CORAL REEFS

The Impact of Restoration Infrastructure on Coastal Communities

WRITTEN BY

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Introduction

Anthropogenic climate change is affecting local ecosystems and the biodiversity of environments including oceanic habitats. The driving forces of climate change can be blamed on the social characteristics and population of the land as well as economic and political impacts but, the underlying causes are based on ongoing trends such as rising temperatures and other factors closely related to climate (Omann *et al.*, 2009, p.25). The rising temperatures and unpredictable weather are becoming more frequent resulting in sea levels fluctuating and putting pressure on aquatic-species as well as bleaching coral reefs (Omann *et al.*, 2009, p.27). This paper aims to explore the impact of infrastructure built to conserve coral reefs on coastal communities.

Greenhouse gas emissions are contributing to climate change as well as ocean acidification, impacting ecosystems (Miller *et al.*, 2018, p.1). These factors have direct links not only to the reduction of species, but also on the diminishing coral reef environments that are being heavily affected leading to damage towards local communities and species (Ceccarelli *et al.*, 2020, p.5). This paper begins with a discussion on the effect meteorological effects have on coral reefs and the restoration of rubble. Following is an analysis of the social and economic impacts associated with the infrastructure that aims to provide assistance to the ecosystem as well as the results on local people and coastal communities.

Case Study: Guam

In Guam, research has been done to analyze the biomass levels at an increased ocean depth in relation to coastal populations as well as protected refuge areas. They found a greater biomass of fish at these deeper levels (Lindfield et al., 2015, p.134). A new refuge habitat provided information to fishery management and served as protection and conservation of these species (Lindfield et al., 2015, p.134). There are many areas that have been exploited for compensation and these deeper areas under surveillance provided chances of replenishment for these species. While this provides a natural recovery strategy, it is not beneficial for the long term as you can not predict weather patterns along with the patterns of the organisms living in the reefs. It is most sustainable due to the lack of human interference with foreign objects, but in some cases, this placement of foreign objects to protect and allow re-building is the most accessible route towards conservation.

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This study is relevant to the further discussion as it explores the path of natural restoration. It is important to consider that most of the infrastructure being placed into these areas are easily accessible to humans and therefore are more likely to be protected. Due to this access, the areas can be easily monitored and tracked. The case study proves that the ecosystem itself can provide habitats and refuge for species who are dependent on coral reefs (Lindfield et al., 2015, p.125), yet at the increasing rate of coral reefs diminishment, it is not a perfect solution.

The mesophotic deeper oceans are essential for fish habitat and refuge but also provide rebuilding zones for disturbed coral reef ecosystems (Lindfield et al., 2015, p.125). The deep water habitats are key environments to consider in terms of sustainability because they are not easily accessible to human damage as seen in the case study. The conservation of coral reefs is symbiotic to the organisms living within them, therefore the deeper you go the more fish are able to protect themselves, hide, and evade extinction. This knowledge has enabled scientists to continue their research to find alternate methods of restoration practices.

Discussion

Coral Reefs: Rubble

The biggest threat to coral reefs is humanity. While they are subject to disturbance related to climate change and other uncontrollable factors, a lot of the damage is done in shallow shores where humans have easy access (Lindfield et al., 2015, p.125). Coral reef environments suffer threats of coral bleaching, storm damage, coastal development, sedimentation and fishing pressure (Lindfield et al., 2015, p.125).

It is important to understand the ecological role of coral rubble and the natural coral recolonisation before introducing foreign objects (Ceccarelli et al., 2020, pp.1-2). The management of coral reefs is important to reduce stressors as well as ensuring its continued health. There are many small-scale projects set up such as exploring the possibility of natural restoration through deeper coral zones, but a lot of reef restoration is done through rubble and active intervention to stabilise structures.

Rubble consists of dead coral pieces and fractured rocks that have been liberated from the skeleton by mechanical or chemical means (Ceccarelli et al., 2020, p.5). This can be from direct or indirect causes such as mortality of live tissue or wave conditions paired with storm

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damage. This along with anthropogenic disturbances such as dynamite fishing as well as boat anchoring are the cause of decline in some aquatic species as well as the coral itself. The conversion of living coral reefs into rubble fields is a big concern considering the natural recovery rate is not able to keep up with the way in which it is diminishing (Ceccarelli et al., 2020, p.5). The natural stabilisation includes layering of rubble into the reef framework allowing the calcification microbialites with high magnesium calcite and aragonite.This process can take up to 10 months to see progress and therefore does not occur at a rate to accompany the natural healing in a productive manner (Ceccarelli et al., 2020).

It is important to place infrastructure or techniques with the rubble because if these pieces of coral are left lying around, they become a bed of killing fields, damaging juvenile corals (Ceccarelli et al., 2020, p.20).

Current infrastructure projects

The coral reefs are surrounded by lots of infrastructure in the ocean as well as along the coast, both having a drastic effect on their rehabilitation. The placed infrastructure generally provides a vertical habitat with the environmental density increasing, resulting in shared spaces and species forced to occupy the only refuge (Bulleri, 2010, p. 28). While it is some refuge, there is not enough, and certain practices can sometimes have the opposite effect. The lack of proper habitats turns a restoration area into a stressful environment. Placement of infrastructure is also a factor to consider whether it is in rocky shores, providing shelter from the possible damage, or in areas with increased steepness and slopes of depth (Bulleri, 2010, p. 29). On a larger scale, disruptions of water flow due to infrastructure could alter patterns of species' populations.

As stated, there are both positive and negative outcomes with foreign infrastructure. Studies have been done to find alternative measures because the positives outweigh the negatives of the situation. Some of these include incorporating elements that are natural to the habitat and familiar to the ecosystem such as wetland vegetation and seagrasses (Bulleri, 2010, p. 30). These engineered projects can also help in the sustainable aspect of communication between engineers and ecologists to build more specific habitats that will not result in worse conditions.

Ceccarelli et al., (2020) did research focussing on the results of coral restoration with the installation of mesh or netting over the rubble (7).

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This includes metal bars to reinforce the rubble, encouraging natural binding and cementation of the coral colonies themselves. The injection of grout and other chemicals is also done to help bond the loose rubble. This process is still under development (Ceccarelli et al., 2020, p.12) but from previous research, it has been found that this process is only beneficial on a small scale. To make this project more sustainable, materials such as discarded metals from cars were recycled into creating structures for the reefs, but despite their best efforts, the results found that there needs to be engineered projects that mimic specific functions of an intact coral reef framework (Ceccarelli et al., 2020, p.13).

Social Impacts

Weather and climate are both important factors in terms of diminishing coral reefs. Aside from pollution, overfishing, and man-made work that is hurting the reefs, they are there to protect the shore in relation to climate-induced trauma such as natural disasters, heavy rain, and winds. The meteorological impacts can be compared to farmers in South Africa who are heavily impacted by rain. While the impact on South African land is in agriculture and the coral reefs are impacting fisheries and a different type of farming, there are many similarities in terms of social impacts. The unpredictability of rain and erratic patterns that arise with climate change (Simelton et al., 2013, p.124) have damaged crops leaving farmers with no funds to support their families, or lives in general. Just like the coral reefs, the environment is ruined by the lack of, or damage done by, unpredictable weather taking away from cultivation whether it be agricultural products or fish in the ocean.

Coral reefs are often situated in remote places home to many indigenous communities, who have knowledge that governments do not. It is important for them to incorporate their local knowledge in order to change and find ways to anticipate impacts of climate variability (Simelton et al., 2013, p.124). This is also the case in South Africa, but it occurs in most environments and communities where government intervention is directed towards economic benefits. Villagers dependent on production and/or fishing for money are experiencing insufficient rainfall and droughts that end up leaving more damage than improvements (Simelton et al., 2013, p.128).

Economic Impacts

As mentioned, coastal communities are often populated in remote areas

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by Indigenous groups. With the diminishing of coral reefs and implications of industrial buildings and engineered projects to work towards their conservation, a lot of factors concerning their health, lifestyle and behaviours are not considered (Richmond et al., 2004, p. 349). Especially in relation to aquaculture, there are certain assumed links between well-being and the environment and understanding these risks and benefits can have social and economic benefits to both parties (Richmond et al., 2004, p. 350). It is very important to work towards conservation of these coral reefs as they provide a source of economic restructuring for commercial fisheries as well as natural resource industries. The health of these environments is directly correlated to their production and ability to provide for people. If local groups and communities and privatized organizations are going to continuously depend on these industries, the health of coral reefs needs to be prioritized. It is the government practices and policies that are needed to make these differences, bringing projects and engineers to the area to implement machineries and other industrialization objects to promote conservation and new growth. Indigenous people of the local communities are often ignored and need their rights and knowledge to be acknowledged in order to promote more sustainable ways that are not common practice (Richmond et al., 2004, p. 351). Where physical health as well as food provision for populations is an integral part of the coastal habitats, it is important to acknowledge that colonial processes will result in suffering (Richmond et al., 2004, p. 355). The implementation of new policies will need to incorporate traditional knowledge and ensure that the loss of access to environmental resources will not put local communities at a disadvantage in order to build the economy.

The conservation of coral reefs can be related to similar situations in environments where poaching is a common practice for financial benefits (Duffy, 2016, p.239). Governments and NGOs are called upon to facilitate further actions for the protection of animals being hunted and sold for economic wealth. Management is needed to organize wildlife conservation, and in the case of poachers it is done through violence (Duffy, 2016, p. 238). The loss of biodiversity brings many concerns in terms of global security and this anxiety is the reason why. In this case of poachers, Duffy (2016) states there is a war by conservation technique used where militarized responses are needed to enforce

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protected areas (238). For local communities dependent on the coral reefs for food or even employment, the fact that they are diminishing can cause anxiety. Where there is anxiety, violence often follows as an outcome of fear in relation to scarcity (Duffy, 2016, p.240). It is important to note that the conservation of coral reefs is needed because there is a chain linking environmental stress with identity conflicts for coastal villages due to economic deprivation in result of resource scarcity. Duffy (2016) concludes that many governments have shifted their force to undermine NGOs, no longer working together democratically to provide security but as an oppressive force (p. 246). In regards to NGOs working towards conservation of coral reefs, it is important to value their opinions and place them as a priority as first-hand information and research comes from these organizations working directly in the field.

Environmental Justice

Among all of this, environmental justice needs to be considered. These new technologies of infrastructure and other engineered projects are obtaining investments from the government and NGOs without input of local knowledge (Sze & London, 2008, p.1332). While funds are needed from higher levels, those who actually work in industries associated with coral reefs and are directly impacted by the loss of these ecosystems should be a bigger part of the process. A relationship needs to be developed between the local and global people (Sze & London, 2008, year, p.1331) in order for the process of restoration to not lead towards further damage to the social impacts of the coastal communities. If a communal understanding is not formed, it could result in negative impacts such as environmental racism where the local's land is exploited and no longer serving them but damaging their community.

Conclusion

In terms of policy, Simelton et al., (2013) suggests many adaptations to benefit the agricultural sector. These suggestions such as adapting to climate change in a top-down scenario needing to be verified with workers' understanding of weather changes (p. 136) can be adapted in terms of coral reef conservation as well. The common understanding of industrial impacts on local communities needs to have a mutual relationship in order to function. The diversity between the contacts at different levels of interaction (Simelton et al., 2013, p.136) with the environment is important to consider, especially in terms of climate change on social and economic implications.

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Overall, having measures that raise awareness whether through government projects and/or the work of organizations, will have a long-term impact. Other legislative contexts include agencies and government regulating measures to minimize contamination, water conventions, transport regulations (Cook et al., 2016, p. 4). A top-down process can help the regrowth of coral reefs as well as the maintenance of the species reliant on the reefs as their habitat.

Infrastructure implemented for the protection and restoration of coral reefs has an impact on the social and economic aspects of coastal communities. Understanding the environment and habitat of the reefs in the ocean and the anthropogenic climate changes that result in damage are the first step. The industrialization happening along the shores impacts not only the oceanic ecosystem but the communities as well. Future research should explore the effect of more inclusive policies to make changes in maintaining the health of these ecosystems.

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