Reclaiming Mangroves Lost to Shrimp Culture

Figure 1. Mangrove roots exit the sediment to retrieve oxygen and cope with waterlogged soil (The Ecologist, 2020)

Mangrove forest ecosystems are relatively small on a universal scale, constituting only 0.7% of all tropical forest areas on Earth (The Ecologist, 2020). However, size does not determine ecological significance. Mangrove forests provide ecological and socio-economic benefits to nearby human populations, marine species and even to our atmosphere. But these forests and their associated benefits are threatened by the growing aquaculture industry, and in particular, shrimp cultivation. Large-scale rehabilitation efforts are required to restore mangrove forests, reverse anthropogenic impacts and prevent further environmental degradation.

Mangrove forests exist in tropical regions where the land meets the sea; estuaries and river deltas are two of the most common habitats in which they flourish (McMeans, 2020). Mangrove trees are terrestrial but can tolerate salinity and cope with waterlogged soil, making their ecosystem exceedingly unique. The roots of a mangrove have the ability to shut out salt while the leaves can excrete salt that has infiltrated the plant. Additionally, mangrove tissues are able tolerate the remaining salt that has not yet been excluded or excreted (McMeans, 2020). To cope with waterlogged soil, the roots of a mangrove exit the sediment, retrieve oxygen from the atmosphere and deliver it to the rest of the plant (see Figure 1). This process benefits the mangroves which would otherwise perish in the coastal anoxic soil (McMeans, 2020).

These peculiar forests provide a multitude of essential ecosystem services. Mangroves act as a coastal defence system, shielding shores and reducing possible water damage from tsunamis, hurricanes, flooding, or even just strong wave action (Kathiresan, 2012; Kumar et al., 2014). Their physical role of buffering storms mitigates consequential effects of coastal erosion. This service was beneficial in 2004, when the Indian Ocean tsunami damaged coastal areas to a lesser extent where mangroves were situated (McMeans, 2020). Mangrove forests also act as a defence system to protect marine life. They actively trap sediment run-off from the land, which would otherwise enter the ocean and limit light from reaching marine ecosystems like coral reefs (Kathiresan, 2012; McMeans, 2020). Another service that benefits marine life is the use of mangroves to breed, nurse one's young and hide from predators (Kumar et al., 2014; McMeans, 2020). Lastly, mangrove forests benefit all life on earth through their superior ability to trap carbon dioxide and store it within sediment. Marine ecosystems that exhibit this process are often referred to as "blue carbon sinks". Blue carbon sinks cover approximately 51 million hectares of land on earth. Of that, 15.6 million hectares (31%) are mangroves (Ahmed et al., 2017). Among all tropical forests, mangroves are the most carbon-rich and can store molecules for extended periods of time through biomass conversion (Kathiresan, 2012). This mechanism ultimately mitigates global climate change effects by storing and converting carbon dioxide that would otherwise warm our atmosphere (Ahmed et al. 2017).

Therefore, the deforestation of mangrove forests is of rising concern as their greater environmental functions would diminish as well. Over the last 50 years, mangrove forests have declined by up to 50% (Ahmed & Gaser, 2016). One of the most significant anthropogenic activities resulting in mangrove deforestation is aquaculture (Duke et al. 2007). Between 1980 and 2005, 1.89 million hectares of mangrove forests on earth were cut down due to coastal aquaculture. Of those removed, 1.4 million hectares were replaced by ponds for shrimp cultivation (Ahmed et al., 2017). The conversion of mangrove forests into shrimp farms is predominant in Asian countries such as Vietnam, Thailand, Sri Lanka, Cambodia, Bangladesh, Indonesia and India, who heavily rely on aquacultural production for economic prosperity (Ahmed et al, 2017; Ashton, 2008; Kathiresan, 2012). As of 2008, Asia produced the 89% of the world's shrimp (Ashton, 2008).

It is no question that the shrimp farming industry is a significant source of income for several countries. But as this industry grows, the critical ecological services of mangroves will deplete. Shores will see greater damage from natural disasters as the lack of mangroves will leave little to no physical buffers (Kathiresan, 2012; Kumar et al., 2014). Coastal waters will have increased sediment run-off, limiting light availability to ecosystems like coral reefs. (Duke et al. 2007; Kathiresan; McMeans, 2020). Additionally, mangrove forest depletion will result in the endangerment or extinction of several other species that depend on them to survive, especially species that utilize mangrove forests as a refuge or nursery (Duke et al. 2007). Nearby ecosystems may also be affected by industrial processes that take place in order for aquaculture to succeed. These processes include increased use of fertilizers, pesticides and antibiotics which, in turn, would harm organisms and negatively affect biodiversity (Ashton, 2008).

Perhaps the greatest impact of mangrove deforestation is the effect that can be detected universally: the release of blue carbon into our atmosphere. By cutting down mangroves and replacing them with shrimp farms, the stored carbon within the sediment escapes and contributes to our planet's increased greenhouse gas emissions (Ahmed et al., 2017). By comparison, the carbon emissions from 1 hectare of deforested mangroves is equal to 5 hectares of deforested tropical evergreens (Ahmed & Glaser, 2016). This signifies mangroves' superiority in sequestering carbon and their crucial environmental function. Without them, the physical impacts of climate change would escalate at a rapid pace and even the shrimp farms that replaced mangrove forests would face climate consequences (see Figure 2). Enhanced rainfall may increase nutrient run-off within the shrimp farms (Ahmed et al., 2017). Warmer water temperatures may reduce dissolved oxygen levels, increase risk of disease or alter shrimp reproduction rates (Ahmed & Glaser, 2016). The effects of climate change are boundless and will ultimately harm the shrimp farming industry that catalyzed such effects in the first place.

"Reducing Emissions from Deforestation and forest Degradation (REDD+)" is a program that has the ability to do just that. REDD+ has the potential to reduce mangrove deforestation, foster restoration and ecosystem conservation, and ultimately mitigate climate change effects (Ahmed & Gaser, 2016) (See Figure 3). This program offers payments to countries or local communities for their (scientifically calculated) reduced carbon emissions. Therefore, those who keep their emissions low through limited deforestation and strong ecosystem management will receive the highest compensation (Ahmed & Gaser, 2016). REDD+ programs are becoming more and more concentrated on mangrove forests, with recent projects focusing on the mangroves lost to shrimp farming in Asia (Ahmed & Gaser, 2016). If REDD+ is able to rehabilitate 25% of all deforested mangroves in Bangladesh for example, up to 2875 tons of blue carbon would return to the mangrove's natural storage system (Ahmed et al., 2017).

In order to succeed with this program, coastal communities must be on board. Farmers will need to relocate their shrimp farms to onshore facilities or near-shore areas. They also have the option translocate their shrimp to integrated multi-trophic aquaculture facilities (IMTA). This modern system, which integrates shrimp with different species of various trophic positions, ultimately improves productivity, sustainability and profitability through efficient nutrient recycling processes (Ahmed et al. 2017). Therefore, workers in the aquaculture industry have the potential to earn enhanced income from newer aquaculture systems *and* the REDD+ program.

Establishing REDD+ projects for mangrove forests is no easy feat. Development is timely and social challenges arise from coastal communities who may not fully understand the global value of their local mangroves. Gaining sufficient financial assistance from supported institutions has also been an uphill battle for REDD+. A group of researchers recently assessed whether or not this program would be feasible for the Matang Mangrove Forest Reserve (MMFR) in Malaysia. Their findings indicated that it this program is not only a practical solution to mass mangrove deforestation but is necessary to restore the MMFR's critical ecosystem services (Aziz et al., 2016). All in all, support is growing for this program as it's socio-economic and environmental benefits outweigh any costs needed for implementation (Aziz et al., 2016).

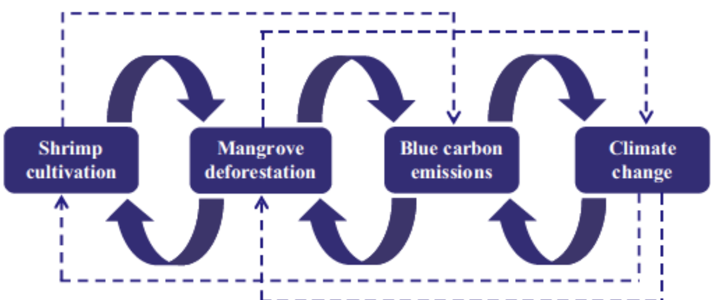

Figure 2. Complex interplay between shrimp cultivation and climate change; one indirectly affects the other and vice versa (Ahmed et al., 2017).

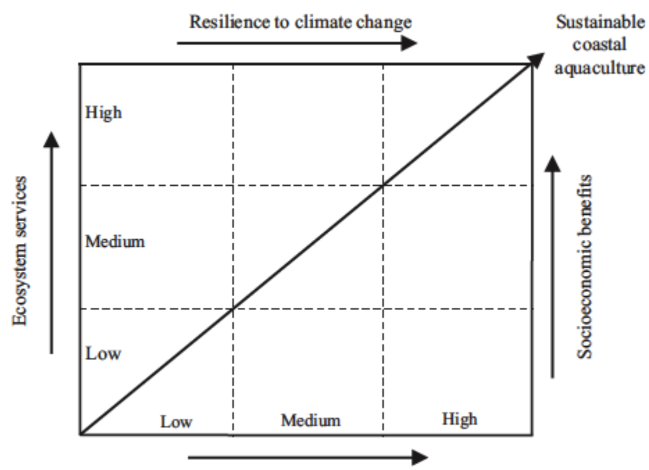

Figure 3. REDD+ enhances mangrove restoration which in turn, increases ecosystem services, climate change resilience and socioeconomic benefits (Ahmed & Gaser, 2016)

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