown in Figure 1. Mangrove swamps prefer locations untouched or undestroyed by human influence.

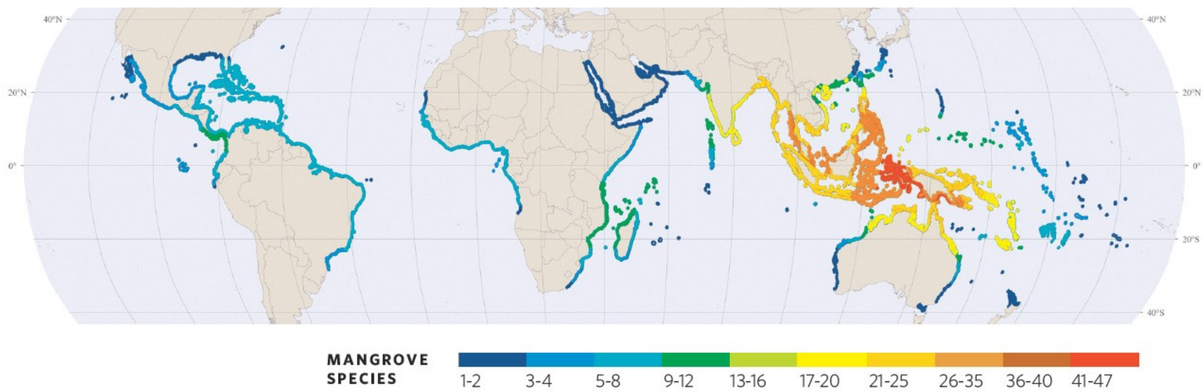


Figure 1. Mangrove coverage species richness - The areas are highlighted using different colors depending on the density of growth of mangrove forests in a given area. Situated in mid-latitude range of tropical and sub-tropical climates (NOAA, 2014)

Extension of the Northern limitation occurs in Japan (31°22`N) and Bermuda (32°20`N), furthermore the Southern limitation occurs in New Zealand (28°30`S), Australia (32°45`S) and on the East coast of South Africa (31°59`S) (Ajonina et al. 2008). The presence of mangroves has been observed as far as South of New Zealand, North Japan, South Australia, South Africa and South Florida but these are exceptional cases which have been favored by local conditions (Ajonina et al. 2008) Decreasing temperature may also influence or even limit the latitudinal distribution of certain types of mangroves. Majority of mangroves can be found in the South East Asian countries, followed by Indonesia, Brazil, Australia and Nigeria have 43 % of the world`s mangroves with Indonesia alone accounting for up to 23 % of the world`s total (NOAA, 2014).

3.1.1 Mangrove definition

Firstly, to understand the topic which this thesis is about to analyze, it is essential to understand what the term mangrove represents. There are many types and species of mangroves with different characteristics and functions but overall there are about 19 families which hold over 70 discovered mangrove species, Worldwide (Polidro et al. 2010).

The definition of mangrove species is a tropical maritime tree or shrub majorly of the genus *Rhizophora* and depends on various anatomical and physiological adjustments to saline, hypoxic soils (Polidro et al. 2010) as shown on Figure 3. These incorporate viviparous or crypto viviparous seeds adjusted to hydrochory; pneumatophores or elevated (aerial) roots that permit oxygenation of roots in hypoxic soils; and salt prohibition or salt discharge to cope or even enable them to profit from brackish water (salty water but not as salty as sea water) with high salt concentrations in the peat and pore water in which mangroves develop (Lugo, 1974).

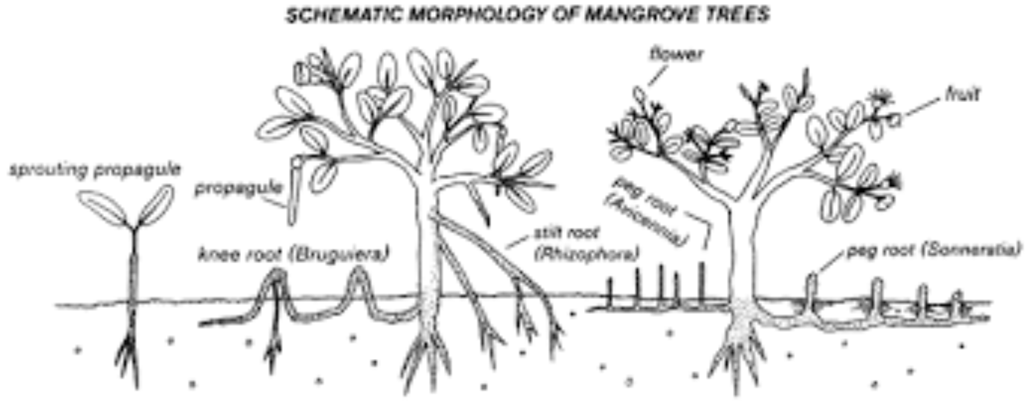


Figure 2. Basic characteristic morphological features of mangrove trees (Peck, 2014).

3.1.2 Environment

The environment can be best categorized where assemblage of salt tolerant trees and shrubs that grow in the intertidal regions of the tropical and sub-tropical coastlines. Located luxuriantly in the places where freshwater mixes with seawater and where sediment is composed of accumulated deposits of mud (Velsam, 2007). Mangrove wetlands are classified into six types based on geophysical, geomorphological and biological factors. First river dominated, second tide dominated, third wave dominated, fourth composite river and wave dominated, fifth drowned bedrock valley mangroves and sixth mangroves in carbonate setting. The first five can be seen on coasts dominated by terrigenous sediments (shallow marine sediment consisting of material derived from the land surface) and last number 6 can only been seen in oceanic islands, coral reefs and carbonate banks (Velsam, 2007)

Physical habitat of mangroves may be explained through couple of sections, either separating terrestrial and aquatic (marine) environments or connecting both of them as shown on Figure 3. The physical habitat carries many inter-connecting relationships which are dependent on each other therefore a balance has to be maintained for a functioning prosperous mangrove environment. The lacking presence of either of the elements will cause and imbalance in the system, therefore disrupting the system flow and potentially causing greater damage (Ozcoast, 2013)

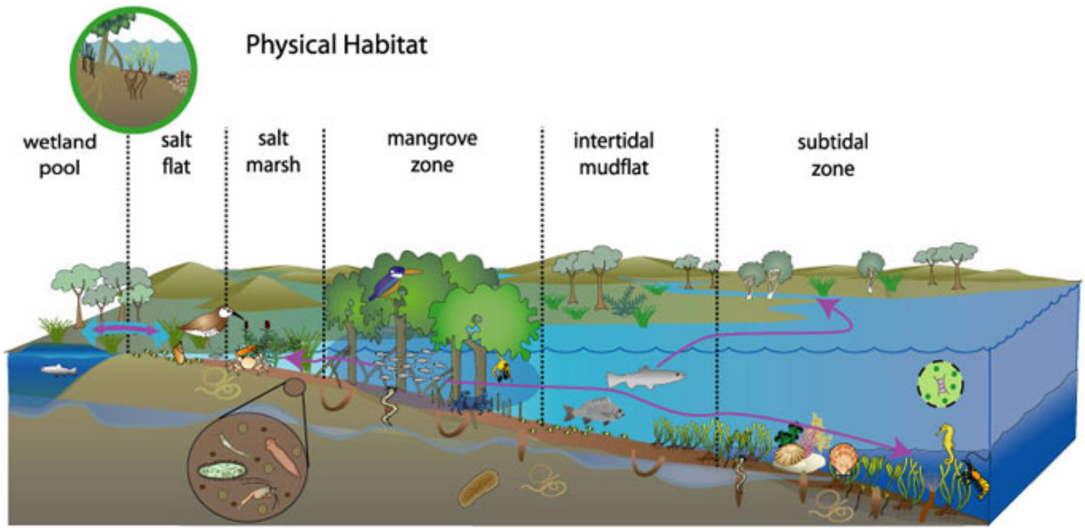


Figure 3. Schematic depiction of mangrove physical habitat. Shows the division into zones. Arrows represent direction of individual interactions (Ozcoast, 2017)

Small fish move with tides to access mangrove areas, where they find protection and to the salt march, where some feed (Connolly et al. 2006). Some fish move upstream and downstream, to the fresh and marine habitats at different stages of life cycles to breed and spawn. Water flow between wetland pools and estuaries during high tides or run-off allows fish to move between these habitats. (Sheaves, et al. 2006). Mangrove shade water and sediment, buffering temperature and blocking UV radiation, providing a habitat for the other organisms. (Hsieh, 1995). Mangroves are important nursery area for some juvenile fish and crustacean larvae (Blaber, 1989, Beck et al, 2001). Many organisms in estuarine wetlands live in burrows or on the sediment, including worms and microbes. Some mangroves prefer more salinity, while others like to be in the proximity of a large fresh water source such as a river. Some prefer to be sheltered from waves, others have their roots emerged and in presence of sea water every

day during high tide. On the other hand, some are very sensitive to salinity and grow further from the coastline. Some even grow on dry land, but still considered a part of the ecosystem.
It can be said that the ideal conditions for the sustainable and efficient development for mangrove forests lie near the mouths of large rivers where more accurately river deltas provide lots of fundamental sediment aka sand and mud (FAO, 2007). The structure of a mangrove forest is majorly composed of trees, shrubs and palms that have adapted to the harsh conditions surrounding them, which include the issues with extensive salinity, warm air, extreme tides, muddy & sediment-laden water and oxygen-depleted soil (FAO, 2007) As shown on Figure 4, those species that are only confined to tropical intertidal natural surroundings have been characterized as "true mangrove" species, while those not selective to this living space have been named "mangrove associates" (Lugo, 1974).

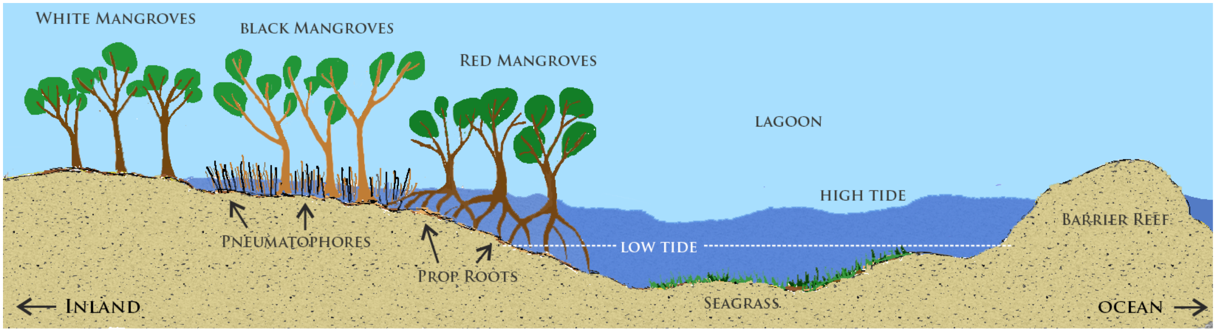


Figure 4. Schematic mangrove zonation expressing the differentiation between true mangroves and associate mangroves (Vierus, 2015)

Interesting fact, that in Maldives, a small number of the plants that are present in terrestrial environment and pure halophytes (plant which grows in a saline environment) are also found within or in the peripheral area of the mangrove wetlands, recognized as mangrove associates (Velsam, 2007). Mangroves are generally divided into groups, either true or exclusive mangroves and associated mangroves. True mangrove species grown only in mangrove environment and do not extend into terrestrial land and plant community. They are morphologically, physiologically and reproductively adapted to saline waterlogged and anaerobic condition (Velsam, 2007). The estimation that overall from around 70 species in 27, belonging to 20 families are recognized as true mangrove species (Velsam, 2007). For example, in other words mangroves in a proximity to the ocean tend to categorize as true mangroves due to their selectivity and mangroves oriented inland tend to be associates due to the lack of selectivity towards the living space. (Tomlinson, 1986) further subdivided these classes into major mangrove segments (true, strict or special mangrove species), minor segments (non-specialized mangrove species), and mangrove associates (non-exclusive species that are commonly never submerged by high tides).

3.1.3 Mangrove interactions & characteristics

It is essential to describe the mangrove ecosystems interactions and its relations. It is likewise important to see how these mechanisms interact with each other and how dependent they are on each other (Hoon, 2015). First level of the mangrove wood web is of course occupied by mangroves which use sunlight and carbon dioxide (CO2) to grow by photosynthesis. Aiming, further level up, detritus can be categorized as fallen debris which becomes food for the bacteria and microbes, where they further convert this debris into dead organic matter. Further level up, crustaceans and bivalves such as invertebrate species incl. worms, shrimp, barracle and mussels feed on detritus. Further level up, small fish and wading birds feed on detritus consuming animals. On the top of the food web large fish enter mangroves with the tide searching and eating small fish and invertebrates. All of these plants play an essential role in this inter-connected and complex structure of not only marine ecosystems but also coral reefs, sea grasses, algae and sandy beaches (Machuca, 2013). Where specific ecosystems are supporting each-others existence and creating a balanced and functional environment for all life as shown on Figure 5.

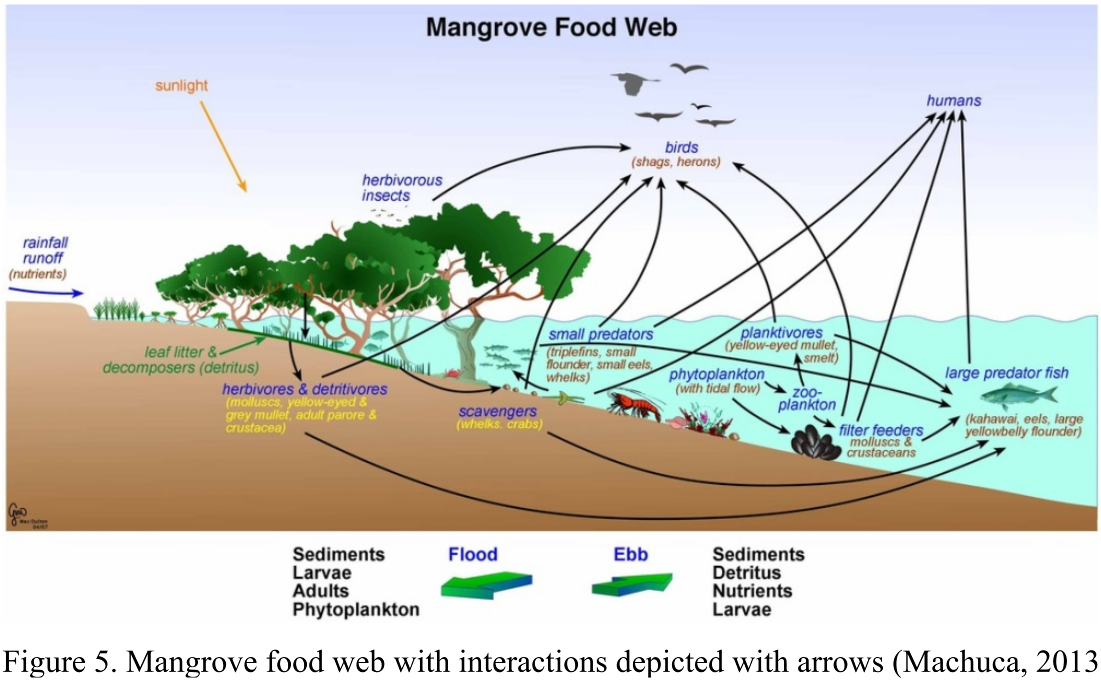
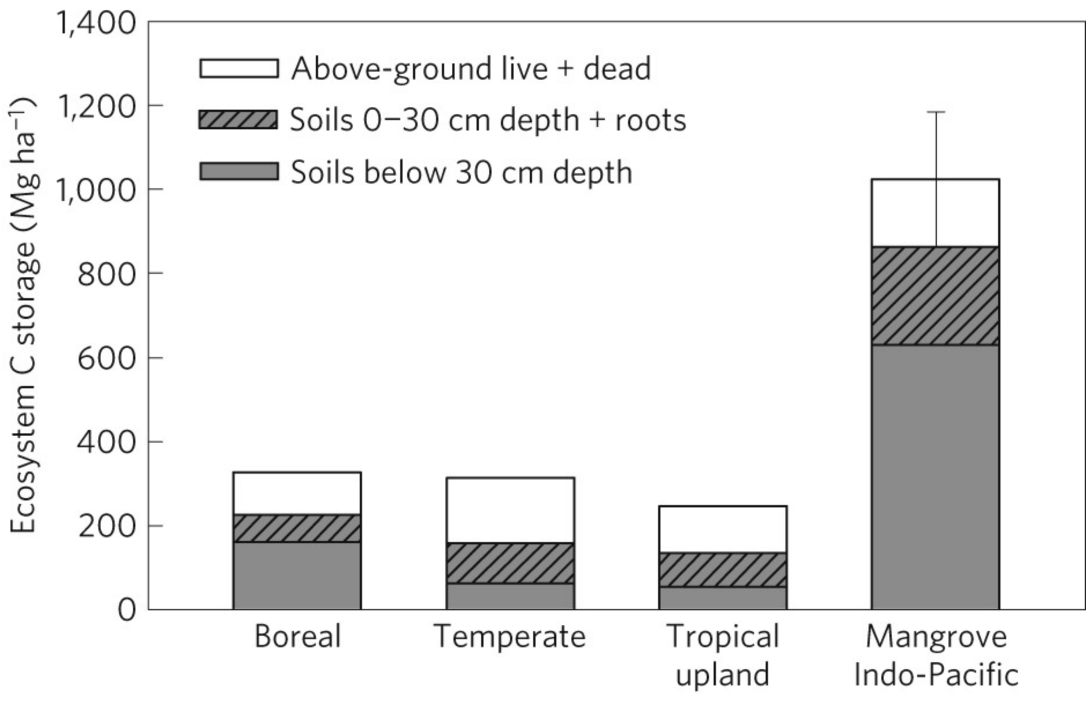


Figure 5. Mangrove food web with interactions depicted with arrows (Machuca, 2013)

3.1.4 Functions and properties of mangrove environments

Mangrove swamps and forests carry numerous positive properties and functions to its surroundings, for example when discussing the maintenance of a functioning environment regarding flora, fauna and us humans. Mangroves have crucial roles in the existence of either the diversity of life forms, the human dependence on them and in the case of Uzi, the stability of the island itself. It is necessary to mention and specify important functions which make mangroves such an essential co-helper in the existence of its environments is very high.
Primarily their ability to absorb and store mainly carbon and other pollutants, improving the clarity and quality of water (Machuca, 2013). Blue carbon is the term used to describe the carbon stored in coastal and marine ecosystems, including mangroves. Carbon is sequestered in their biomass and extensively in the coastal soils, where it can remain trapped for long periods of time, resulting in very large carbon stocks (Howard *et al.* 2014). The carbon stocks in mangroves are the highest of any ecosystem on earth, storing 4 times as much carbon as tropical rainforests (Donato *et al.* 2011) as shown on Graph 1.



Graph 1. Total ecosystem carbon pools for forest cover types of the world (Donato et al. 2011).

The tangled root systems effectively filter runoff that may include impurities, trap sediments and debris from land. The diagram presents the carbon and nutrient flux dynamics in mangroves, describing flow of CO2, O2, organic matter and inorganic nutrienst as shown in

Figure 6 and the relations between those and mangroves, detrivors, macrofauna and microphytobenthos (Bumler et al. 2017).

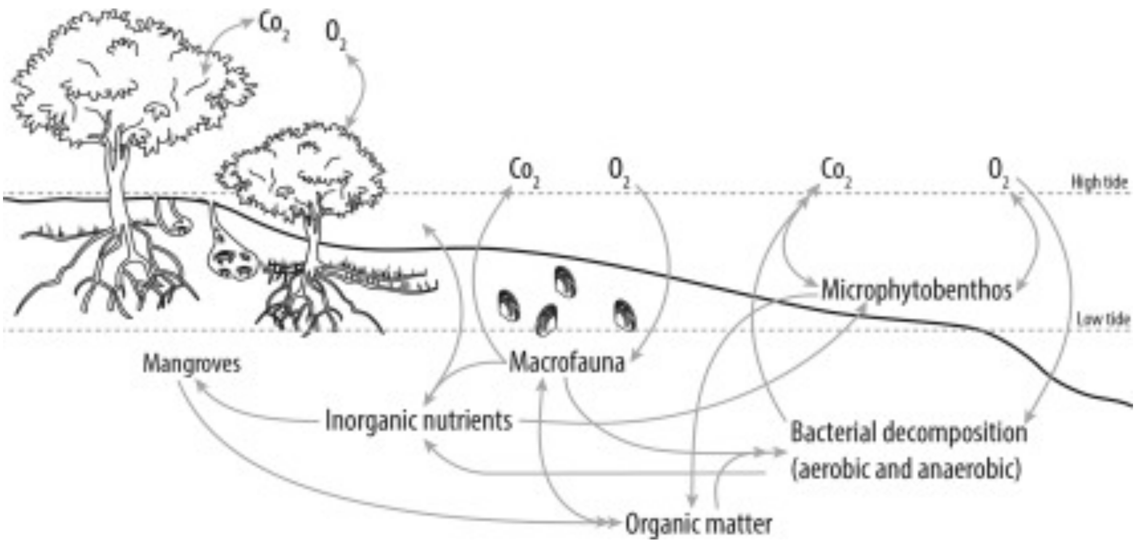


Figure 6. Schematic representation of the carbon and nutrient flux dynamics in Mangroves (Bumler et al. 2017)

The initial process regarding carbon dioxide begins with the absorption, precisely the sequestration of carbon dioxide (CO2). Where Mangroves take up atmospheric CO2 to form their leaves, stems, branches, trunks and roots. Later an essential storage process takes place where buried C can be stored for a very long time until they are cut down (Halpern B, Lowndes J.S, 2015). Overwhelmed carbon containing branches, leaves and stems fall, where accumulating sediment and detritus buries them, reducing oxygen levels and slowing their decomposition by bacteria. The last process is the release, where carbon remains in storage until it`s eventually released through respiration or if mangrove-sediments are disrupted by storm or human activities. There are two possibilities how the release can be initiated, either from the disturbance of sediments by severe natural events (hurricane, tsunami etc.) or human activities. These expose buried carbon to oxygen which triggers quick release of stored carbon to the atmosphere as CO2- (Hoon, 2015).

Secondly, they provide specific conditions for a diversity of marine dependent ecosystems vital for feeding, breeding, where they are fertile nurseries for a variety of different species, invertebrates like crustaceans (prawns, crabs), shellfish, fish or even endemic species (Blaber, 1989, Beck et al, 2001).

Thirdly, the mangrove massive root systems become also potential hiding spaces for these smaller animals. These ecosystems also have their significance for its predators such as shorebirds, crab-eating monkeys and fishing cats, all belong to this interconnected environment (Krause, 2002).

Fourthly, indirectly sustaining a wide range of social and economic activities for the inhabitants of the island which are strongly dependent on this source, for such as providing raw material for cooking, food (hunting) and building (raw) material.

Fifthly, probably the most essential service it provides regarding coastal conservation (Mchenga & Ali, 2015), is coastal erosion protection, where roots hold loose soil and sediment together to improve stability.

Sixthly, these precious ecosystems serve as a fundamental defense mechanism against natural disasters. They also serve as buffers and aid in reducing damaging effects from tsunamis or hurricanes by dissipating wave and wind energy and clearly demonstrating that wave height decreases with distance travelled through mangroves (Machuca, 2013).

This conservation and protection technique can be slightly explained through this characteristic feature provided by mangrove roots: the assemblage of sediments, decreasing the speed of the water flow, improving the stability of coastline, therefore aiding in the protection and preventing of erosion. The endurance and lifetime of a mangrove tree/shrub is crucial, to provide a possibility for the roots to toughen through the collection of sufficient amounts of debris and mud for the extension of the edge of the coastline further out, thus expanding the coastline (Lugo, 1974).

3.1.5 Mangrove adaptations

The environment of mangrove occupied areas is considered highly dynamic even harsh therefore mangrove species need to be variously adapted to cope with these environmental conditions. Generally, it is necessary for mangroves to maintain their trunk and leaves above the water level, likewise need to be securely anchored to the ground so that their bonds are not disrupted by the movement of waves (Tomlinson, 1986). Starting from the bottom of the soil going upwards to the top of the tree, the adaptive features will be explained in detail as shown in Figure 7.

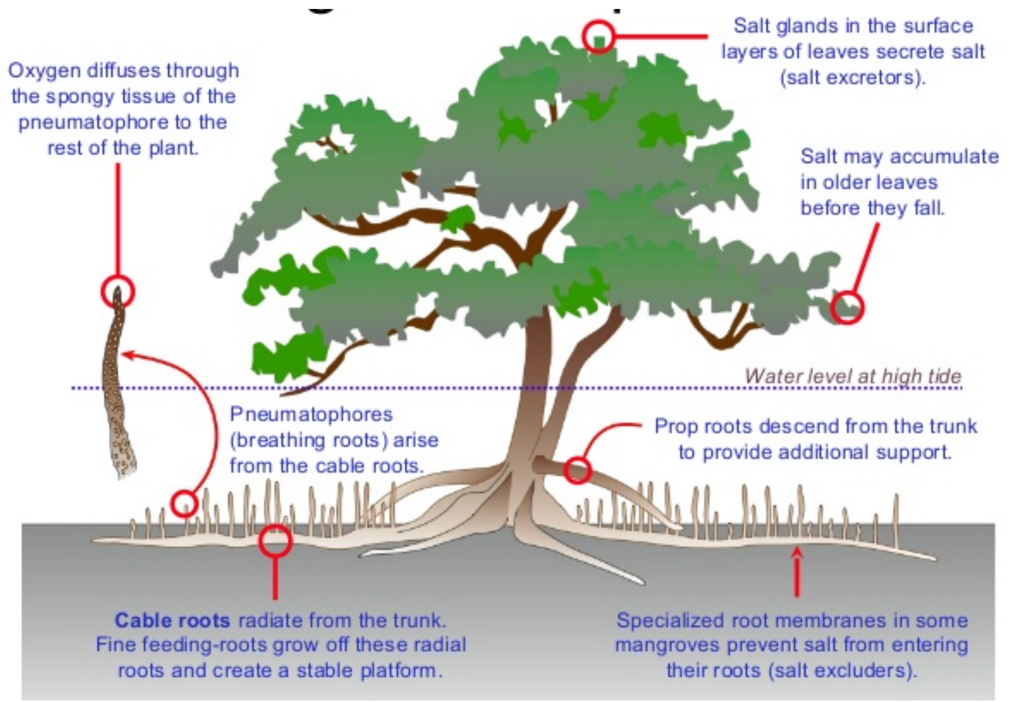


Figure 7. Basic description of different mangrove adaptations depicted on this scheme (Pinterest, 2019)

3.1.5.1 Roots

There are three main types of roots occurring in the mangrove population. These adaptive features resulted through constricted availability of vital elements and to aid with anchorage, oxygen intake and reproduction (Krause, 2002).

Looking at the Figure 7 it is obvious the most important and significant organs are the roots, they carry the highest importance regarding adaptations. As for mangroves any part of a root that emerges above water level channels oxygen to the plant below the water level (Tomlinson, 1986). Over time as soil begins to build up, these roots produce additional roots that become embedded in soil, these roots are called anchor roots and they provide mainly anchorage and stability. Above those the cable roots can be found, which radiate from the trunk alongside of the soil surface, still submerged below. (Polidro et al. 2010) These roots have other smaller fine feeding roots called pneumatophores which grow radial roots, thus creating a more stable platform. The main function of these roots aren`t only improving stability in the system but mainly for the property of oxygen uptake, or in other words they are called the breathing roots. Oxygen diffuses through the spongy tissue of the pneumatophores to the rest of the plant (Tomlinson, 1986). These roots have specialized root membranes in some mangroves preventing salt from entering their roots (salt exudates). Further up, these prop (stilt) roots descend from the trunk to provide additional support. In Figure 8 four different types of roots can be seen with little schematic images.

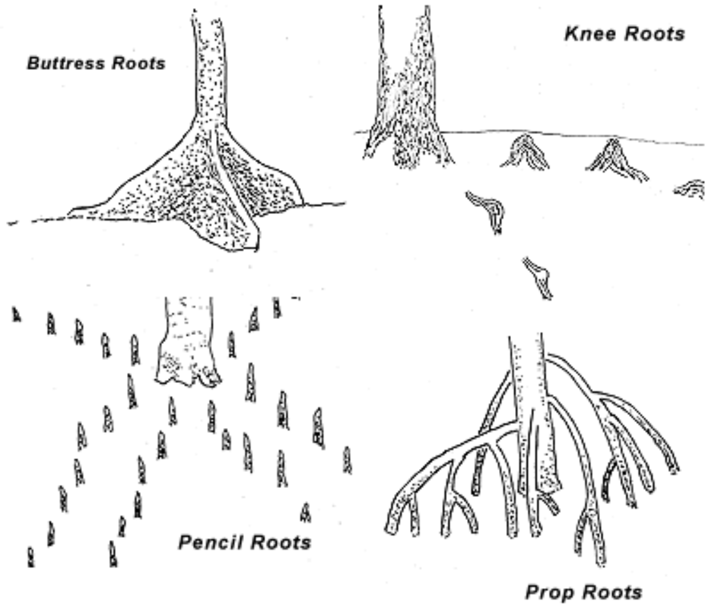


Figure 8. different types of mangrove root adaptations (TWTHA, 2015)

First adaptive type is the breathing roots, in other words level-growing roots which twist upwards (emerging on water surface) and downwards (Krause, 2002). In the soil of any mangrove environment the presence of oxygen is very limited or even sometimes nil. As any underground tissue of any plant, requires oxygen as the primary source for respiration, these conditions forced the plant to adapt and increase the mangrove root system to obtain "up" oxygen from the atmosphere. Therefore, mangroves specialized above ground roots called as already mentioned "breathing roots" or pneumatophores (FAO, 2007) as shown in Figure 9.

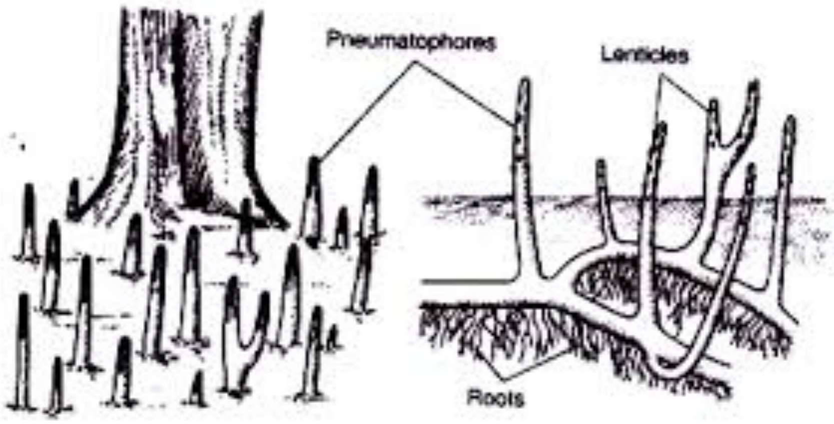


Figure 9. Pneumatophores of mangrove plant depicted in a smaller schematic diagram (Biology Discussion, 2019)

In some species they are pencil sized and peg like, in others they are knee shaped. Those roots have numerous pores through which oxygen enters into the underground tissues. On the other hand, buttress roots function as breathing roots and also provide mechanical support in some plants (FAO, 2007).

Second adaptive type is the stilt root, support roots which pierce the soil directly as shown in Figure 10. They are called this way due to their appearance which results in the primary physical support provided by these roots. Roots diverge from stems and branches where they penetrate the soil a bit away apart from the main stem, they also have numerous pores through which atmospheric oxygen intake exchange occurs. (Biology Discussion, 2015)

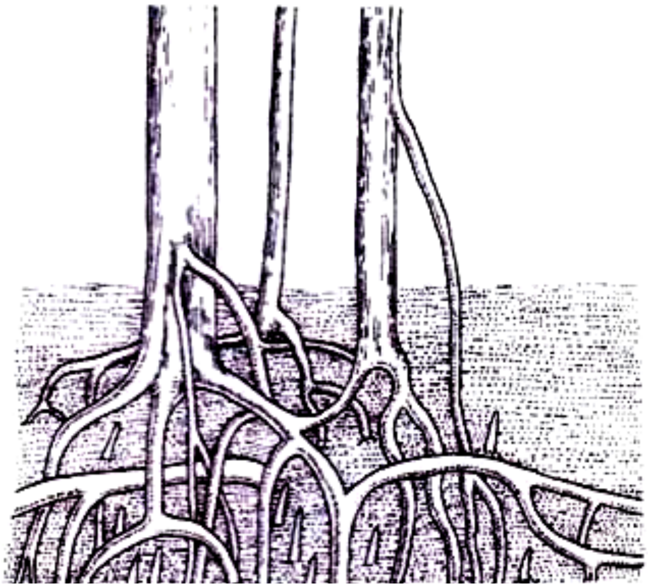


Figure 10. Supporting stilt roots developing from the trunk (Biology Discussion, 2015)

Third adaptive type of roots is vivi-parity, where saline water and unconsolidated saline soil is present with little or no oxygen isn`t really a conducive environment for seeds to germinate and establish. Mangrove species have a unique way of reproduction which is categorized as vivi-pary. This method of reproduction (Velsam, 2007) includes the seeds to germinate and develop into seedlings which are called propagules as shown in Figure 11, which photosynthesize while still attached to mother tree. They are buoyant and float in water for some period of time before rooting themselves on suitable soil. Parent tree supplies necessary nutrients and water (Bojang. F, Atanga A.N. 2009)

Interpetiolar stipules are small, triangular, leaf-like outgrowths on the stem between and so at right angles to the opposite leaf stalks; they are usually a trademark of the coffee family, Rubiaceae, and mangroves are one of the very few other groups of plants to have this feature. (Glen, 2005).

3.1.5.2 Inquisitive features of fruits, seeds and leaves

3.1.5.2.1 Ripe fruit

One of the inquisitive features of mangroves is that even an evidently ripe fruit is neither a fruit nor a seed. Large numbers of fruits are developed, with most of them reaching the full ripening status. Further the seed germinates inside the fruit, develops a long hypocotyl so when that falls on to the ground it is properly called a propagule or a germinating seedling (FAO, 2007).

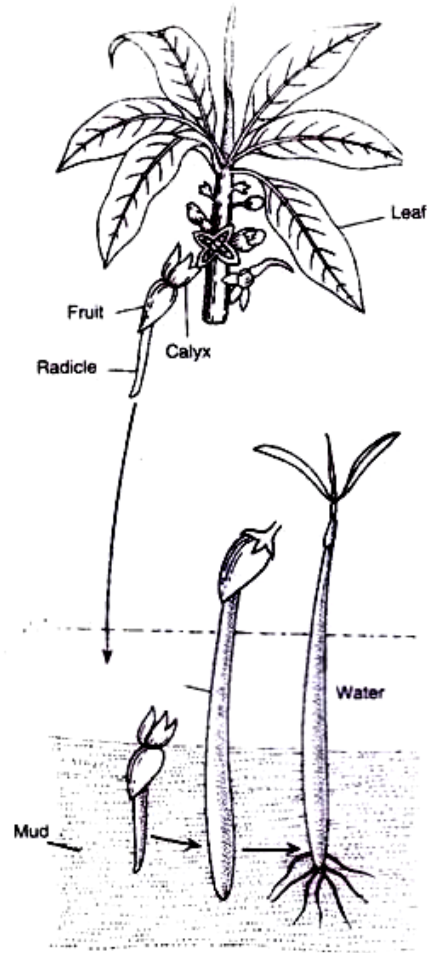


Figure 11. Viviparous seedling in Rhizophora (Biology Discussion, 2015)

3.1.5.2.2 Germinating seedling or propagule

Mangroves hold and interesting adapting feature in the germinating seedlings. The weight is distributed throughout the seedling in a very effective manner to maximize the amount of successfully developed trees (Tomlinson, 1986). The hypocotyl develops with having the weight on one end, ensuring the propagule to land in an upright position in the mud/sand, most likely with enough force to penetrate through enough land to withstand the pressure of currents and inter-coastal tides. If the seed does not successfully anchor in the ground it is either swept into the sea, meanwhile automatically growing a few pairs of leaves which ensures it to float to another shore/coast or consumed by the crabs ensuring nutrition intake and a tasty treat (Hsieh, 1995).

3.1.5.2.3 Leaves

Locating now above the water level at high tide, it is time to mention the significant importance of the mangrove biomass. Leaves are the number one tool through which mangroves can get rid of excess salt out of the overall system (Tomlinson, 1986). Meaning that salt may accumulate in older leaves before they fall off. On the other hand, salt glands in the surface layers of leaves secrete salt crystals as shown in Figure 12, thus gaining the name salt excretors (Velsam, 2007). However, allowing the plant to either use over-whelmed, old leaves or use surface of leaves to get rid of excess salt concentrations.

Figure 12. Salt crystal formed on *Avicennia marina* leaf (Wikimedia, 2019)

3.2 Local scale

This section contains information from a personal interview with a local skilled mentor and my personal experience which was obtained during my stay in Uzi. It contains description of the location, the overall description of the Island and a first hand mangrove inventory from Abdulah.

Uzi island is located in the South of Zanzibar where it`s connected by a causeway to the main land of Unguja, South East side of Africa as shown on Figure 13, approximately one and a half hour by the ferry away from Tanzania.

There are 10 officially reported species of mangroves on the territory of Zanzibar Island and Unguja which is shown on Figure 14, where 9 can be still found to the present day, but 1 species is said to be extinct. These species are also amongst those which can be found in the surrounding countries of the Western Indian Ocean.

The main activity of the mangroves is located in the north and northwest, south and southeast with as already mentioned 9 different species in Uzi Island. The following species are observed to be in higher densities distributed amongst the coastal and terrestrial areas throughout Uzi, such as; *brugulera gymnorrhiza, ceriops tagal* and the dominating *Rhizophora mucronata*.(Abdulah, 2017)

Figure 13. location of Zanzibar, off the east coast of Tanzania, Africa (Furian, 2015

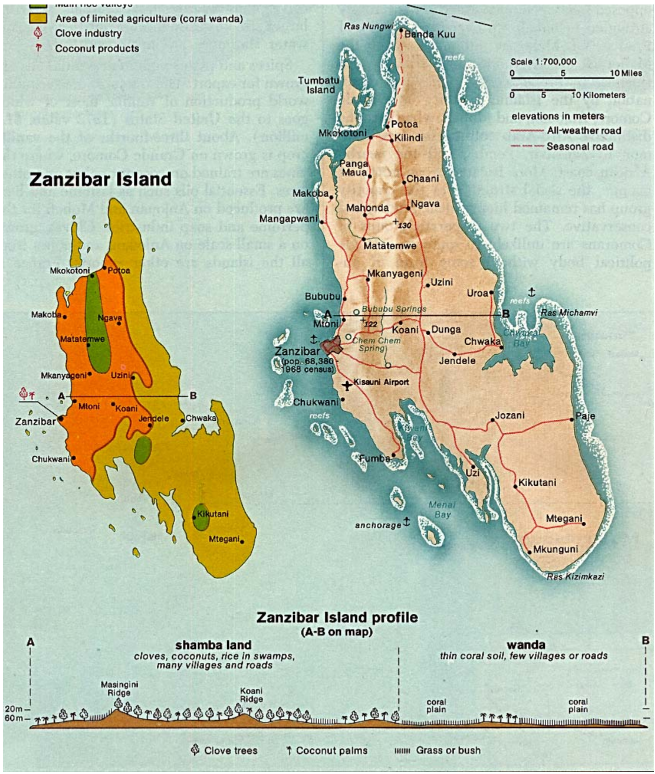


Figure 14. Topographic map of Zanzibar, off the east coast of Tanzania, Africa (UICS, 2012)

The exact geographical location of Uzi and Vundwe islands lies at 6°18’-6°24’S and 39°23’-39°26’E (Google Maps, 2019). For proper orientation: Uzi is a small island connected to Unguja by a narrow isthmus of tidal mangrove swamps, common for intertidal margins of low-energy coastlines. Approximately 25 kilometers from the capital of Zanzibar City, Stone Town and lies along the Uzi Channel on the southwest coast of Unguja (Abdulah, 2017). Territory of Uzi island can be recognized as two main islands: Uzi Island and Vudwe Island. as shown on Figure

15. Both of these islands lie along the Uzi channel and are connected to Zanzibar Island via a narrow & rocky road filled with tidal and coastal mangrove swamps. one larger in surface area which is occupied by people and officially called Uzi Island. The second with an area of only 1,4km^2 called **Vudwe** Island on the other hand is uninhabited by people, located only 300m from the southern tip of Uzi (Abdulah, 2017). Its most significant feature is the presence of high forest species with tall relict trees such as the legendary ancient baobabs (*Adansonia digitata*), which are historically found at higher densities in Uzi.

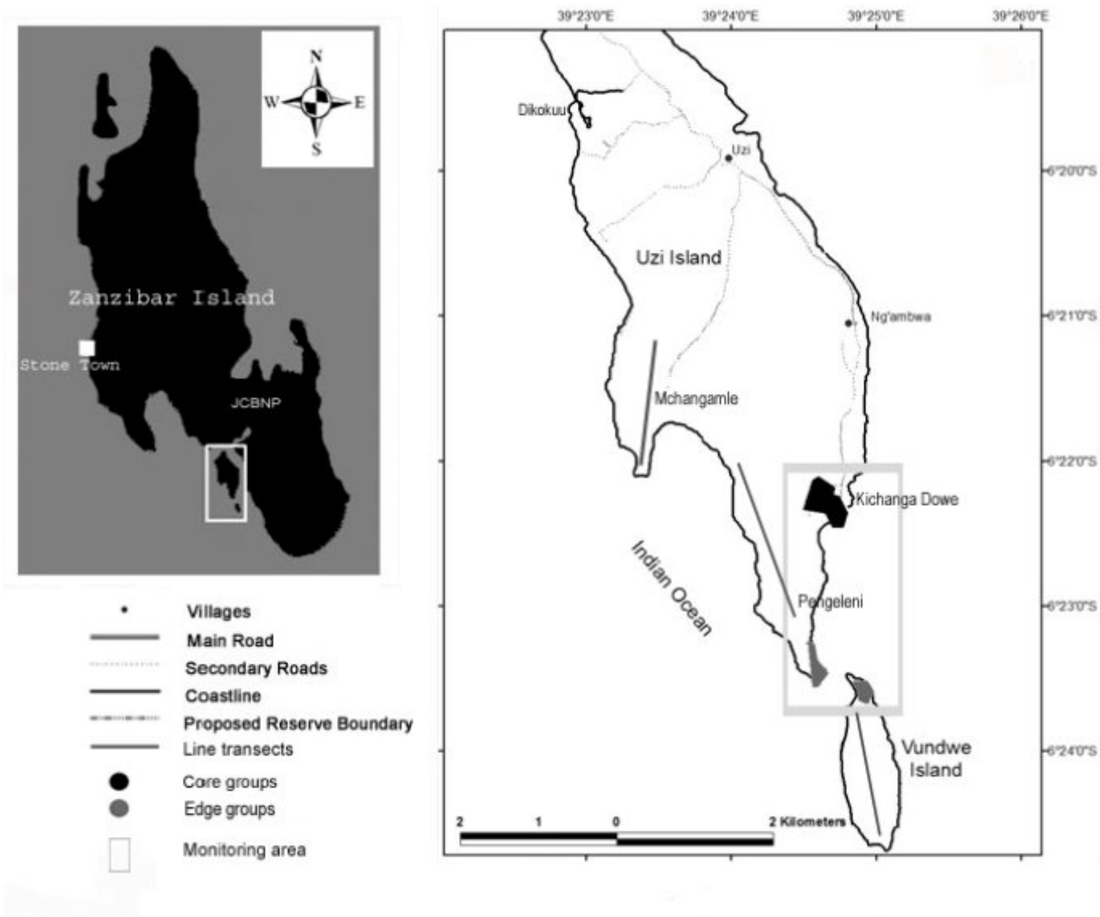


Figure 15. Representation of Uzi Island territory (Perkin, 2009)

With the tide in mind it can be a very limiting factor which can drastically influence the movement of traffic, people and goods in or out of Uzi (Abdulah, 2017). The high tide quickly covers this passage with water and its strong currents of the ocean make it impossible to pass to Uzi at its highest point. Therefore, it is essential to be constantly on track regarding the times when high and low tides will be occurring (Abdulah, 2017). During the high tide the swamps are flourishing with diverse life, engaging bright colors and relaxing sounds of the water movement. On the other side when the low tide replaces this oasis of life, it becomes a mud filled desert revealing the depressing sites filled with trash brought by the tide.

There is approximately 3,000 people combined from two main villages; Uzi Uzi and Uzi Ng'ambwa who are dependent on traditional agriculture such as: inter-tidal harvesting - seaweed farming as shown in Figure 20, fishing either using self-made dug-out canoes and boats or using fish traps as shown in Figure 21.

Figure 16. Algae traditional rope and stick technique of inter-tidal farming in Uzi (Dreamstime, 2019)

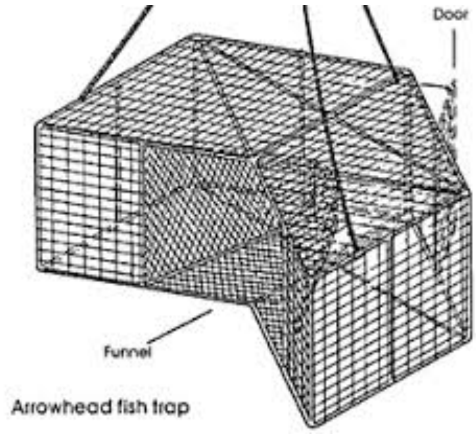


Figure 17. Traditional „heart-shaped", arrow-head fish trap including door and funnel body (Munro et al. 1971)

Uzi possesses an area of 15,6km^2 with at least 60 % of marine and terrestrial land converted to agricultural practices and used for habitation. Talking about *shamba* (cultivated and profitable land) and general concentration of its residents as they are located in the eastern part of the island. The rest of the land is occupied by mangrove, abandoned farmland, patches, scrub and vast coral rags.

An existing study has proven that along the coastal belt of Zanzibar about 49 % of the beaches are delineated by rock or showed a high presence of trees and other vegetation along the beach (Mchenga, 2015). Due to the lack of available information the extent of the exploitation and proper management can't be evaluated or stated completely. Proper policies, planning, decision making and research is required for a final and reliable conclusion.

In a short distance to the south, there is this reservoir of peculiar vegetation and rich populations of different & specific animals and insects called the Jozani Chwaka Bay National Park (JCBNP). This park holds many interesting specimens to witness in both fauna and flora. From different types of bush babies (*galagoides zanzibaricus*), syke monkeys (Cercopithecus albogularis), more than 40 species of butterflies to 50 species of birds and glorious mangrove swamps. Further, the jewel in its forests is the endemic species of the Zanzibar red colobus, *Procolobus kirkii* as shown in Figure 18.

Figure 18. Photograph taken by me of the endemic species of red Columbus (*Procolobus kirkii*) in the Jozani Chwaka Bay National Park (JCBNP).

3.2.1 East African Mangrove species distribution summary

In Eastern Africa *Sonneratia alba* is one of the most frequent types of mangroves occurring in muddy soils where salinity levels are high, therefore close to sea water. Can be categorized as a hardy primary colonizer and resistant to physical disturbance, thus often situated along outer margin. *Rhizophora mucronata* however dominates on muddy soils and is frequently found in large homogenous stands on upper river banks. *Brugiera gymnorrhiza* frequently occurs between *Rhizophora mucronata* and *Ceriops tagal* zones or dispersed throughout them. *Ceriops tagal* on the other hand has a weaker root system, therefore is less capable of resisting strong currents and waves, causing their occurrence to be situated in upper intertidal areas where the sediments are thicker. *Heritiera littoralis* can be found in explicitly flooded inland areas only by spring tides, on river banks and in estuary mouths where salinity levels are low. *Xylocarpus granatum* can be found dispersed on higher ground in *Avicennia marina* stands, where sea water flooding is rare or only few days a month, where contact with freshwater prevails and has greater impact. *Avicennia marina* is euryhaline and endures an assortment of flooding regimes and substrates however is most generally found on firm sandy soil. It is a frequently distributed species and an essential or primary colonizer of exposed to oceanic regions. *Lumnitzera* *racemosa* is related with *B. gymnorrhiza* and different representatives of the genus *Xylocarpus* along river banks. Examples of zonation can be changed by aggravation in light of the fact that intensely utilized species may not recover first and newly interfered regions might be colonized by pioneer species (Taylor M, Ravilious C, Green EP, 2003).

Brief: Classification, taxonomy and research process

As already mentioned, the region is occupied by 9 mangrove species which are divided into seven families of flowering plants. There are many different physiological characteristics, features and functions, which can be examined for the determination of these different mangrove species using **a.** crown, **b.** leaves, **c.** flowers**, d.** fruits and **e.** trunk and roots.

3.3 Mangrove inventory

& enriched with personal interview from Abdulah, 2017.

3.3.1 Bruguiera gymnorhiza - Family RHIZOPHORACEAE (Glen, 2005) (Velsam, 2007)

Table 1. Basic information of Bruguiera gymnorhiza

Scientific name	**Regional name**	**English name**
Bruguiera gymnorhiza	Kiswahili, Mshinzi	Black mangrove
Plant type	evergreen Tree	
Soil type	sandy, brack/saline	
Habitat	mid and high tidal areas of the intertidal region	Indo-Pacific Ocean

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Malpighiales	Rhizophoraceae	Bruguiera

Evergreen tree moderately sized with maximum height at maturity around 18m or more. Single-stemmed tree with short buttresses and knee-shaped above ground breathing roots**.** First crown is conical, later becomes irregular. Upper part of the tree dense branches with long leaves, bush-like appearance. Leaves are simple, opposite, from 5 to 15cm long and from 4 to 8cm wide. Dark green turning yellow with age, oval, opposite & crowded at the end of branches (brugiera), with pointed tip (missing spine at tip), hairless, glossy. Flower up to 40mm long, petals and sepals from 8 to 18, petal creamy white, falling with stamens. Pollinated by insects and small birds (eg. sun-birds Nectariniidae). (latin)), flowering process occurs throughout the year. New growth is a fleshy berry, cigar shaped, germinating directly on the tree, to form a ribbed, brown hypocotyl (incipient root). Seeds are green, further turning red-ish into viviparous propagules, glossy and hairless. Buoyant, thick, tapering, smooth and relatively short (up to 11cm long) with a persistent, spiky, green plus red calyx pointing downwards. The trunk is relatively thin, bark is pale black or brown, hard, thick and rough, but the lower part of the trunk is composed of multiple thick spreading roots, forming a pyramid-like base. The roots are growing in the upwards direction, forming arches and arching above the surface (mud), "knee roots" also providing surface for extra oxygen exchange (breathing roots). This species is very widespread and dominant upon mangroves in Uzi Island. It is observed to be seen at variable salinity, very often mixed or in-between of *Rhizophora mucronata* and *Ceriops stagal* zones. Able to grow in slightly dry and well aerated soil in the mid and high tidal areas of the intertidal region. One of the most shade tolerant mangrove species. This species tolerates a maximum salinity of 40 ppt and a salinity of optimal growth of 8-33 ppt. (Robertson and Alongi 1992).

3.3.2 Rhizophora mucronata – Family RHIZOPHORACEAE (Velsam, 2007)

Table 2. Basic information of Rhizophora mucronata

Scientific name	**Regional name**	**English name**
Rhizophora mucronata	Kiswahili, Mkoko	Red mangrove
Plant type	aquatic, tree	
Soil type	sandy, clay, brack/saline	
Habitat	eulittoral, variable muddy soils	W Indian Ocean to W Pacific Ocean

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magoliopsida	Malpighiales	Rhizophoraceae	Rhizophora

Small medium-sized, maximum height at maturity from 2 to 10m**.** Conspicuous, dense bunch-like crown, which is round in shape. The proportion of crown (1,3/3 and trunk (0,4/3) and roots (1,3) is very interesting where crown and roots dominate, and trunk is relatively short**.** Leaves are from 4 to 8cm wide and from 9 to 18cm long with a spike (up to 5mm long) on the apex. Dark green, simple, leathery, opposite & elliptical in shape, small dots may be present on the under surface. Flower is creamy white, fleshy and fragrant**.** Calyx is deep four lobed and pale yellow, petals are four in number, light yellowing, densely haired along margin**.** Flowering throughout the year**.** Elongated viviparous propagules of the size from 20 to 40cm long, rough, warty surface, capable of developing roots and grow (emerge) from the mud after dropping off the tree. The bottom part of the fruit (seed), is ended by a spike (sharp edge) to ensure correct penetration through the mud when it`s ripe enough to fall. The trunk similar to previous species also relatively thin, bark is black and rough, but in the lower part of the trunk is composed of multiple thick spreading roots, forming a pyramid-like base. Much-branched, stilt roots loop from branches and stems at the same time providing support to the tree. Dense rooted complex of thin to thick strong roots, anchored in mud/sand branching out of the water surface**,** mostly curved wild branching. The roots are also growing in the upwards direction, forming arches and arching above the surface (mud), prop-roots**.** Stilt roots up to 3m long. Prefers soil rich in soil organic matter and the upper soil level (eulittoral), at variable muddy soils, forming extensive, pure stands in estuarine conditions. Present mixed *with Bruguiera spp., avicennia marina* and *ceriops tagal.*

3.3.3 Ceriops tagal - Family RHIZOPHORACEAE (Velsam, 2007)

Table 3. Basic information of Ceriops tagal

Scientific name	**Regional name**	**English name**
Ceriops tagal	Kiswahili, Mkandaa	Yellow mangrove
Plant type	aquatic, shrub, tree	
Soil type	sandy, loam, brack/Saline	
Habitat	littoral fringe, on land ward side	W Indian Ocean to W Pacific

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Malpighiales	Rhizophoraceae	Ceriops

Maximum height of tree at maturity 7m or more, usually smaller than *Rhizophora mucronata.* Numerous branches create a very dense crown with a round shape. Leaves are simple, opposite, shiny, kind of inverted-egg shaped that are from 2 to 5cm wide and from 3 to 10cm long with a rounded tip (up to 5mm long) on the apex. Yellowish green, opposite, broadly elliptical, smooth and almost shiny-waxy texture. Petals five numbered, white, yellow and brown, two lobes, from 2 to 4 bristles terminus. Seed green to brown, from 8mm to 12mm in diameter, narrow, elongated propagule with ridges up to 25cm long in length**.** Warty and ridged surface of propagules, buoyant-dispersed by currents. The apex of the fruit (seed), is ended by a sharp spike to ensure anchorage and quick establishment after dropping off the parent tree. Dense rooted complex of thin to thick strong roots branching from a relatively short and thick trunk anchored in mud/sand. Branches growing upwards to form a net of intervening complex. Bark is light orange to greyish red and smooth. Occupies littoral fringe, on land ward side of mangrove forest. When the leaf exceedes salinity holding capacity it falls to the ground and considered as a very tasty treat for crab species (most favourite type of mangrove to consume).

3.3.4 Avicennia marina – family AVICENNIACEAE (Velsam, 2007)

Table 4. Basic information of Avicennia marina

Scientific name	**Regional name**	**English name**
Avicennia marina	Kiswahili, Mchu	White/grey mangrove
Plant type	aquatic, tree	
Soil type	sandy, clay, loam, brack/saline	
Habitat	intertidal regions	W Indian Ocean, Red Sea, gulf to Pacific Ocean

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Lamiales	Acanthaceae	Avicennia

Evergreen shrub or tree with maximum height at maturity about 10m. Tree located in close distance to water, crown peaking always from the sea level. Leave are small up to 10cm, oval to elliptical shape, single, opposite, shiny, leathery, yellowish-green and hairless above and paler silver-grey below apex, due to presence of fine hairs. Underside may be coated with tiny salt crystals secreted by salt glands (secretion of excess salt). Numerous, conspicuous, narrow and flexible pneumatophores, capable of preventing salt from entering the main root system. Flower small from 3mm to 5mm diameter pale yellow color, sessile, sweetly scented, condensed terminal flower head. Flowering occurs usually between October and January, producing nectar to attract a variety of insects, including honey bees. Fruits are from 2 to 5cm in diameter, heart shaped, rounded, with a prominent beak early in development that almost disappear at maturity. Outer skin greyish with fine hairs and inside radiant green, brown or dark green. Fruits split before germinating. Bark is whitish to greyish, yellow or brown-green in color, often peeling in patches, smooth, powdery or scaly. Roots are pencil sized, peg type above ground roots, which are called pneumatophores. Grows predominantly in any position in the intertidal regions of estuaries, lagoons, backwater. Is able to grow in sandy soils and rocks, even though it prefers fine clay and alluvial soils more for improved performance. Not only is it highly saline tolerant but also tolerates the widest range of soil salinity but also highly tolerant to aridity. Suitable on compact substrates, sand flats and newly deposited sediments. Tolerates high salinity and varied flooding regimes, thus widespread throughout the mangrove forest, often found on the landward margin either as pure stands or in association with Sonneratia spp., Ceriops spp. and Xylocarpus spp. Propagules of grey mangroves don`t look like typical spindle-shaped propagules of some other mangrove species because embryonic axis (hypocotyl) of the developing embryo does not penetrate the seed coat. (Veslam, 2007). We can deduce that propagules of grey mangroves look very similar to normal seeds by appearance, therefore called crypto viviparous propagules.

3.3.5 Sonneratia alba – family LYTHRACEAE (Hai, 2017)

Table 5. Basic information of Sonneratia alba

Scientific name	**Regional name**	**English name**
Sonneratia alba	Kiswahili, Mpira	Mangrove Apple
Plant type	tree	
Soil type	upper soil level (eulittoral)	
Habitat	Low-intertidal zone	W Indian Ocean to W Pacific Ocean

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	Sonneratia

Maximum height at maturity 12m or more with large, stumpy, vertical pneumatophores. Leaves are opposite, simple, broadly rounded, thick and very green from 3 to 12cm long and from 2 to 9cm wide. Flowering throughout the year, conspicuous mass of white filamentous stamens, dusk opening. This species is often pollinated by bats and hawk moths. Berry like fruits up to 6cm in diameter, which have a spine at the apex and numerous small seeds inside. The trunk is very short but densely occupied by branches and aerial roots.

3.3.6 Lumnitzera racemosa – family COMBRETACEAE (Velsam, 2007)

Table 6. Basic information of Lumnitzera racemosa

Scientific name	**Regional name**	**English name**
Lumnitzera racemosa	Kiswahili, Mkadaa dume	Black mangrove
Plant type	Aquatic, Shrub, tree	
Soil type	Sandy, loam, brack/Saline	
Habitat	Border of open and closed lagoons	W Indian Ocean to W Pacific Ocean

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Myrtales	Combretaceae	Lumnitzera

Mainly occurs as a shrub maximum from 2 to 5m tall. Thin dense branches growing upwards together**.** Leaves are simple, alternate, spirally arranged, with tiny or no petioles, fleshy and with small rounded apex. From 2 to 8cm long and from 1 to 3cm wide, very light green to almost yellowish. Flowers are small white, five-petaled, erect with green colored calyx, five lobes at tip. No vivipary or cryptovivipary. Seed buoyant, indehiscent (not opening at maturity) and crowned by a persistent calyx (clove like fruit), single-seeded green capsule. It is self-water dispersed or strong hurricane which lead to patchy dispersion. Bark is grey and fissured longitudinally in older trees. Above-ground breathing roots normally absent, but in moist environments lateral looping roots may occur mainly simple roots. Always found as a landward mangrove in the littoral fringe, where there is an influence of fresh water**.** Provides good source of timber, used in boat making, construction. Also acts as excellent fuel wood and source of charcoal.

3.3.7 Pemphis acidula – family LYTHRACEAE (Velsam, 2007)

Table 7. Basic information of Pemphis acidula

Scientific name	**Regional name**	**English name**
Pemphis acidula	Kiswahili, Mkaa pwani	Iron Wood

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	Pemphis

Distribution around Indio-Pacific Ocean. Maximum height of creeping shrublet 15cm or shrub at maturity from 1 to 5m tall. Multi-stemmed plants of hard wood with numerous slender branches. Leaves are opposite, from 1 to 2cm long, elliptical and slightly succulent like. Leaves small, glossy, juicy, light greenish-yellow. Flower axillary, white and small, flowering throughout the year. Seed dark reddish-brown, with numerous small seeds. Simple, creeping roots. Prefers supra-littoral fringe, common in landward reaches of mangroves and on sandy beaches but also can occur further inland.

3.3.8 Heritiera littoralis – family STERCULIACIAE – RARE (Velsam, 2007)

Table 8. Basic information of Rhizophora mucronata

Scientific name	**Regional name**	**English name**
Heritiera littoralis	Kiswahili, Mkunguu	Looking-glass plant

Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Plantea	Tracheophyta	Magnoliopsida	Malvales	Sterculiaciae	Heritiera

Distribution around Indian Ocean to Pacific Ocean. Crown categorized as medium to large sized. Maximum height at maturity up to 35m. Very branched, evergreen tree. Leaves simple, alternate, elliptical, oblong, quite long up to 20 cm long and 12cm wide. Dark green with yellow veining on top side and white to silver glossy on the bottom side. Flower small, densely haired and unisexual (male smaller than female flower), petals are purplish to brown. Fruit large, woody, smooth and elliptical, with prominent ridge on one size (acts as sail), color changes from green to brown when mature. Non-viviparous, medium to large sized, boat-shaped, with a hard shell which opened with maturity to release seed and buoyant. Mature trees have ribbon roots and no aerial roots. Smaller trees have buttress roots, where they develop into plank roots, thus air-breathing roots plus provide mechanical support to trunk. Bark is fissured, greyish and scaly. Especially river mouth in the sandy loam and inland.

3.3.9 Xylocarpus granatum – family MELIACEAE – RARE (Abdulah, 2017)

Table 9. Basic information of Xylocarpus granatum

Scientific name	**Regional name**	**English name**
Xyplocarpus granatum	Kiswahili, Mkomafi	Cedar mangrove
Plant type	tree	

Kingdom	Phylum	Class	Order	Family	Genus
Plantea	Tracheophyta	Magnolipsioda	Sapindales	Meliaceae	Xylocarpus

Distribution around W Indian Ocean to Pacific Ocean Maximum height at maturity 6m. Leaves have a pattern by 2,4 or 6 leaflets. They are large, simple, oblong or elliptic. Dark green with yellow veining. Flower small, white, produced July-August. Non-viviparous seed, large and round up to 25cm in diameter weighing from 1 to 3kg and are divided into numerous wedge-shaped seeds. Mature trees have ribbon-like roots and breathing roots**.** Prefers usually at landward margin of mangrove forests in the littoral fringe, where there is an influence of fresh water**.** This species is regarded as an associate mangrove due to the absence of specifications for coping with saline conditions, thus not halotolerant or a halophyte.

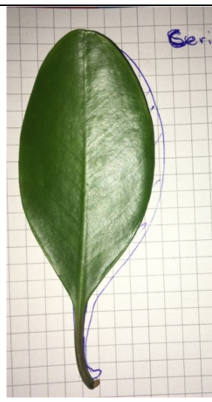
3.4 Storage and propagation

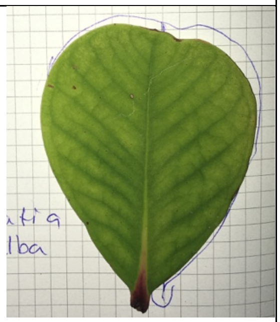
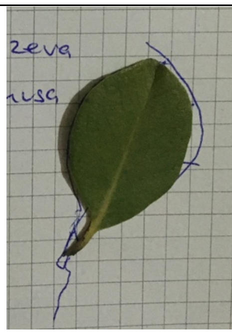
It`s very similar to all mangroves, where large numbers of propagules are produced and already matured propagules can be either picked from trees or if freely floating in water, can be easily collected by scoop nets or hands (Velsam, 2007). Propagules can be stored for about a week by keeping the lower portion in brackish water (to facilitate shedding of the outer coat) or by wrapping them with wet jute bags (Velcam 2007). Naked propagules can be directly planted in selected fields by inserting them up to one–third of their length. Nursery-raised seedlings about 30-35 cm in height can be used for outplanting. Direct planting is most successful and economical.

3.5 Conclusion of mangrove uses

In general, the wetland mangrove environment in considered to be and multi-use ecosystem. It has been acknowledged that mangrove ecosystems are amongst the leading forms of coastal bio-shielding. This is due to its critical importance in reduction of the impact of hurricanes, tsunamis, cyclonic storms upon human lives, property and belongings (Danielsen et al.2005; Selvam, 2005). Not only does it decrease negative impact, it also holds many other important functions which have been already slightly mentioned in this document. These essential traits also aid in reduction of soil erosion, enhances productivity of economically and socially profitable industries, such as fisheries, specifically adjacent coastal waters by providing adequate nursery habitats for commercially important fish, crustaceans and supplying organic and inorganic nutrients (Ajonina, 2008). Being rich is biodiversity they also act as great habitats for wildlife.

Table 10. Demonstration of the uses and differences between leaf types of mangroves in Uzi Island

Name of mangrove	**Use**	**Leaf Photograph**
Bruguiera gymnorhiza (Pelser P.B & Barcelona J.F, 2012)	Mainly for timber, waterproof, resistant to borers, very tough Making boats, fishtraps, construction High in tannins, black dye	
Rhizophora mucronata	Tannin source, leather production Stilt root stripped-off bark = construction Dying agent either for fishing lines to make the surface waterproof or as paint fue to it`s thick texture	
Ceriops tagal	Cloths dyeing, high quality tannin used for tie-dye technique, yellow to brown color on cotton cloth Due to structure and properties, durable, thus excellent charcoal and firewood	

Avicennia marina	Suitable for coppice (regular cutting to form new shoots) Excellent firewood Large trunks as dug-out cannoes	
Sonneratia alba	Aerial roots mainly used by fisherman as floats	
Lumnitzera racemosa	Provides good source of timber Used in boat making or construction. Excellent fuel wood and source of charcoal.	
Pemphis acidula	Very nutritious, possible to use like a vegetable. Due to its high salt content, is used as an alternative to normal salt.	

Heritiera littoralis (Pelser P.B & Barcelona J.F, 2012)	wood extremely tough and used for timber in ships furniture, bridges and salt water pilings.	
Xyplocarpus granatum (Pelser P.B & Barcelona J.F, 2012)	Fruits used for medicine by coastal communities.	

3.6 Problems and benefits of mangroves

If the rate of destruction of mangrove swaps continues in such a rate that is predicted in the nearby future, the consequences might be tragical. With the declination of these precious elements in such rapid rate we might lose such important benefits which these plants bring to the community. Not only maintaining a well functioning system, but also providing positive health impacts toward humans (Bochove, 2014). Regarding the social aspect fragmentation of communities, loss of social cohesion, loss of cultural values, social & wealth & gender inequality, lack of identity and isolation may all be the negative outcomes between recreational, spiritual and cultural areas (Glen, 2005).The following areas are affected negatively with the demolition of mangrove ecosystems: timber and forest products, fisheries, climate regulation, shoreline stabilization, coastal protection. Security is also negatively influenced by the where increased exposure to storms, vulnerability to sea level rise, coastal erosion, loss of land, loss of access to resources may occur (Bochove, 2014). The topic which has to be addressed the most is deffinetly the health related one. Lack of nutrituos and diverse food, polluted water, lack of medicine, poor health, increased food prices, reduced protein intake may occur (Bochove, 2014).

(-) Constant pressure on mangrove swamps from different dirrections cause negative influence upon the whole balance of the ecosystem and the relevant environments. These originate from social, agricultural, industrial aspects and ofcourse urban development. Then factors such as climate change, weak forest management capacity are also important. Such as increase of sea level, unexpected environmental changes and anthropogeic interactions may alsao affect the overall balance in the system (Glen, 2005).

(-) A common difficulty in mangroves is the permanent presence of their roots in waterlogged mud, which causes a limited source of air, which they still need to survive. Mangroves have adapted to this issue and have evolved different structures to deal with this, where on top of each structure develops a callus-like tissue where air exchange occurs (Glen, 2005).

(+) The vital issue for plant species growing in high salinity conditions, is in fact how to get rid of the excess salt. Most mangrove species deposit this excess salt into old leaves, which die off eventually when the limit is reached. This process is all year long and is normally observed in healthy and sick mangroves by yellowing and falling of leaves. This is beneficial to the crab community, due to them being a major item in their diet. They are lurking for these leaves to fall, where they can grab them and take them to safety (Glen, 2005).

3.7 Danger and threats

Generally, mangrove species are more at risk from coastal development and extraction at the extremes of their distribution and are likely to be contracting in the areas more than in other areas. It is also likely that changes in climate due to global warming will further affect these parts of the range. Although there are overall range declines in many areas, they are not enough to reach any of the category threshold. Mangroves are disappearing at a rate of 1 to 2 % per year (Duke 2007). Loss of mangrove habitat throughout its range: a) extraction for usage of the locals, for household purpose; cooking, building material and b) coastal development, where an estimated 20 % decline in mangrove area within this species Brugiera gymnorhiza (Duke 2007).

3.7.1 Threats and vulnerability

Table 10. Consists the potential sustainable aspect, their threats and vulnerability

Potentially sustainable	Unsustainable
Food	Eutrophication from the influx of nutrient from sewage discharge
Tannin and resins	Habitat modification/destruction/alteration for coastal development, including pond aquaculture
Medicines and other bioproducts	Disruption of hydrological cycles such as dams
Furniture, fencing, poles	Release of toxins and pathogens from industrial and domestic outfalls
Artisanal and commercial fishing	Introduction of exotic species that negatively affects the local species
Charcoal	Fouling by litter
Cage culture	Build-up of chlorinated and petroleum hydrocarbons
Ecotourism	Shoreline erosion/siltation accelerated by deforestation, desertification and other poor land use practices
Recreation	Uncontrolled resource exploitation
Education	Global climate change
	Noise pollution affecting the mangrove megafauna
	Mine tailings
	Herbicides and defoliants

3.8 Socio-economic exploitation statement

Waterfront biological systems are versatile living spaces due to their high practical decent variety and beach front networks are socially and monetarily strong due to the strength of the environment whereupon they depend through the accessibility of differing monetary exercises (Adger, 1997). Be that as it may, as strong as mangrove biological systems show up, these imperative backwoods are additionally powerless and are in effect immediately drained because of increased human unsettling influences and poor administration rehearses. Uncontrolled reaping and devastation of mangrove woodlands can for all time change these biological communities (Pearce, 2002). In the same way as other different pieces of the world, the mangroves of Zanzibar are undermined by obliteration personally connected with human exercises, for example, gathering for timber and fuel-wood (Hussein, 1995; Semesi, 1998), land recovery for aquaculture and salt-lake development (Terchunian et al.,1986; Primavera, 1995), contamination and damming of waterways that adjust water saltiness levels (Lewis, 1990; Wolanski, 1992), oil slicks have affected mangroves significantly (Ellison and Fransworth 1996). The key reason for overexploitation of mangrove backwoods is the expansion in populace weight along the coast, neediness, absence of work alternatives, change in qualities and open access nature. Mangroves are likewise compromised by the effect of worldwide environmental change, which generally affects temperature change, carbon dioxide, modified precipitation example, storminess and eustatic ocean level ascent. Be that as it may, the environmental change is an outcome of long-term impact of anthropogenic exercises (Pearce, 2002).

3.9 Conservation actions

In the western Indian Ocean many mangrove forests are threatened by unsustainable human development. Future research should focus on the preparation of the detailed maps and inventories of these mangrove areas then identify most threatened, therefore priority location for conservation and exploitation. The inter-relationship between the sea and the mangrove forests needs to be studied further as do the impacts of land-based developments upstream, and the consumption and demand of fuel wood (Bojang. F, Atanga A.N. 2009).

3.9.1 Restoration

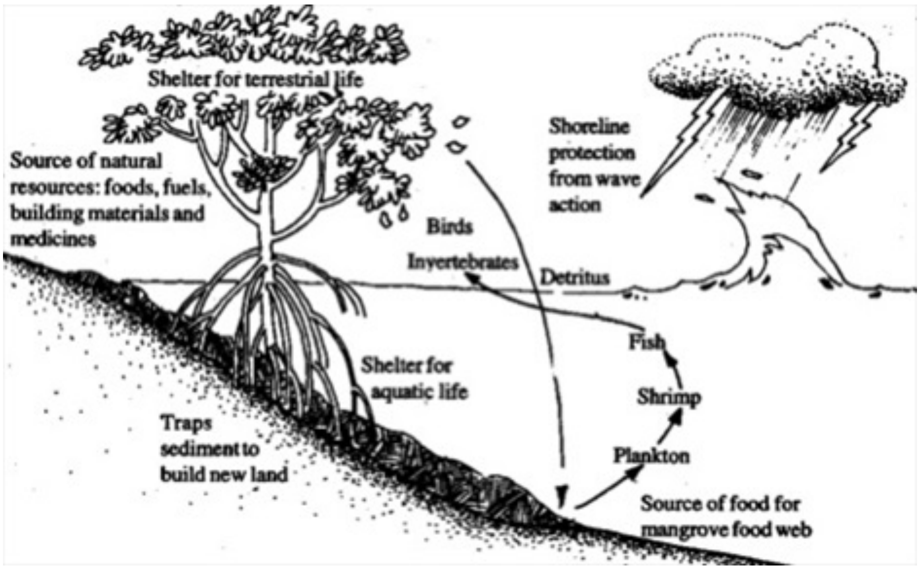


Figure 19. Restoration cooperation between ecosystems (Ketelaars et al. 2013)

Restoration cooperation mechanisms through natural environments occur quite sponatniously, with clearly set features and properties, all connect into one whole system to bring positivite outcomes and maintain the ecosystems strong. Ofcourse even a slight distruption may cause the system to crubble to small pieces as shown in Figure 19.

Mangroves are a very rich source of natural resources such as different types of foods, fuels, building materials and medicine. The crown of mangrove provides shelter for terrestrial life, where roots on the other hand provide shelter for aquatic life and trap sediment too expand the coast, thus building up new land (Ketelaars et al. 2013). Plankton, small crustaceans, fish, detritus and invertebrates are live all a part of the maintenance of the environment, providing food and benefits to the ecosystems. With the increasing density of mangroves towards the ocean, the stronger the shoreline protection from waves will be.

3.9.1.1 Natural regeneration (Kairo et al. 2001)

This approach uses naturally occurring mangrove propagules as the source for regeneration. The composition of the regenerated species depends on the species mix of the neighbouring population. In Ihe family Rhizophoraceae. propagules furnished with pointed hypocotyls fall freely from the parent and plant Ihemselves into the mud (La Rue and Muzik 1954) or
they may be stranded and planted away from the parent plant (Rabinowitz 1978, Van Speybroeck 1992). Whether mangroves disperse through self-planting or stranding strategies will depend on the forest conditions (cut or not cut). tides, as well as the stability of the soils. Harvesting too many trees from Ihe forest diminishes stability of the soil, which causes the propagules and saplings to be washed away with the tides and makes natural regeneration impossible. Mangroves are a source of natural resources such for food, fuels, building material and medicine. The crown is shelter for terrestrial life and the roots don`t only trap sediment to build new land but also shelter aquatic life. These forms of life such as plankton, shrimps, fish, detritus, invertebartes play a key role in mangrove ecosystems. Shoreline protection from waves is also maintained by a dense mangrove environment.

3.9.1.2 Types of benefits of mangrove restoration

Direct harvesting	**Indirect use, monetary value**	**Non-use or preservation (intristic)**
Forestry	Flow regulation and flood mitigation	Biologic diversity
Fish production	Prevention of saline water intrusion	Gene bank function
Fuel production	Sediment retention	Cultural and historic value
Harvestable goods	Nutrient retention and biological filter	Aesthetic value
Transport function	Toxicant removal or retention	Wilderness value
Tourism	Protection against natural forces	Uniqueness value

3.9.1.3 Existing Successful Case Study

The IUCN Red List Categories and Criteria were applied to 70 species of mangroves, representing 17 families. Hybrids were not assessed as the IUCN Red List Guidelines generally exclude all plant hybrids for assessment unless they are apomicts. Species nomenclature primarily followed Tomlinson (Tomlinson, 1986), and family nomenclature primarily followed Stevens (Stevens, 2009), with the exception of Pteridaceae.
The IUCN Red List Categories are comprised of eight different levels of extinction risk: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) and Data Deficient (DD). A species qualifies for one of the three threatened categories (CR, EN, or VU) by meeting the threshold for that category in one of the five different available criteria (A–E). These different criteria form the real strength of the IUCN Red List as they are based on extinction risk theory and provide a standardized methodology that is applied consistently to any species from any taxonomic group (Schipper et al 2008), (Stuart, 204), (Butchart, 2004).

3.9.1.3.1 Case Study Thailand (Halpern, 2015)

Established in 1986, Leam Markham is a 235-acre community-managed mangrove forest and sea grass conservation zone in the Trang Province in Thailand. Years of collaboration between local conservationists, economists, scientists, grassroots activists, students and citizens have protected mangrove forests from logging, development and destruction for aquaculture, and seagrass beds from damage by trawling, dynamite fishing and pushnets. Leam Markham’s success has led to the introduction of an additional 10 community-managed mangrove forests in the area, where inter-village committees are responsible for overseeing the sites and providing management for local resources.

3.9.1.3.2 Case Study Florida (Halpern, 2015)

In 1996, the Mangrove Trimming and Preservation Act was put into effect, providing legislation to protect the 555,000 acres of mangroves in Florida. The Act bans the alteration or trimming of mangroves on uninhabited public land and allows private property owners to trim mangrove trees in accordance with established guidelines. The Act has effectively protected coastal ecosystems by ensuring continued shoreline protection while simultaneously enhancing coastal economies.

4 Conclusion

To make this bachelor thesis complete, it is essential to refer back and reflect upon the objectives that have been set and evaluating their effectivity. An attempt to give a structured overview, basic knowledge and definition was attempted, to clearly state the situation and the issues allocated with this topic. The approach was fullfilled in the extent that was intended. Clear facts prove that the trend of mangrove populations are going to decrease rapidly if proper research and measures will not be put in place immediately. The struggles that are faced in developing countries tend to decrease speed and the effectivity of such attempt of conservation. The extend was described regarding global and local scales into detail and the importance, significance and connectivity of these plants were emphasized adequetly throughout this thesis. The main HOW and WHY factors were answered in multiple forms, ways and the major physiological and characteristic features were explored thotoughly. A detailed inventory of mangroves was constructed to clearly understand and imagine the diversity which is present in Uzi Island. This representation was enriched with actual photographs of tree, leaves, fruits and flowers. Furhter the social, health and ecological aspects were discussed such as benefits, threats and uses in slight detail to link the effects of declining mangroves towards the effects to coastal communities. Existing starategies that are already taking place with the aid towards the situation of mangroves were mentioned an in two countries and clear understanding how conservation is important.

5 Bibliography

Abdulah (2017. September.15) [Personal scientific interview] Šárka Zděnovcová

Adger, N. 1997. Sustainability and Social Resilience in Coastal Resource Use. CSERGE Working Paper GEC97-23, University of East Anglia, Norwich & University College London, London, UK. 39 pp.

Ajonina, GN. 2008. Inventory and Modelling Mangrove Forest Dynamics Following Different Levels Of Wood Exploitation Pressures in the Douala-Edea Atlantic Coast of Cameroon, Central Africa [Ph.D Thesis]. Albert-Ludwigs-Universität Freiburg im Breisgau, Germany, 2008.

Beck MW, Heck KL Jr, Able KW, Childers DL and 9 others 2001 The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. BioScience 51:633–641

Biology Discussion. 2019. Biology Discussion. Classification and Character of Halophytes. Fig. 10.2.Pneumatophores of mangrove plant. Digital Image Available from http://www.biologydiscussion.com/plants/halophytes-classification-and-characters-of-halophytes-with-diagram/6932 (accessed January 2019)

Biology Discussion. 2019. Biology Discussion. Classification and Character of Halophytes. Fig. 10.3 Supporting or tilt rootsof mangrove plants eveloping from the bark. Digital Image Available from http://www.biologydiscussion.com/plants/halophytes-classification-and-characters-of-halophytes-with-diagram/6932 (accessed January 2019)

Biology Discussion. 2019. Biology Discussion. Classification and Character of Halophytes. Fig. 10.6. Vivipary in Rhizophora. Digital Image Available from http://www.biologydiscussion.com/plants/halophytes-classification-and-characters-of - halophytes-with-diagram/6932 (accessed January 2019)

Blaber SJM, Brewer DT, Salini JP 1989 Species composition and biomasses of fishes in different habitats of a tropical northern Australian estuary: their occurrence in the adjoining sea and estuarine dependence. Estuar Coast Shelf Sci 29:509–531

Bochove, J. V., Sullivan, E., & Nakamura, T. 2014. The impact of diminishing ecosystem services derived from mangroves to human well-being.[Digital image]. Retrieved from https://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/276/original/DEPI_Mangrove_ES_report_fig_3.9.jpg?1416237462

Bojang. F, Atanga A.N. 2009. The relevance of mangrove forest to African fisheries, wildlife and water resources. FAO Regional Office for Africa. Accra, Ghana.

Bumler, R. H., Schwendenmann, L., Lohrer, A. M., & Lundquist, C. J. (2017, May 21). Sediment carbon and nutrient fluxes from cleared and intact temperate mangrove ecosystems and adjacent sandflats. Digital Image Available from ttps://www.sciencedirect.com/science/article/pii/S0048969717312391 (accessed January 2019)

Butchart SHM, Stattersfield AJ, Bennun LA, Shutes SM, Akcakaya HR, et al. (2004) Measuring global trendes in the status of biodiversity: Red List indices for birds. PLoS Biol 2: 2294–2304.

Donato, D., Kauffman, J., Murdiyarso, D., Kurnianto, S., Stidham, M.,Kanninen, M. (2011). Mangroves among the most carbon-rich forests in the tropics. Nature Geoscience. 4: 293-297

Dreamstime, 2019, Digital Image Available from https://www.dreamstime.com/rows-seaweed-seaweed-farm-rows-seaweed-seaweed-farm-jambiani-zanzibar-island-tanzania-image107863179 (accessed March 2019)

Duke, N. C. et al. (2007). A World Without Mangroves? Science 317, 41–42.

Furian P.H. 2015. Zanzibar Map. Alamy StockVector. Digital Image Available from https://www.alamy.com/stock-photo-africa-tanzania-zanzibar-map-atlas-map-of-the-world-travel-africa-147038049.html (accessed January 2019)

Glen H.F., KwaZulu-Natal Herbarium. 2005. PlantzAfrika.com : Bruguiera gymnorrhiza (L.) Lam. South Africa. Available from: http://pza.sanbi.org/bruguiera-gymnorrhiza

Guest, M.A., Connolly, R.M., Lee, S.Y., Loneragan, N.R., Breitfuss, M.J., 2006. Mechanism for the small-scale movement of carbon among estuarine habitats: organic matter transfer not crab movement. Oecologia 148, 88–96.

Hai HD. 2017.The Worldwide Fruits. The Worldwide Fruits, Vietnam. Available from https://www.worldwidefruits.com/sonneratia-alba.html (accessed April 2019)

Halpern B., Lowndes J.S. 2015. Ocean Health Index. Available from http://www.oceanhealthindex.org/methodology/components/mangroves-condition

Howard, J., Hoyt, S., Isensee, K., Pidgeon, E., Telszewski, M. (eds.) 2014. Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows. Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Arlington, Virginia, USA.

Hsieh, H.L., 1995. Spatial and temporat pattern of polychaetecommunities in a subtropical mangrove swamp: influences of sediment and microhabitat. Mar. Ecol. Ser. 127, 157-167

Hussein MZ (1995) Silviculture of mangroves. Unasylva 46: 36-42 Jimenez JA (1990) The structure and function of dry weather mangroves on the Pacific coast of Central America, with emphasis on Avicennia bicolor forests. Estuaries 13: 182- 192

Institute for Marine and Atmospheric Research Utrecht (IMAU). 2007. Science Direct. Elsevier B.V. Digital Image Available from https://www.sciencedirect.com/science/article/pii/S156826920280033X (accessed January 2019)

Krause, J. 2002. Missouri Botanical Garden. Mangrove Forests. Available from: www.mbgnet.net/salt/sandy/mangroves.htm.

Lewis RR (1990) Creation and restoration of coastal wetlands in Puerto Rico and the US Virgin Islands. In: Kusler JA, Kentula ME (eds) Wetland Creation and Restoration: The Status of Science, Vol. I: Regional Reviews, Island Press, Washington DC, pp 103–123 A6

Lugo AE, Snedaker SC (1974) The ecology of mangroves. Annu Rev Ecol Syst 5: 39–63.

Mace GM, Collar NJ, Gaston KJ, Hilton-Taylor C, Akçakaya HR, et al. (2008) Quantification of extinction risk: the background to IUCN's system for classifying threatened species. Conserv Biol 22: 1424–1442.

Machuca, I. 2013. Mangroves [Scholarly project].In OceanaTeachBz. Digital Image Available from https://www.oceanateachbz.com/uploads/1/8/3/9/18397615/mangroves.pdf (accessed January 2019)

Mchenga ISS, Ali AI. A review of status of mangrove forest in Zanzibar Island, Tanzania. Int J Res Rev. 2015; 2(8):518-526.

Munro, J. L., Reeson , P. H., and Gaut, V. C. (1971). Dynamic factors affecting the performance of the Antillean fishisn trap. Proceeding of the Gullf Caribbean Fisheries Institute 23:184- 194.

Ozcoast. 2013. Physical habibat. Digital Image Available from http://www.ozcoasts.gov.au/conceptual_mods/processes/habprov.jsp (accessed january 2019)

Pearce, G. (2002) Transplant techniques for sapling mangrove trees. [http//www.iucn.org/marine]. Accessed on January 2019

Peck, L. (2014). Mangroves. Digital Image Available from http://w3.shorecrest.org/~Lisa_Peck/MarineBio/syllabus/ch6producers/producer wp/cw/ashleycwmangroves.html (accessed January 2019)

Pelser. P.B & J.F.Barcelona. 2012. Image of Bruguiera gymnorhiza. Available from http://131.230.176.4/imgs/pelserpb/r/Rhizophoraceae_Bruguiera_gymnorrhiza_48618.html (accessed March 2019)

Pelser. P.B & J.F.Barcelona. 2012. Image of Heritiera littoralis. Available from: http://phytoimages.siu.edu/imgs/pelserpb/r/Sterculiaceae_Heritiera_littoralis_48393.html

Pelser. P.B & J.F.Barcelona. 2012. Image of Xylocarpus granatum. Available from: http://phytoimages.siu.edu/imgs/pelserpb/r/Meliaceae_Xylocarpus_granatum_43619.html

Perkin A. 2009. Researchgate.net. Digital Image Available from https://www.researchgate.net/figure/Map-of-Uzi-and-Vundwe-Islands-showing-locations-of-three-line-transects-and-focal-colobus_fig1_237601815 (accessed January 2019)

Pinterest. 2019. Digital Image Available from https://i.pinimg.com/564x/ec/a6/30/eca63073b5e9f654f314efdae8c7d712.jpg (accessed January 2019)

Polidoro BA, Carpenter KE, Collins L, Duke NC, Ellison AM, et al. (2010) The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern. PLOS ONE 5(4): e10095. https://doi.org/10.1371/journal.pone.0010095

Polidoro, Beth A. Mangrove Species Richness: Native Distributions of Mangrove Species.8 Apr. 2010, Digital Image Available from: www.ncbi.nlm.nih.gov/pmc/articles/PMC2851656/ (accessed January 2019)

Primavera JH (1995) Mangroves and brackish water pond culture in the Philippines. Hydrobiologia 295: 303-309

Rabinowitz D (1978) Early growth of mangrove seedlings in Panama, and an hypothesis concerning the relationship of dispersal and zonation. Journal of Biogeography 5: 113-133

Reid, Natasha. Global Mangrove Species Distribution Zones (NOAA 2014). 2014, Digital Image Available from response.restoration.noaa.gov/sites/default/files/Oil_Spill_Mangrove.pdf. (accessed January 2019)

Semesi AK (1998) Mangrove management and uti lization in eastern Africa. Ambia 27: 620--626

Sheaves M, Johnston RW 2008 Influence of marine and freshwater connectivity on the dynamics of subtropical estuarine wetland fish metapopulations. Mar Ecol Prog Ser 357:225–243

Schipper J, Chanson JS, Chiozza F, Cox NA, Hoffmann M, et al. (2008) The Status of the World's Land and Marine Mammals: Diversity, Threat, and Knowledge. Science 322: 225–230.

Stal LJ. 2001. Coastal microbial mats: the physiology of small-scale ecosystems. South African Journal of Botany. Netherlands.

Stevens PF (2001) Angiosperm Phylogeny Website Version 9, June 2008. Available: http://www.mobot.org/MOBOT/research/APweb/. Accessed 2009 July 25.

Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, et al. (2004) Status and trends of amphibian declines and extinctions worldwide. Science 306: 1783–1786.

Taylor M, Ravilious C, Green EP. 2003. Mangroves of East Africa. UNEP World Conservation Monitoring Centre. Cambridge.

Terchunian A, Klemas V, Alvarez A, Vasconez B, Guerrero L (1986) Mangrove mapping in Ecuador: The impact of shrimp pond construction. EnVironmental Management 10: 345- 350
The wet tropics world heritage area. 2015.Wet Tropics Management Authority. Digital Image Available from https://www.wettropics.gov.au/mangroves-info (accessed January 2019)

Tomlinson PB (1986) The Botany of Mangroves. Cambridge, UK: Cambridge University Press. 413 p.

Uzi Island Conservation Society. 2012: Zanzibar Ecotourism. Digital Image Available from http://zanzibar-ecotourism.org/ (accessed January 2019)

Van Speybroeck D (1992) Regeneration strategy of mangroves along the Kenyan coast: A first approach. Hydrobiologia 247: 243-251

Velsam, V. 2007. FAO.ORG. Mangroves Trees and Shrubs of the Maldives. Mangrove trees and shrubs., Thammada Press Co.,Ltd., Bangkok.

Vierus, Tom. Schematic Mangrove Zonation. 5 Oct. 2015. Digital Image Available from www.livingdreams.tv/oceans/marine-ecology/what-are-mangrove-forests. (accessed January 2019)

Wikimedia Foundation,Inc. 2019. Wikipedia The Free Encyclopedia. Mangroves. Digital Image Available from https://upload.wikimedia.org/wikipedia/commons/thumb/e/e8/Saltcrystals_on_avicennia_marina_var_resinifera_leaves.JPG/800px-Saltcrystals_on_avicennia_marina_var_resinifera_leaves.JPG (accessed January 2019)

Wolanski E (1992) Hydrodynamics of tropical coastal marine systems. In: Connell D, Hawker D (eds) Pollution in Tropical Aquatic Systems. CRC Press, Boca Raton, Florida, USA, pp 3–27

WoRMS. 2016. World Register of Marine species. 2006. Flanders Marine Institute. Worldwide Cooperation.

6 APPENDIX

6.1 Uzi Island community – Own experience

Uzi Island, even due to the fact that it has a small population and quite large land, it has been categorized as very rich in raw products. Personally, my opinion is very rich in natural raw resources, with large, robust fruit trees on every corner. If properly approached, it has such great potential regarding possible future business plans. The aspect that is lacking most to speed up the process of development, is mainly education and financial situation of habitants.

Uzi Island description of fauna and flora

1. Number one on the list are **sea-weed** farms.

Figure 1. Traditional stick and rope technique of inter-tidal farming of algae

Figure 2. The drying process of seaweed after it reached adult stage

2. Rich variety of fruit trees
   a. Jack fruit

Figure 3. Jack fruit tree in the village

b. Coconut trees

Figure 4. Coconut trees everywhere

c. Banana tree

Figure 5. Banana trees on every corner, plus specific plantions too

d. Lemons

Figure 6. Lemon trees next to the ancient baobab trees

e. mango

Figure 7. Mango tree on the beach, right next to the coast

1. Dug out canoes – mainly mango and mangrove


Figure 8. Hand-made mango tree dug-out canoe


Figure 9. Couple of hand-made tree dug-out canoe from different material

2. Henna painting


Figure 10. Dried henna leaves

3. Fish traps


Figure 11. Traditional heart-shaped fish traps

4. Sea cucumber


Figure 12. Phylum Echinodermata Sea Cucumber Holothuria

5. Crabs


Figure 13. Purple and green crab species

6. Small fish, sea-snails, octopus

Figure 14. Old shells of crustaceans

Figure 15. Small fish caught by local fisherman

In my opinion there is quite a colorful future full of business opportunities for Uzi island. The only problem is that the island is unknown by many, very poor and pretty small. If the inhabitants would have better access to education or if modern technology would be cheaper, the maintanence of mangrove ecosystems would be so much easier and sustainable. One of the finest products which is a large contribution to the local economy, is seaweed. It is apparently exported as an expensive delicasy to Asian countries, mainly China and Japan.

My contribution to the Uzi environment consisted of deep understanding and significance about the topic. Regarding the purpose of my contribution was picking ripe germinated seedlings of the mangrove trees, where trees were over-packed with ready ripe seeds. After the collecting, we later planted them according to need. For example, next to the coastal areas, to aid costal mangroves, where previous mangroves have been cut down or generally patchy areas which needed human influence. We used a simple measuring tool which we created from two sticks and a piece of rope to ensure the adequate distance between planted seeds. We anchored each side of the measuring tool, so that the rope is nicely tight and so that a straight line was established, to clearly mark where individual seeds will be planted. It was necessary to anchor the seeds enough so that high or low tide doesn`t swipe them all away. Ofcourse, there wasn`t a 100 % chance that all of the planted seeds will be anchored enough but ofcourse we tried our best to establish seeds deep enough into the sand. If seeds were swept away, nothing happened because seeds are buoyant and could anchor naturally somewhere further from our location or end up eaten by crabs.

Figure 16. Seed planting method demonstration, using two sticks and rope to choose the appropriate distance between seeds.

Figure 17. Photograph of typical housing techniques

Figure 18. Bag of collected seeds that are ready for planting. That yellow rim means the seed is ripe and germinating.

6.2 Extra representative tables

Table 1. Physiological characteristics plant presentation of mangroves on Uzi Islands represented through images (Abdulah, 2017).

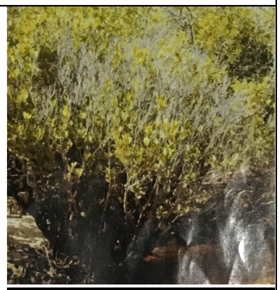
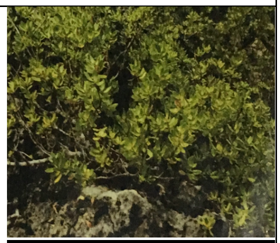
Name	**Plant**	**Name**	**Plant**
Bruguiera gymnorhiza		Lumnitzera racemosa	
Rhizophora mucronata		Pemphis acidula	
Ceriops tagal		Heritiera littoralis	
Avicennia marina		Xylocarpus granatum	
Sonneratia alba			

Table 2. Image representation of the flower/seed portion of the mangroves. The inventory is consisting of different species of mangroves that can be found on Uzi Island, Zanzibar (Abdulah, 2017).

Name	**Flower/Seed**	**Name**	**Flower/Seed**
Bruguiera gymnorhiza		Lumnitzer a racemosa	
Rhizophora mucronata		Pemphis acidula	
Ceriops tagal		Heritiera littoralis	
Avicennia marina		Xylocarpu s granatum	
Sonneratia alba