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The Mangroves of Curaçao: An Ecosystem Worth Protecting

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Author

Asirvadam, Lalitha

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The Mangroves of Curaçao: An Ecosystem Worth Protecting



Lalitha Asirvadam

Center for Marine Biodiversity and Conservation
The Scripps Institution of Oceanography
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Executive Summary

Currently in Curaçao, mangroves are not protected by law and are destroyed by human activities such as clearing for land reclamation, tourist resorts, and pollution. For my Capstone project, I have written a report on the importance of mangroves, explaining the possible values gained and opportunity costs if the government took advantage of this valuable natural resource (mostly through tourism) and provided recommended actions. I hope that it will help influence policy and urge the government to consider legislation to protect mangroves. I plan to present the following report to the proper channels in Curacao. I first plan to submit to colleagues at the Caribbean Research and Management of Biodiversity center (CARMABI), to get their feedback. With a well-vetted product, I will submit the report to the Curaçaoan government. It is my anticipation that government officials realize that it is in their best interest to protect mangroves, since they are the support system for exactly what attracts tourists to Curaçao.

Tourism is a major source of revenue for Curaçao, with most people being attracted to Curaçao's for their nature and beautiful coral reefs. However, without the mangroves, the reefs would likely suffer, and therefore tourism could also suffer. I wanted to promote the notion that in order to protect Curaçao, they must also protect mangroves. I have written this report detailing the definition of mangroves, their global distribution, how they are specially adapted to their unique intertidal habitat, as well as describing the fauna that live there. Also, I describe the history of mangroves on the island and how they have been degraded. I go into detail about the critical ecosystem services that mangroves provide to the island. I then discuss the economic benefits of mangroves regarding fisheries and tourism. I also offer eco-tourism in the mangroves as an untapped source of revenue that could greatly benefit the island. It could be a source of pride for a nation

who is struggling with their new identity. I go on to discuss how mangroves can be a great asset for the island as consequences of climate change occur in the future. I discuss how the 2004 tsunami in the Indian Ocean served as a wakeup call regarding the benefits of having intact mangroves. I hope that it will influence them to realize that this resource is one worth protecting, and perhaps learn from the mistakes of other countries.

I then discuss the progress of local celebrity Ryan de Jongh. He has gone to great lengths to restore some of the mangroves that have been lost, but his work and the support he has garnered may be in vain if there are no laws that protect the mangroves for future damage.

I end the report by making recommendations of what can be done. First, by creating legislation that prohibits the damage and destruction of all mangroves on the island. Next, I suggest expanding eco-tourism to mangroves as well as creating education programs on mangrove ecosystems. Also, I suggest that Curaçao should join more international treaties, such as the Ramsar Convention, that will give the people a sense of pride of being a part of the international community that also protects their nature.

Capstone Advisory Committee Final Capstone Project Signature Form

The Mangroves of Curaçao: An Ecosystem Worth Protecting

Lalitha Asirvadam

Spring 2014

MAS Marine Biodiversity and Conservation

Capstone Project

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The Mangroves of Curaçao: An Ecosystem Worth Protecting

Introduction:

Mangroves are a vital component of coastal systems. They are responsible for important ecosystem services that maintain the coasts and attribute to the health of near-shore habitats and marine life.

Straddling both land and sea, mangroves are uniquely adapted to live in harsh environments in tropical and subtropical coastal areas around the world. They are most recognizable by their prop roots, which allow them to handle the daily rise and fall of the tides.

They are also biologically rich and provide a sanctuary to diverse species as well as serving as nurseries for marine life, including important coral reef fishes and commercially important fishes (Nagelkerken 2002). Young species rely on seagrass beds and mangroves' complex web of roots to protect them as juveniles before they are large enough to migrate to the reefs or out to sea. The degradation or loss of these habitats could have significant impacts on reef-fish stocks in the Caribbean (Nagelkerken 2002). Fish is a major source of protein for the people of Curaçao. The loss of adequate nurseries could

affect fisheries on the island as well as people's livelihoods. They also act as biofilters by sucking up nutrient run-off from land and act as a critical sediment trap for pollution, as well as sewage before it reaches and harms other coastal habitats (Wolanski 1995). Also, they are robust coastal shields that protect shorelines from erosion due to wind, waves and storms.

Mangroves were once abundant in the Caribbean but have been steadily declining due, mostly, to coastal development projects. In Curaçao, the coverage is less than half of what it was a century ago (Nagelkerken 1998).

The vibrant reefs attract divers and tropical destination aficionados from around the world. If the reefs are left to die and the waters turn green, tourists may go elsewhere where nature is better managed. Also, they are extremely resilient and will be important as climate change and sea-level rise becomes more of a threat to Curaçao. However, the mangroves in Curaçao are being destroyed due to clearing for tourist resorts, land reclamation and pollution. These are actions that could jeopardize the state of other habitats on the island that are ecologically connected to mangroves.



Figure: Mangroves at Santa Cruz



1. Overview of Mangrove Ecosystem

1.1. Definition

Mangroves are a taxonomically diverse group of trees and shrubs that live in the intertidal zone of tropical and subtropical regions of the world. Mangroves are mainly arboreal, flowering plants (Ellison and Stoddart 1991). They have been defined as a tree, shrub, palm or ground fern, generally exceeding more half a meter in height, and which normally grows above mean sea level in the intertidal zones of marine coastal environments, or estuarine margins (Duke 1992). They thrive in saline water. Some can live in areas that have a salinity as high as 90 parts per thousand, which is nearly three times as salty as the ocean (Smithsonian 2008). The word “mangrove” can refer to the entire ecosystem or to individual plants (Tomlinson 1986).

1.2. Global Distribution

Coastal shorelines throughout the warm tropics are fringed with mangroves communities. The lushest forests are in the tropical and sub-tropical areas where water temperature is greater than 24 °C and where there is a lot of rainfall (Shedd). The countries in the world with the most mangrove area covered are: Indonesia, Brazil, Australia, Mexico, Nigeria, Malaysia, Myanmar, Bangladesh, Cuba, India, Papua New Guinea, and Colombia (Spalding 2010).

Mangroves have been hugely undervalued, world wide. Since they fringe the coastlines, they are often seen as a nuisance, blocking ocean views. They therefore have become prime targets for conversion into large-scale development projects, such as agriculture, aquaculture, salt extraction and infrastructure (Rönnbäck 1999).

2. Global Loss

Mangrove forests provide at least US \$1.6 billion each year in ecosystem services and support coastal livelihoods globally (Polidoro 2010). Worldwide, mangrove areas are declining rapidly, between 35 and 86% during the last quarter century and continue to decrease by 1% every year (Duke 2007) due to human activities such as coastal development, aquaculture and logged for timber and fuel production (Polidoro 2010).

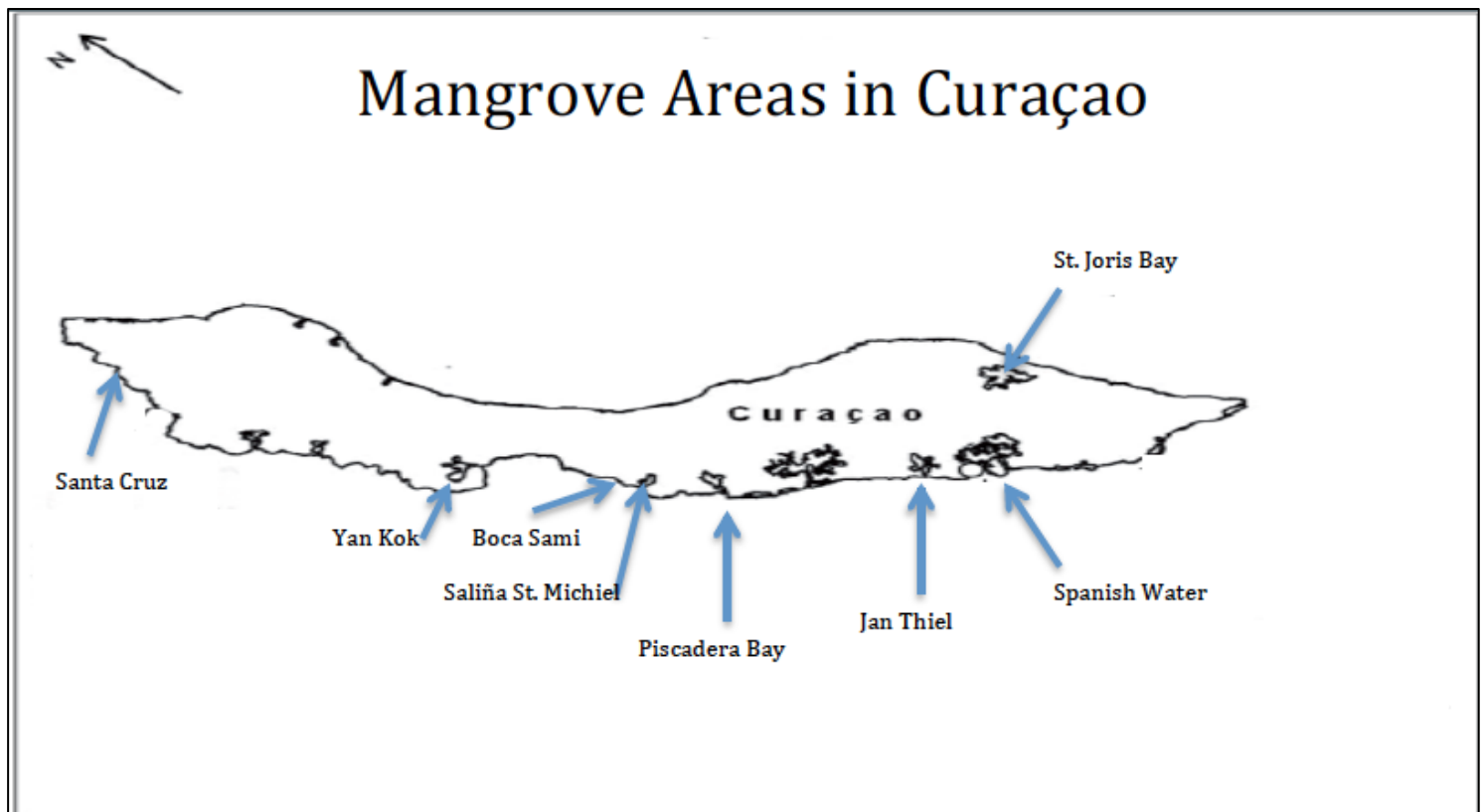
3. History of mangroves in the Caribbean and Curaçao

“The Caribbean was blessed with an abundance of [mangroves], but ... they are in trouble everywhere and need to be protected and restored,” said Aaron Ellison of Harvard University (IUCN 2007). In the entire Caribbean, mangroves have declined by 42% in the past 25 years, with two of the eight Caribbean species now considered *Vulnerable* to extinction and two more in the *Near Threatened Status* (IUCN 2007). In Curaçao, mangrove cover has been decreased dramatically due to continued destruction (Negelkerken 1998). Curaçao has approximately 55 ha of mangroves left (0.12% of the surface area), which much of the remaining area is threatened by coastal development (Debrot and de Freitas 1991). The current coverage is significantly less than half of what it was 100 years ago (Negekerken 1998).

4. Current Mangroves on Curaçao

4.1. Distribution in Curaçao

Mangroves are located mostly in the inner bays of Curaçao. The main areas are: Santa Cruz, Yan Kok, Saliña St. Michiel, Piscadera Bay, Janthiel, Spanish Water, St. Joris Bay, Boca Sami and Rif in Willemstad. They are essential for erosion control for these inner bays and the interior of Curaçao.



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4.2. Fauna

Mangroves are one of the most productive ecosystems on earth. On Curaçao, at least 69 different species rely on mangrove habitats for their survival, including 41% of the total number of birds on the island (de Freitas et al 1992). Mangroves provide a safe haven for a large majority of reef fish and many invertebrates during some period of their lives (DCNAnature 2014). The complex and intricate system of mangroves, from the tops of the trees, the thick of the brush, to the intertwining roots, above and below the water, are rich with fauna.

In Curaçao fish that call mangroves their permanent homes include: killifish tarpon, snook, and mangroves snapper (DCNAnature 2014). Some of the fish that take advantage of mangrove's nursery properties are: parrotfish species, great barracuda, snapper species, grunts, sponges, scorpion fish, boxfish, damselfish, grouper, wrasse, pufferfish, butterflyfish, and cardinal fish (Nagelkerken 2002). Another commercially important species, the spiny lobster, uses the mangroves to spawn. A total of about 60 to 80 different species of fish can routinely be found in mangroves (DCNAnature 2014).

The roots also serve as their own mini-habitat within the mangroves. They often covered in oysters, barnacles, mussels, anemones, sponges, tunicates, stinging hydroids, and worms (DCNAnature 2014), many of which help filter the surrounding water.

Crustaceans also play a huge role in mangrove systems. Fiddler crabs, who create the distinctive holes in mangrove soils, actually play a significant role in mangrove's growth. In one study, the burrowing action significantly increased mangrove height by 27%, trunk diameter by 25%, and leaf production by 15%, compared to mangroves in crab exclusion enclosures (Smith et al 2009). Grapsid crabs live underwater but appear at low tide to feed on the mangrove forest floor (DCNAnature 2014).



Figure: Parrotfish; Photo taken in Piscadera Bay



Figure: Sponge on mangrove roots; Photo taken in Spanish Water



Figure: Fiddler Crab; Photo taken in Piscadera Bay

5. Function of Mangroves

Mangroves are quite remarkable plants and have evolved to thrive in the constantly moving intertidal zone, one that most plants cannot survive. They have a great many special adaptations and ecosystem services.

5.1. Salt Tolerance Adaptation

A major feature that makes mangroves so unique is their salt tolerance. They are one of the only plants that can live in extreme salinities. Certain types of mangroves, such as red mangroves, have the unique ability to *exclude* salts by filtering water at the surface of the root (Gilbert et al 2002). Root membranes block salt from entering the plant while allowing water to pass through. This is how the plant eliminates much of the salt from seawater (Gilbert et al 2002). However, black and white mangroves *excrete* salt. Salt is taken up through the roots and is excreted through glands on their leaves (Gilbert et al 2002). The tree discards the salt when the leaves ultimately drop (Gilbert et al 2002).

5.2. Filter Toxins and Sediments

Mangroves filter sediments and pollutants from seawater. The roots uptake toxins and nutrient run-off from the land caused by agriculture. Excessive nutrients in ocean water create algal blooms that can suffocate coral reefs and kill them (Wolanski 1995). Also, many of the toxins that are introduced to the water by humans are soaked up in the mangrove system, stopping toxins from reaching coral reefs and the open ocean (Wolanski 1995).

5.3. Faunal Filters

Not only do the roots filter the water, but there are numerous filter-feeders that are attached to the roots such as: barnacles, sponges, and shellfish (Tan 2001). These filter feeders clean the water of nutrients and silt, resulting in clear water that washes out to sea, which aide in corals reefs' health, as they need nutrient poor waters to thrive (Wolanski 1995). Also, micro-organisms in soil and on roots also play a role in removing toxins and nutrients, adding to the natural filters in the murky water. (Wolanski 1995)



Figure: Mangrove roots; Photo taken in Piscadera Bay



Figure: Bivalves on mangrove roots; Photo taken in Spanish Water



Figure: Mangroves at Santa Cruz

5.4. Coastal Protection

5.4.1. Erosion Control

Mangroves are excellent coastal buffers. Their elaborate intertwining roots help slow down destructive waves that would otherwise erode away the coastline, reducing land. The thicket of roots slow down fast flowing sediment-laden water and deposits sediments in the mangrove system (IUCN 2007).

5.4.2. Storm Buffer

Mangroves have proved to be valuable natural defense against powerful storms, including the 2004 tsunami in the Indian Ocean. Much less destruction occurred where mangroves were kept in tact. This is discussed further later in the report (Danielsen 2005).

5.4.3. Land Building

Mangroves have the unique ability to build land and bind shorelines. Slow moving water carries sediments to mangroves where they accumulate between their complex root system (McKee 2007). This could prove vital if sea-level rise becomes a reality from climate change.



5.5. Nursery for Reef Fishes

Although not valued significantly by humans, mangroves are a necessary part of many sea creatures' lives. They use them as breeding, spawning, hatching, and nursing grounds. There have been many studies in the Caribbean that acknowledge the importance of mangroves and seagrass beds as habitats for fishes (Nagelkergen 2000). Mangroves and seagrass beds have been proven to have high diversity and abundance of estuarine and/or coral reef fishes in the Caribbean (Nagelkergen 2000). The theory is high abundance of juvenile fishes in these habitats may attribute to avoidance of predators, the abundance of food, and the interception of fish larvae. Reasons for this are thought to be:

- The structural complexity of these biotopes provide excellent shelter against predators (Parrish, 1989; Robertson & Blaber, 1992),
- These biotopes are often located at a distance from the coral reef or from offshore waters and are therefore less frequented by predators (Shulman, 1985; Parrish, 1989);
- The relatively turbid water of the bays and estuaries decrease the foraging efficiency of predators (Blaber & Blaber, 1980; Robertson & Blaber, 1992)
- These habitats provide a great abundance of food for fishes (Odum & Heald, 1972; Carr & Adams, 1973; Ogden & Zieman, 1977) and
- These biotopes often cover extensive areas and may intercept planktonic fish larvae more effectively than the coral reef (Parrish 1989).

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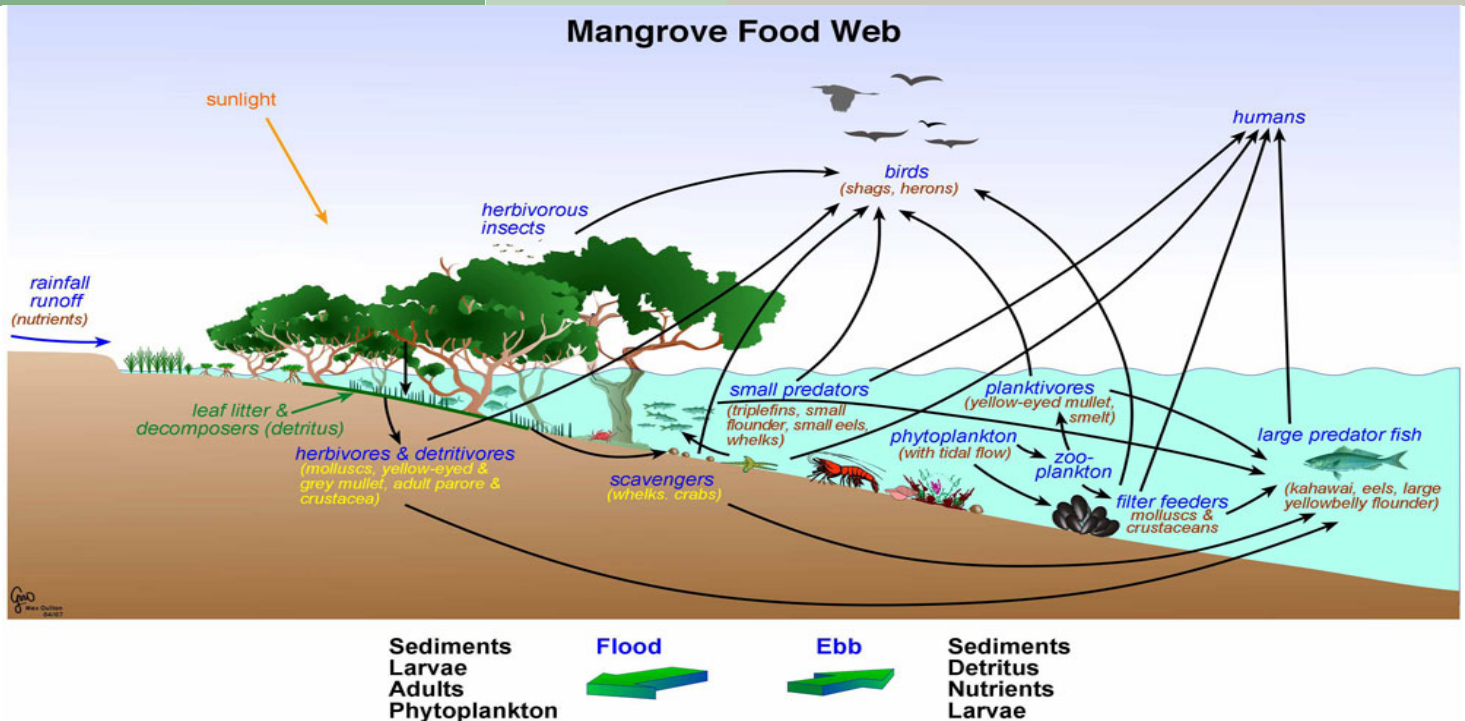


Figure 1 Mangrove Food Web; Figure shows the distribution of various food sources and how they are distributed within a mangrove system and out to the deeper pelagic species. (waikato.ac.nz 2013).

5.6. Feeding Ground

Another reason so many fish and invertebrates utilize mangroves is attributed to the huge food source, or primary production, mangroves provide. Primary production can be credited to multiple sources:

- The trees themselves
- Their associated epiphytes (plants that grow, non-parasitically, on other plants)
- Other larger plants
- Phytoplankton (microscopic, floating plants)
- And benthic micro algae (Rönnbäck 1999).

Carbon fixed by mangrove trees is likely to be the main carbon source for organisms in the systems with turbid waters and a relatively high proportion of forest to open water (Robertson et al. 1992). In areas where mangroves border coastal lagoons, or on small islands in relatively clear water, food webs are more likely to be more complex (Robertson et al. 1992).



Figure: Coral reef at Santa Cruz

5.7. Support System for Coral Reefs

Most people would be surprised to learn that mangroves play a critical role in coral reef health. There have been numerous studies on the importance of mangroves to coral reefs, particularly, in Curaçao and the entire Caribbean. Mangroves have the ability to boost the biodiversity and development of reef fishes and predators, as they provide food and protection for juveniles (Nagelkerken 2002). In Curaçao, studies show how inland bays containing mangroves and seagrass beds are highly associated with at least 17 Caribbean reef-fish species that use them as nurseries (Nagelkerken 2002). On reefs of islands without mangroves and seagrass beds, none to very little densities of species were observed for 11 of the 17 species, many of which are commercially important to fisheries (Nagelkerken 2002). This discovery suggests that the densities of several fish species on coral reefs are representative of the presence of mangroves and seagrass beds bays nearby and the loss of these habitats could result in the substantial effects on reef fish stocks in the Caribbean (Nagelkerken 2002).

A variety of fish and invertebrate species at coral reefs are replenished by inshore coastal ecosystems (i.e. mangroves and sea grass beds) that use them as nurseries. The complexity of the habitats play an important role in using them as hiding places, i.e. between the roots and grass, in the murky water, and utilizing routes too hard for large predators to maneuver through. This is very important for Curaçao because 60% of all individuals belonging to certain fish species that are found on the reef (and are often commercially important, such as yellowtail snappers) lay their eggs in these mangrove bays (Vermeij 2012).

6. Economics

6.1. Fisheries

Artisanal fisheries contribute to much of the fishing in Curaçao; however several longline fishing operations also occur (Project GloBAL). Studies done in Curaçao show that at least 17 different reef fish species, many that are commercially important to the reef fisheries including the yellowtail snapper, striped parrotfish and great barracuda, use mangroves and seagrass beds as nurseries (Nagelkergen 2002). If these vital nurseries are destroyed, fisheries are likely to suffer.

6.2. Tourism

Tourism is a major source of revenue in Curaçao accounting for 15% of its GDP, and continues to become a newly discovered tropical vacation destination. Curaçao is known all over the world for its beautiful coral reefs with more than 160 dive sites. Presently, a kilometer of healthy Caribbean reef is estimated to generate approximately \$1-1.5M annually through coastal protection, fisheries and tourism alone. (Burke et al 2011).

6.3. Economic Value of Mangroves on Curaçao

Since mangroves support coral reefs, they also, in turn play a role in supporting the entire island. Tourism is a major source of revenue in Curaçao, accounting for about 15% of the GDP (IMF 2011). Allowing the mangroves, and thus the coral reefs, to decline, will cause severe economic consequences for Curaçao. Coral reefs are the foundation of the island's tourism and fishing industry.

The above-mentioned ecosystem services mangroves provide represent the classic problem of public goods. These public goods are shared by all and owned by no one; they include water filtration, storm buffers, carbon

sequestration, and habitat for vibrant biodiversity (Keohane 2007). Since there is no market for these services, the social value of wetlands in these dealings is fundamentally ignored (Keohane 2007). As a result, the mangroves have been seriously depleted by such activities as the conversion of land use for urbanization and agriculture (Keohane 2007). The destruction of important nursery habitats, like mangroves and seagrass beds, due to anthropogenic impacts, will have significant negative impacts on reef fish stocks and yields in the Caribbean (Nagelkerken 2002). There have been countless studies around the world on the economic value of mangroves to local coastal communities, as well as entire nations.

6.4. Opportunity Costs

An opportunity cost, in this instance, is the possible revenue lost by not utilizing something, or completely removing them (Keohane 2007). The removal of them would result in opportunity costs that could have been gained through eco-tourism. Currently, direct tourism of mangroves in Curaçao is very little with just a few individuals and hotels offering kayak tours through them. However, utilizing mangroves for eco-tourism could very well be a substantially greater source of revenue for Curaçao.

Locals and tourists alike are becoming interested in mangroves due to local celebrity Ryan de Jongh, kayak champion, mangrove conservationist and mangrove restorer. He is bringing awareness to the issues surrounding mangroves and this is an optimal time for the government to take advantage and expand eco-tourism in the mangroves. Other countries have tapped into this new way for people to experience nature; however, due to the dangers of their

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mangroves (such as saltwater crocodiles, snakes and fishing cats) expensive boardwalks must be constructed and extra safety measures must be taken; which in turn, can have their own negative impacts on the habitat. However, Curaçao has the fortunate advantage of having safe mangroves and these kinds of expensive and invasive precautions are not necessary. Curaçao can safely exhibit their mangroves as an attraction that is safe to kayak or snorkel through.

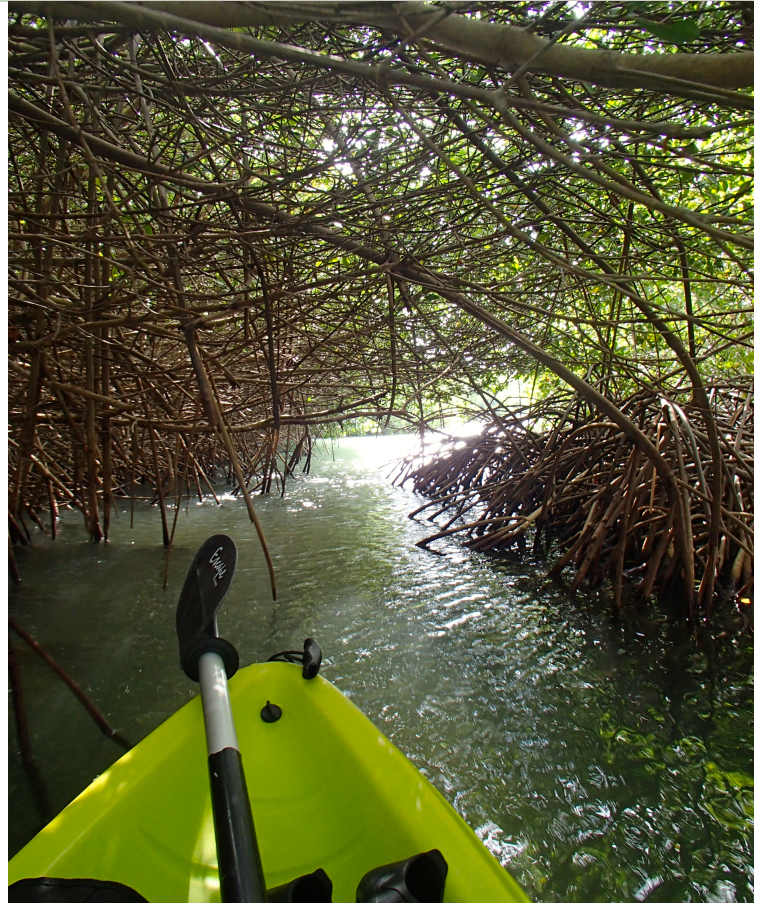


Figure: Kayaking through mangroves at Santa Cruz



Figure: Snorkeler in the mangroves at Spanish Water

7. Current Threats to Mangroves

Although mangroves are supposed to be extremely resilient, they cannot cope with human's destructive practices. The Caribbean has the second highest area loss, relative to other countries, after Indo-Malay Philippine Archipelago (Polidoro et al 2010) with 24% of mangrove area lost over the past 25 years. There are numerous threats including coastal development, upland runoff of pollutants, sewage, and sediments, petroleum pollution, solid waste, clear cutting, land reclamation and tourism (Polidoro et al 2010).

7.1. Coastal Development

One of the biggest threats to mangroves in Curaçao is coastal development. Mangroves are often seen as obstacles to beach access and ocean views for seaside hotels. Mangroves are often bulldozed through with little regard for the nature that is being irreparably damaged. These large-scale projects seem to benefit only a few, while the rest of the population suffers from losing their natural resources. However, the irony is, those who 'benefited' from the developmental projects are also losing by carelessly eliminating a valuable natural protector and supporter of the entire island ecosystem. Also, removing coastal vegetation, such as mangroves, takes away an essential sediment trap that might otherwise prevent damage to near shore ecosystems, such as coral reefs (Vermeij 2012).

7.2. Sewage

One major issue involving Rif mangrove area in central Willemstad is that there is a major sewage pipe discharging into the mangroves. According to a researcher from Caribbean Research and Management of Biodiversity (CARMABI), "It has been suggested by many stakeholders that the cause for this structural discharge is lack of maintenance of the sewage system and the fact that the current system



Photo Credit: www.caribbeanfootprint.com

cannot support the volume of the produced sewage and rainwater from Otrobanda." This also has become a nuisance of mosquitoes that breed in the many pockets of stagnant water present in the area (especially when water levels drop e.g. during the dry season). It was suggested by CARMABI that better water circulation is be created in order to eliminate the stagnant water pools. Apparently, a nature park has been proposed here, which would be an excellent way to conserve the area; however, without a definite structural solution, it is not likely that a park will be created with the current problems any time soon.

8. Climate Change and Blue Carbon

Outside impacts, such as global climate change and sea level rise, is basically beyond the control of local management. However, with the appropriate knowledge of climate science and other functions of mangrove ecosystems, some of the possible devastating affects maybe hindered if the correct measures are taken. Mangroves provide an invaluable ecosystem service that is very rare on this planet. They have extremely high carbon sequestration potential (Spalding 2013). This means that their destruction and loss significantly diminishes human's ability to mitigate, adapt to, and predict climate change conditions (Spalding 2013). Removal of mangrove trees frees huge amounts of 'blue carbon' that have been stored in their soils for millennia or more (Spalding 2013). Deforestation is the second largest cause of anthropogenic carbon dioxide emissions, contributing 12–20% of the total (Hutchinson 2013). Countries that enact and enforce strict laws, in addition to implementing a monitoring program is a start to curbing their contribution to carbon dioxide emissions, while also protecting themselves from more immediate threats like sea level rise (Spalding 2013). In addition, it could provide jobs to largely unemployed local population. The damage caused by the 2004 Asian tsunami was exacerbated by over clearing of mangroves and other coastal bioshields, inappropriate coastal development, and insufficient information and readiness (McLeod 2006). Mangroves act as a crucial biological defense in reducing the impacts of climate change by providing a buffer to coastal areas from tsunamis and cyclones (Climate Citizen 2013). Losing mangroves accelerates the disaster risk for locals from storms and flooding (Climate Citizen 2013).



Figure: Deforestation of mangroves in Madagascar. Photo Credit: Bluecarbonportal.org

8.1 Mangroves and sea-level rise

Mangroves have adapted special prop roots to live in muddy, fluctuating, and saline conditions. Mangroves may adapt to changes in sea level by growing upward in place, or by expanding landward or seaward (IUCN 2007). This would further protect the coast. Mangroves are able to produce peat through the decomposition of fallen leaves, add to root growth, as well as by trapping sediment in the water (IUCN 2007). The process of building peat could help combat sea-level rise (IUCN 2007). For example, in western Jamaica, mangrove communities were able to sustain themselves because their rate of sedimentation exceeded the rate of the mid-Holocene sea-level rise (ca. 3.8 mm/yr)(Hendry and Digerfeldt 1989). However, it is worth noting that if sea-level rise occurs too quickly, mangroves may not have enough time to adapt to these changes (IUCN 2007).

9. Mangroves and Tsunamis

Mangroves have proven to be a better defense system against storms than anything manmade. Regarding the 2004 tsunami in the Indian Ocean, mangrove forests were the most important coastal defense in the area (Danielsen 2005) Studies done on wave forces and fluid dynamics modeling suggest that mangroves may buffer coastlines from tsunami damage by reducing wave amplitude and energy (Danielsen 2005). Analytical models show that mangroves may reduce the greatest tsunami flow pressure by more than 90 percent (Danielsen 2005).

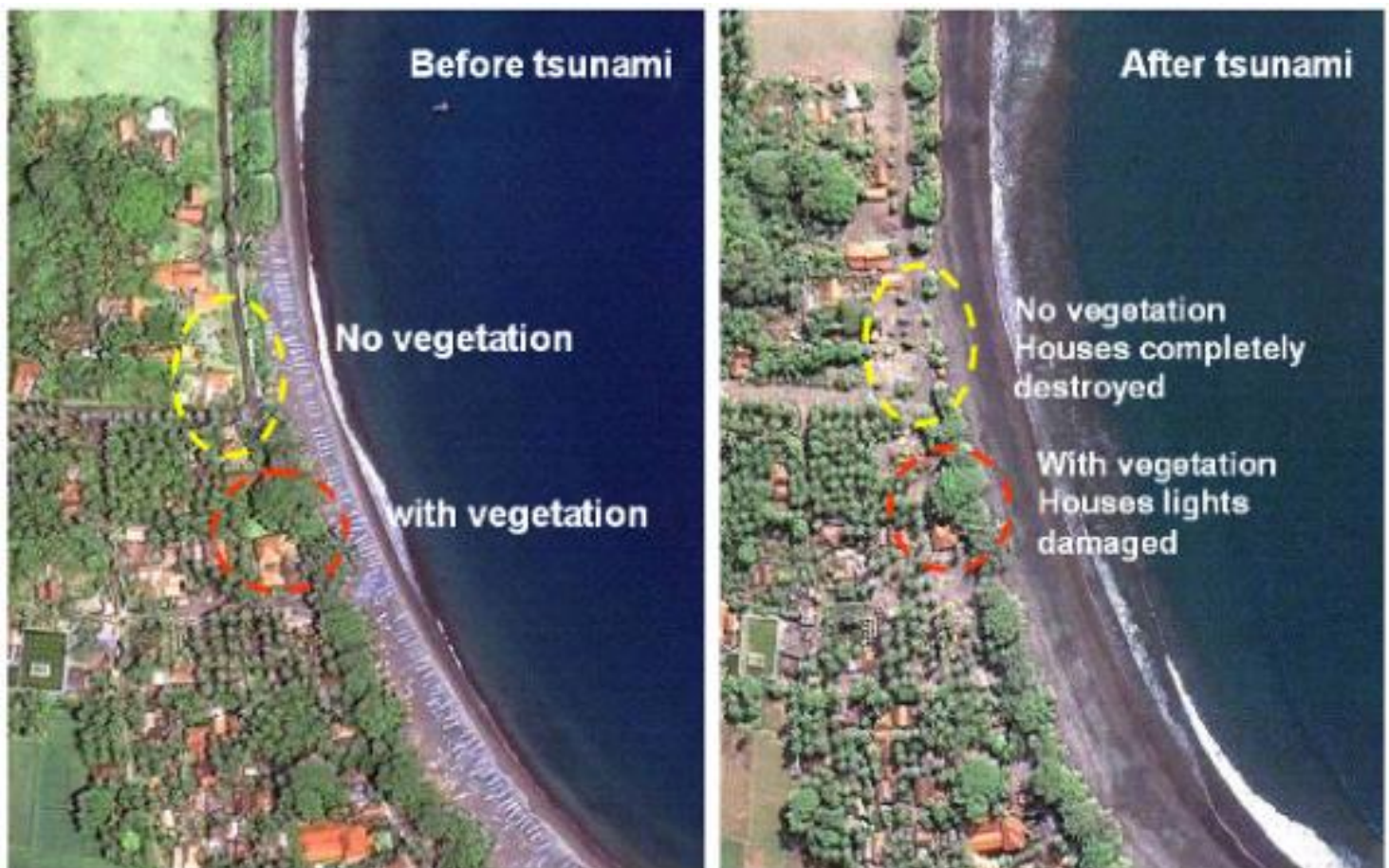


Figure: Before and after photos of tsunami damage with and without mangroves. Photo Credit: fao.org

10. Efforts by Ryan de Jongh

Native Curaçaoan, Ryan de Jongh, uses his celebrity as a record-breaking kayak champion to promote nature conservation and has been restoring mangroves on the island for many years. Most impressively, he has taken it upon himself as a personal mission to replant the mangroves on Curaçao. So far he, along with volunteers, has replanted about 60% of the island. However, not all have survived due to anthropogenic manipulation of the environment. Ryan is currently testing out what he calls “floating plantations”. He takes discarded items that he finds around the island and constructs these “plantations” with mangroves planted in them and seagrass underneath. He is hoping they will take root and fill in some of the bays. He is the first person in the world to try this method. However, all of Ryan’s efforts might be futile if the government does not create laws to protect mangroves.



Figure: Ryan de Jongh educating tourists about Curaçaoan mangroves at Santa Cruz and his “floating plantations”.

11. Ramsar Convention

The Ramsar convention is an international treaty that serves to conserve wetlands and their resources. There are only a handful of Ramsar Sites in Curaçao as of right now, which is far from enough to fully protect all the islands' wetlands. Many countries around that world that have mangroves created extensive protected areas for their mangroves under the Ramsar Convention and their local government. Curaçao has the opportunity to join more and can be looked at as a leader in environmental protection and conservation.

12. Recommended Action

12.1 Create legislation protecting mangroves

Ryan and other groups have taken it into their own hands to help restore the unique nature of Curaçao, but they need government help to ensure that their efforts have not been done in vain. Curaçao can learn from other countries that were too late in protecting their mangroves. Curaçao must consider to enact legislation that will protect all mangroves on the island from damage and destruction. This will ensure that mangroves are not carelessly destroyed for development projects, which only help a few with deep pockets, but do not benefit the general public. The people of Curaçao will be the ones who suffer if this protective barrier from the sea is removed.

Not only is it Curaçao's obligation to protect mangroves for the welfare of their own country, they must also do it for the greater good for the planet. Deforestation is the second largest cause of anthropogenic carbon dioxide emissions, contributing 12–20% of the total (Hutchinson 2013). Enacting and enforcing strict laws, in addition to implementing a monitoring program is a start to curbing their contribution to carbon dioxide emissions, while also protecting themselves from more immediate threats like sea level rise. In addition, such a program could provide jobs to the local population.

12.2 Expand eco-tourism in the mangroves

Tourism in Curaçao is mostly based on exploring the unique nature of the island. People come from all over the world to dive, snorkel, and visit the national parks. Expanding tourism to the mangroves is another way that people can experience this special part of nature. There is very little cost involved in bringing mangrove eco-tourism to Curaçao. As stated before, there are not the same dangers that other countries around the world have in their mangroves. People merely need a kayak and/or snorkel to visit the mangroves.

Eco-tourism could also bring additional benefits to local communities and regional economies (Salam 2000). Well-organized tourism could offer economic and political incentives for appropriate management and for conservation. Gaining public support for protecting part of their country could be very popular, if the public is educated on the issues surrounding loss of mangrove habitats.

12.3 Solve sewage problem at Rif

The problem at the mangrove area Rif, in the center of town must be solved. It currently has a major sewage pipe discharging directly into it. The area's structure was manipulated to the point where there isn't adequate circulation of ocean water, so stagnant pools of water have created a huge mosquito problem, as well as it not smelling very pleasant. It seems to be giving mangroves a bad reputation on the island. Because of this structural failure, the mangroves are suffering and the public is extremely frustrated that no action is being taken to remedy this problem. This is unfortunate because this area has the potential to bring in more tourism, and the possibility of it becoming a mangrove nature park is being discussed; however, at this time it's a public nuisance and there needs to be immediate measures to solve the sewage problem. Permitting locals, as well as tourists that visit the island, to have the impression that mangroves are solely mosquito-infested swamps that should be done away with, is a misrepresentation and will not benefit the island or its image. The government is best advised to correct this problem in order to enhance tourism in the area and create the nature park in the mangroves.

12.4 Promote education of mangrove importance

Educating Curaçaoans of better treatment of mangroves in order to make them more aware of the degradation of a vital habitat is a crucial step to solving the continued human impacts. Currently, mangroves are littered, cut down and suffocated, sometimes unknowingly by those who think it is a wasteland (CUNACO 2012). Joined with CARMABI, educational programs and campaigns should be created in order to inform the public about the importance of mangroves. There is public support, as Amigu di Tera started a petition to have government protection; however, not enough people signed the petition and no action was taken. With mounting issues like Rif, the time is now to educate the people and to protect mangroves.

12.5. Join more international treaties that protect wetlands

Curaçao must also enter more international treaties, such as the Ramsar Convention, that vow to protect wetlands and their resources. This should be done in order to not only protect their valuable nature, but to lead by example in conservation efforts. This could be a way that Curaçao is seen as a leader in the Caribbean, in the international community, as well as a progressive country that realizes the value of its natural resources. As a nation struggling for a sense of identity, protecting a unique habitat could be a way to unite Curaçaoans. It seems this could be a resource that they could embrace as special and something they can be proud of if they knew more about it.

13. Conclusion

Mangroves were once abundant in Curaçao, protecting the shorelines and supporting the island. However, with coastal development and pollution increasing, their existence is being threatened. Mangroves play a major role in marine and coastal systems. They are robust and can withstand powerful storms, waves and wind. They are the protector of shorelines, as well as a sanctuary for juvenile fish. This attribute gives them the power to support other ecological, economic, and social issues. If they are degraded, coral reefs will suffer, and in turn tourism and fisheries will suffer, which will create serious problems for the local population. They also play a critical role in protecting the island from effects of climate change that no other manmade design is capable of doing. Other countries have realized the value of their mangroves, but sadly, only after catastrophic events have taken place. Curaçao has the chance to act now to prevent such tragedies.

There are locals that are trying to replant and restore mangroves on the island. However, government legislation that vows to protect mangroves from destruction must be enacted to ensure they have a chance to survive.

Also, eco-tourism in mangroves is a unique way for people to experience this special habitat. Tourist can get up and personal in the mangroves, since Curaçao is only of the only countries in the world that has mangroves that are safe to explore from just a kayak or even snorkel. Promoting eco-tourism in mangroves would be a very simple and inexpensive way that Curaçao could expand eco-tourism, and thus benefit the economy.

The sewage problem at Rif must be solved as it is a public nuisance, and is a deterrent for tourists to sightsee in the area. Solving the sewage problem and establishing the area as a mangrove park would be extremely beneficial for the area and economy.

Also, education on mangrove ecology should be promoted to ensure the general public is aware of the benefits gained by having mangroves, as well as to ensure locals take part in protecting them. Finally, joining more international treaties, such as the Ramasar Convention, is in the best interest of Curaçao, as it showcases Curaçao's initiative to protect this vital part of the island.

While mangroves have the perception of not being the most pleasant habitat, this report was written with the hope that their many benefits are seen for what they are: essential for the health of connected ecosystems such as coral reefs, and as a result, the entire island. These habitats must be protected to ensure that they continue doing their job: protecting Curaçao.

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