INNOVATIVE ENERGY TECHNOLOGY SYSTEMS AND ENVIRONMENTAL CONCERNS: A SUSTAINABLE APPROACH
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Global Climate Change, El-Niño Events and Coral Reefs: A Case Study of Coral Bleaching in Madagascar

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Abstract

Madagascar, an island country off the coast of Southeast Africa is one among the bleaching affected hot spots in Indian Ocean. Large areas of coral reefs are under threat mainly from global warming (increasing trend of SST and reductions in coral calcification due to changes in sea-water chemistry with increasing carbon dioxide concentrations) and El-Niño. This study focuses on coral bleaching and its consequences in terms of their impact on marine ecology and economic life of the island country. The concluding part focuses on the attempts and achievements of community and NGOs based marine resources management system and recommends measures which can be adopted to foster corals.

1. Introduction

Corals are the defining species in one of the most diverse marine ecosystems: coral reefs. Coral reefs benefit the environment and people in numerous ways. For example, they Protect shores from the impact of waves and from storms provide benefits to humans in the form of food and medicine and provide economic benefits to local communities from tourism. Healthy coral reefs are critical to the livelihoods and cultures of millions of people in tropical coastal environments like Madagascar and also form part of the crucial life support system of the biosphere[3].Over the last three decades, outbreaks of coral bleaching and disease have resulted in global reductions in coral reef diversity.

Madagascar is the world's fourth largest island, approximately 1,600 km long and 580 km wide situated in the Western Indian Ocean spanning tropical and subtropical latitudes(Figure:1). Coral diversity in Madagascar is high with 304 scleractinian coral species present. Bleaching has impacted large areas of coral reef in Madagascar, especially in 1998 when coastal water temperatures were 2ºC above the seasonal average. Mortality was 80 to 90% in some areas.

2. Methodology

In order to assess the intensity of Coral bleaching, NOAA's Coral Reef Watch images have been analysed. Impact of coral bleaching on the economic life of the people has been discussed on the basis of survey data obtained from literatures.

A Brief Discussion on Coral Bleaching: Its Causes and Impact

Large-scale bleaching events on coral reefs are caused by higher-than-normal sea temperatures. High temperatures make light toxic to the algae that reside within the corals.

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The algae, called zooxanthellae, provide food and give corals their bright colors. When a coral bleaches, it loses its zooxanthellae, and will die within a matter of weeks unless the zooxanthellae can be replaced.

Fig. 1: Map of Madagascar showing distribution of coral reefs (courtesy Cooke, A. 2004)

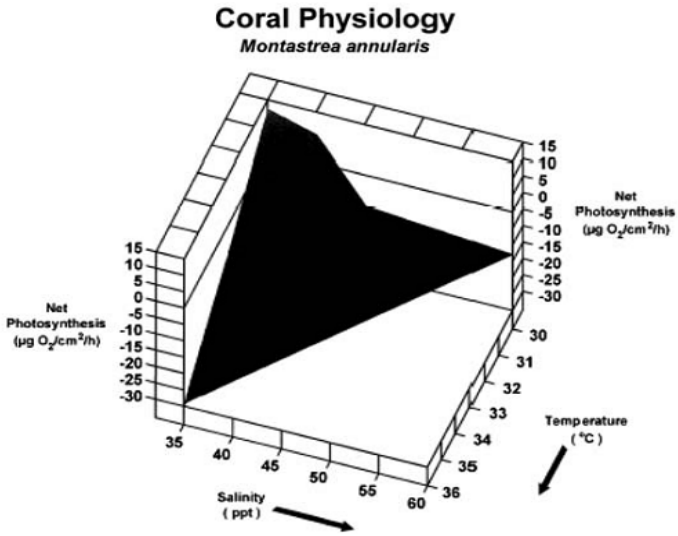

Fig. 2: Coral physiological stress to two stressors, salinity and temperature.

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In combination, these factors profoundly lead to coral bleaching. (from Porter et al., 1999)

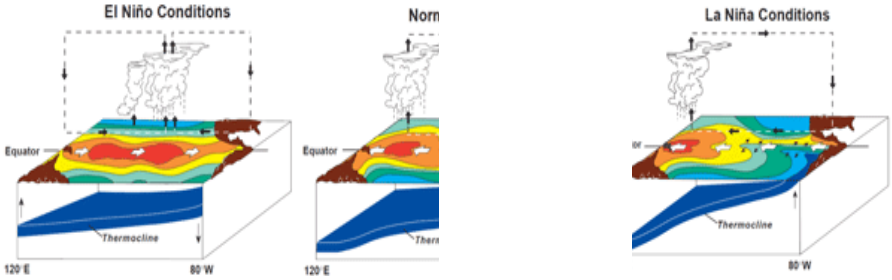
When zooxanthellae are lost, corals appear white, or bleached. In other words it can be said that bleaching events are a classic response of tropical hermatypic corals to a variety of environmental stressors (Figure:2).Bleaching events caused a reported 16 percent loss of the world's coral reefs in 1998according to the Global Coral Reef Monitoring Network.Coral bleaching is not well understood by scientists. Many different hypotheses exist as to the cause behind coral bleaching, but the strongest evidence points to unusually warm sea surface temperatures as being the main factor [7] Coral bleaching events worldwide have been attributed to sea surface temperatures (SSTs) rising and staying as little as 1°C higher than the usual average monthly maximum SST during the hottest months of the year [6].

The death of corals and the resulting disappearance of reefs would result in the loss of an uncountable number of marine invertebrates and fishes that rely on the physical structure of the reef for survival. Coral reefs are home to hundreds of thousands of species, including many not yet known to science. The elimination of coral reefs would also result in great losses of income and resources from tourism, fishing, and the discovery of new medicines [5].Coral reefs also protect coastlines by absorbing constant wave energy from the ocean, thereby protecting people living near the coast from increased storm damage, erosion and flooding.

The sensitivity of corals to small temperature changes gradually became a major concern of researchers as predictions of global warming and stronger, farther-reaching El Nino events came to light. The 1997-98 El Nino event is the strongest on record to date, resulting in unprecedented coral bleaching and death across the globe [8].SSTs are expected to continue to increase worldwide[1] and El Nino events are expected to increase in frequency, strength and duration, endangering the future survival of coral reefs.

3. El Niño and Global Climate Change: What's the connection?

As a record El Niño event changes temperature and precipitation patterns over a large part of the globe, it's natural to ask whether these changes have anything to do with the warming air and changing precipitation caused by human beings.



Source: NOAA/PMEL/T ɛ.

Fig. 3: A model of surface temperatures, winds, areas of rising air, and the thermocline (blue surface) during El Niño and Normal conditions.

Temperature and rainfall change naturally from season to season, but they also change on longer time scales--over the course of several years or decades. El Niño is a naturally occurring, longer-cycle mode of variability or change (Fig. 3). When scientists look at the records of climate, the natural variability makes it hard to pick out any changes that may have come from human activities. Even harder is discerning how this natural variability itself could have changed.

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4. Health of Coral Reefs in Madagascar:

The percentage of dead coral cover was generally less than 10%, which suggests the coral reef areas were not strongly affected by the 1998 global coral bleaching event. However, there was some evidence of low levels of bleaching at all of the North Nosy Be, North West Nosy Be and Lokebe Reef. Different parts of Madagascar eport much higher levels of bleaching.

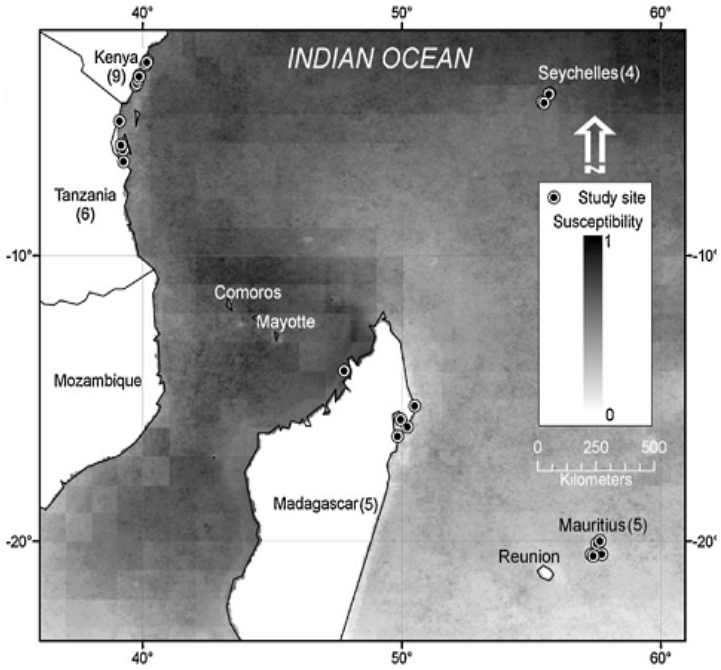

Fig. 4: Map of study sites and their level of exposure to coral bleaching. Darker ocean areas have a higher level of exposure. Adapted from Maina et al. (2008) and McClanahan et al. (2009)

Neighbouring Northern areas (Belo sur Mer) were strongly affected by bleaching in February/March1998. According to satellite imagery analysis, it was concluded that the warm water mass did not seriously affect this area. At Ifaty, one transect was established on the outer slope. Live coral cover was 40.7% (20% Acropora and 20.7% non Acropora species).

Approximately 14% of the 54.8% dead substrate was found to be recently dead and thought to be related to the bleaching event. Of the 36.8% dead coral cover at Nosy-Ve, 26% were reported as covered by recent algal turfs. These data support the idea that coral bleaching did occur in coral reefs from Toliara region but was not reported during the onset phase.

The southeast coast of Madagascar was hit by the warm water mass early in 1998. Bleaching was not significant while in the northern location of Belo sur Mer, most corals turned white.

Later on it can be found that northern and western part are continued to be the most severely bleached area than other coastal parts of Madagascar (Fig. 4).

2010 El Niño event One of the worst years for coral bleaching since the 1997-1998 El Niño event which resulted in extensive bleaching and mortality across the Indian Ocean(Fig. : 5). More recently, NOAA satellite images give clear and more reliable information about the intensity of coral bleaching in terms of Annual

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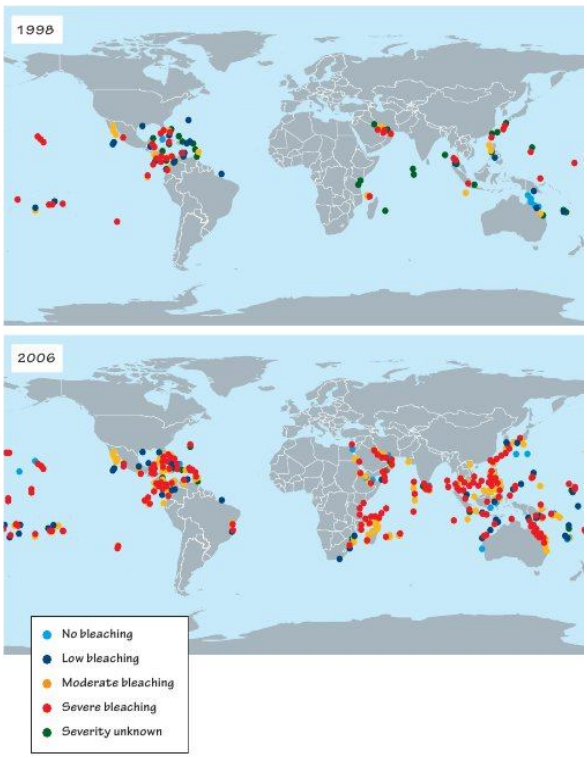

Source: Great Barrier Reef Marine Park Authority, November 30, 2006

Fig. 5: Global trends in the extent and severity of mass bleaching.

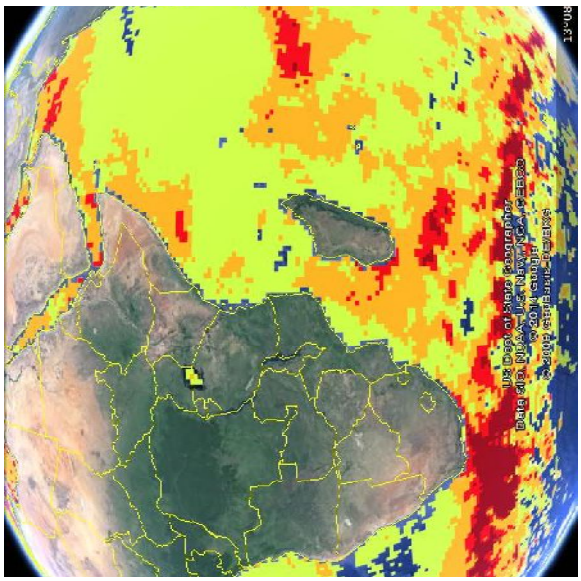

Fig. 6: NOOA Coral Reef Watch Bleaching Thermal Stress Area (2013)

Maximum Composite Index of the year 2013 (Fig. 6).As per this index, the south western parts are coming under alert level 1 and 2 whereas western parts are showing warning condition.

Existing and Possible Effect of Bleaching and Coral Reef Degradation on Ecology and Economy

In terms of existing effect of bleaching, it can be said that it has affected the fishing community of some of the northern and north-western part of Madagascar. However, there is no significant information on the effect of coral degradation on tourism activity.

Near complete recovery is expected for most reefs that did not suffer major damages. Enough corals typically survive in deeper waters, and these can provide new larvae for recovery in damaged areas. In addition, there are often some living polyps in otherwise dead colonies, these may reproduce asexually and overgrow the clear areas. It can be assumed that many reefs in the Madagascar will probably recover relatively rapidly—within 5 to 10 years. Overfished or polluted reefs will recover much more slowly. A dead race will initially be dominated by algae which form thick green or brown mats. Fish productivity may remain stable or show increases in herbivore species such as parrot fish. surgeon fish. and rabbit fish.

However, the extent of bio erosion caused by mollusks. sponges and worms will increase, resulting in a massive weakening of the fabric of the reef. As a result, the coral reef framework will gradually collapse and degenerate into a low profile pile of rubble. Such rubble will provide very limited hiding places for fish and poor substrata for new coral recruitment. Fish productivity will most likely fall slowly and remain low until there is reasonable recovery of reef structure.

5. Madagascar's Coral Protection and Conversation Strategy

There are no Malagasy institutions with the technological resources or technical capabilities to undertake research and assessment studies that support site specific or regional level coastal management planning.

However, Considering current potential threats to the region's reefs, and as a priority within the framework of the National Strategy for the Conservation of Biodiversity in Madagascar, it was considered critical that data be gathered for use in local environmental management plans. Because of this, Blue Ventures Conservation, a UK-based marine conservation organisation working in collaboration with Madagascar's national marine research institute (the Institut Halieutique et des Sciences Marines - IHSM), recently established a three-year marine research program in Andavadoaka, a village sites at the northern end of a reef system that extends from the Grand Recif of Toliara, some 250km to the south.

In June 2003 a collaborative venture was launched in Andavadoaka between Blue Ventures Conservation and the IHSM, Madagascar's national marine research institute, in response to the need to develop a better understanding of the area's unique marine and coastal habitats.

This collaboration quickly expanded to include a range of additional partners, both within and outside the village. These partners include Cooperation Maritime du 22eme Parallele, Wildlife Conservation Society (WCS), Insitut de Recherche pour Development (IRD) etc.

6. Recommendation

Addressing the many threats to coral reefs cannot be approached separately when working in actual geographic areas. Implementation of activities to conserve coral ecosystems must be integrated into an ecosystem-based management approach to ensure a holistic and integrated management approach to support healthy, resilient coral reef ecosystems.

Understanding the biological, chemical, and physical aspects of complex coral ecosystems is critical for successful management. Research in support of reef management urgently needs to increase the scale of experiments, sampling, and modeling to match the scale of impacts and key biological processes (e.g., dispersal, bleaching, and overfishing) and go beyond the current emphasis on routine monitoring and mapping.

Emerging research on marine reserves and how they work to protect harvested stocks needs to be expanded and applied specifically to the tropics. Many of the anthropogenic impacts affecting Madagascar's coral reef habitats are linked with poverty, inadequate planning and legislation, combined with a lack of political will and/or capacity for implementing methods to address these problems. Across the full range of responsible institutions and resource users in Madagascar, there is a critical need for better knowledge and understanding of marine and coastal ecosystem processes, and for better access to information and technical capacity to devise management solutions.

The IHSM is Madagascar's primary marine education and research institute with 150 students from undergraduate to PhD level. Despite its national importance, the IHSM does not yet have the technological or human capacity to perform in house analysis to independently inform coastal management decisions.

In addition to the technical expertise needed for such training and capacity building, the partnership requires assistance in developing fund raising initiatives for the IHSM and other partners.

Further support is needed in developing the long term business plan for the partnership, to ensure continued effective income generation to support this community-centred conservation initiative. Implementation of community-run marine and coastal conservation initiatives is required beyond Andavadoaka.

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