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Coral Reefs within Australian Coasts: Impact of Climate Change and Environmental Threats

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Abstract
During the last 50 years, coral reefs throughout the world have exposed to a continual deterioration. The natural stresses like sea level changing, tectonic plate movement, storms and volcanic activity are considered as the key reason for coral reef deterioration. On the other hand, the growth of anthropogenic stresses in recent years increased the declines and losses within coral reefs cover and their resources. The key risks obtained from anthropogenic stresses are: ocean acidification, habitat destruction, destructive fishing, climate change, sedimentation, overfishing, predation, pollution and diseases. This paper aims to discuss the impact of climate change and environmental threats on the coral reefs within Australian coasts. The paper based on the literature to address and solve this problem. The status of coral reefs within Australia has been discussed by showing the key risks that face the reefs cover within different locations in Australia and the impact of these risks. Also, the paper controls these risks by discussing the main actions and plans that established to preserve the reefs within GBR and various locations in Australia. The solution of this problem has been summarized by many recommendations at the end of the paper.

Keywords: Coral reef, Natural stresses, Anthropogenic stresses, Deterioration, Climate change

1. Introduction

In general, coral reefs can be considered as ecosystems of shallow-water that composed of multiple reefs. The calcium carbonate represents the main component of these reefs where it secreted via encrusting large algae and coral reef-building. Further, coral reefs provide several ecosystem services and goods like attractive tourism environments, marine protection and fisheries home (Wild et al., 2011). The majority of coral reefs throughout the world is exposed to deterioration risk. Until the beginning of 1980s, most of disorders that impact on coral reefs were caused by human and they were considered as local disorders such as pollution, overfishing, unsustainable development of coasts and nutrient enrichment. After that, the disorders obtained from ocean warming become diffused and the concern about ocean acidification effect was increased (Burke et al, 2011). During the year of 2002, about 95% of existing coral reefs were bleached due to the effect of ocean warming. The figure below reviews the coral reefs after and before the bleaching.

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Figure 1: Coral reefs before bleaching, (Burke et al, 2011).

Figure 2: coral reefs after bleaching, (Burke et al, 2011).

The GBR within Australia involves about 17% of the coral reefs within the world. However, the vicarious pressures that obtained from climate variance increased the concern for coral reefs within Australia. Ocean acidification, floods, growth tornado intensity and increased temperature of sea-surface are the key pressures that obtained from climate variance. Thus, Australia increased their management efforts in order to preserve their coral reefs by building MPAs. The aim of building these areas was to confirm that the coral reefs have high flexibility to face the growth variance of climate (Caillaud et al, 2012).

The percentage of coral reefs over the world that influenced by flooding and runoff is 25%. However, just 5% of coral reefs within Australia are exposed to the ground runoff (Burke et al, 2011). Further, there are too nutrient runoff that travel from rivers toward the Australian East coast (Kroon et al, 2011), where this will influence on the coral communities of the GBR and this impact can be appear via the spread of the crown-of-thorn starfish (De'ath et al, 2012). Thus, the effect of floods and runoff on the Australian reefs will be significantly increased.

One of the tools that utilized to preserve the coral reef is the "Marine Protected Areas (MPAs)". The "World Resources Institute (WRI)" retrieved that about 2,679 MPAs are distributed in a manner that compatible with the areas of coral reef that extended around the worldwide. These MPAs involve about 27% of the coral reefs within the world (Burke et al, 2011). However, the studies retrieved that only 6% of worldwide coral reefs are protected via the MPAs and this refers to the insufficiency within organizations enforcement, management and planning.

The MPAs structures are extended between "Large Scale Marine Protected Areas (LSMPAa)" and "Small Units to No-take Areas Networks (NTMRs)". The initial constructed MPA located in Australia and it was built in 1975. This MPA is known as the "Great Barrier Reef Marine Park (GBRMP) and it has 20,679 Km^2 as a covered area for coral reefs. Aother MPA is located in Australiaand it is known as "Coral Sea Commonwealth Marine Reserve (CSCMR)". CSCMR was established in 2011 with area equals to 989,842 Km^2(Wilkinson et al, 2016).

1.1 Main Problem

Australia is considered as one of the significant countries that contains huge number coral reefs. GBPMP is one of the greatest places in Australia to preserve the community of coral reefs. About 1.9 million tourists visit the GBPMP every year and this provided the economy of Australia with 54,000 different jobs and $5.4 billion. During the last years, the impact of climate change and natural threats on coral reefs within Australia has been increased. Thus, several measures and steps should be performed to solve this problem.

1.2 Aim of Paper

This paper aims to discuss the impact of climate change and environmental threats on the coral reefs within Australian coasts. Further, the paper aims to find suitable solutions and recommendations to solve this problem.

2. Literature Surveys

According to Loder et al (2012),"Reef Check Australia's (RCA)", which is an important monitoring program thatis established to observe the key variations within the examined coral habitat health.This program aimed to observe the anthropogenic and natural effects that impact on the habitats of coral within Australia. The "Australian Government's Caring (AGC)" was the main funding for the RCA program in order to build novel monitoring locations on the Coast of Fraser to address and observe the quality of water within the water bodies of the island.

Corals in Fraser Coast faced fresh-water stress, turbidity and excessive temperature variations from the neighboring Mary River. Beside to the natural excessive environmental conditions that face the coral reefs, there is an increased in human use and costal community growing toward these corals. Thus, the surveys of Reef Check were established to gather data about the indicators of reef health in order to observe the long-term variations in patterns and directions over the time. On the other hand, the marginal communities of coral as those existed on Fraer Coast are considered as essential observation locations within the light of varying climate conditions. Hence, RCA attempts to raise their location connectivity alongside the area of Queensland Coast via these observation locations. The locations were elected via a survey that conducted between 18 and 20 August, 2012. Five locations were elected, where two of these locations were in the Woongarra sector of the "Great Sandy Marine Park (GSMP)" and they were known as Barolin Rocks and Burkitt's Reef. The other three locations were elected on the shoreline of GSMP and they were known by "Gataker's Reef West", ESA Park and "Big Woody Island Reef" (Loder et al, 2012).

Other surveys had been conducted to observe the status and health of corals and to determine the effect of various threats. One of these surveys is that achieved by DeVantier (2010). The survey was aimed to observe the ecological condition and structure of coral types. Eight locations within Hervey Bay were included within the survey, where the reported information was given to the "Wildlife Preservation Society of Queensland (WPSQ)" within the section of Fraser Coast. The survey retrieved about 46 types of coral reefs that was registered during the extended period between 2007 and

2010. Further, the survey found that the largest diversity was existed within Woody Island, which involved about 31 types. The percentage of dead coral was lower than 5%, while the percentage of low coral was extended between 20 and 40%. In addition, the survey retrieved that the communities of coral within the waters of Eastern Australia were rare and this referred to the subtropical environments nature within Fraser Coast.

A study was performed by Butler et al (2013)to measure and compute the real impacts of the 2011 flood of Mary River on the inshore communities of coral at various six locations within GSMP. The data before and after the flood were utilized within the study. The reef locations involved: Mile Reef, Big-Woody Island, Vernon West, Pialba, Vernon East and Burkitt's Reef. The obtained findings proved that the degradation percentage of soft coral and hard oral as 40% throughout all locations. Further, the mortality was mutable depending on the locations close from the mainland. The mortality was high in four locations: Burkitt's Reef, Vernon East, Pialba and Vernon West. The maximum percentage of mortality was in Vernon East with percentage reached to 89%.

According to Jones and Berkelmans (2014), the rainfall within Queensland registered the highest level within December 2010, where this level of rainfall led to flood the Fitzroy River. About 40% to 100% mortality of coral reefs that located at 12 Km away from the beach of Queenslandcoast was resulted from the flood. This large percentage of mortality was obtained due to the low salinity of seawater, which largely impacted on the life of coral reefs. Thus, a long period that extended between 10 to 15 years was required to recover the dead reefs from the flood of Fitzory River. This estimated period was determined depending on the historical periods of recovery from an identical event that occurred in 1991. This long period will influence on the entertainment usage and the number of visitors for the purpose of tourism. At the same time, many activities such as coral viewing, diving and snorkeling can be achieved to keep the few numbers of reefs that stay alive after the flood occurred. Further, the tourism can be supported by various measures like reef rehabilitation, restoration and regeneration. On the other hand, the forecasts of the high level of summer rain, low rainfall and warm climate within the coastal and central areas of Australia throughout the following decade, jointed with the recent anthropogenic impacts on the quality of water will make the regeneration process more difficult. The figure below illustrates the plume of Fitzory River flood.

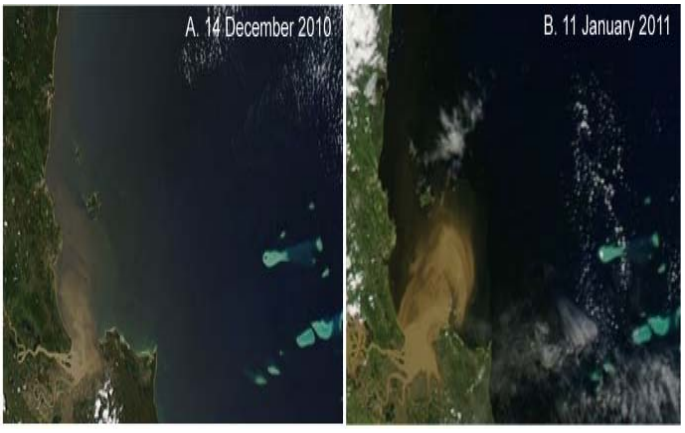

Figure 3: Fitzory River flood, (Jones and Berkelmans, 2014).

Speed et al (2013) utilized meta-analytical method to evaluate the data of coral cover through the west coast of Australia. The study involved data from 25 years, where these data were relevant to the Ningaloo area. The recent evaluations retrieved that the cover of coral extended among 3-44% within the coral environments. Further, the Poritidae and Acroporidae coral families were taken control within the northern areas. However, the cover of coral reefs within Nigaloo stayed stable with time, while the north-southern and north-eastren regions exposed important degradation. The periodic disorders like thermal anomalies and cyclones were the key reason of the degradation, where these disorders were extended from 1998 to 2011. Moreover, this study can be enhanced by utilizing the standard monitoring methods that utilized by the research and management agencies. These methods can provide better foundation for coral reef preservation and stronger evaluation of reef condition.

D'Olivo et al (2015)utilized the compositions of boron isotopic to rebuild the pH of reef-water within the central GBR. Further, these compositions were utilized to evaluate how the river runoff effects on the coastal reefs. However, the corals within mid-shelf and inner-shelf locations exposed to identical decreasing during the period of 1940 and 2009. The key reason of this deterioration was ocean acidification impacts. The results confirmed that the compositions of boron isotopic within inner-shelf corals have more changeable and higher values than the mid-shelf corals.

D'eath et al (2012)examined the key temporal and spatial dynamics of the reef cover by measuring the possible recovery rate of the GBR and determining the key factors that lead to coral mortality. About 2,258 surveys that conducted on 4214 reefs and over the 1985 and 2012 period were utilized within this study. Based on these surveys, the cover of coral was deteriorated from 28% to be 13.8%, which equals to 50.7% loss in the cover of coral. Further, the coral bleaching, coral predation via "Crown-of-Thorns Starfish (COTS)" and tropical tornados led to loss about 10%, 42% and 48% of coral cover respectively. The surveys showed that there is no deterioration within the northern area of the GBR. Further, the cover of coral can be raised by 0.89% with the COTS absence. However, losses from bleaching and tornados still presented. Hence, the populations of COTS can be minimized by enhancing additional control measures and water quality and this can enhance the future of the GBR and avoid the additional deterioration.

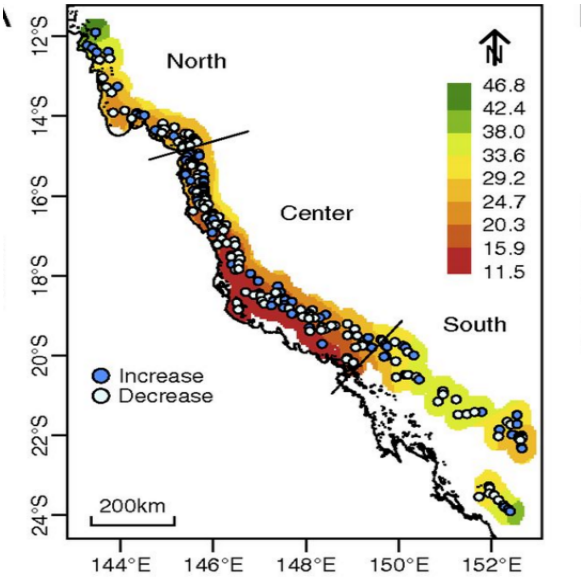

Figure 4: coral cover over the map of GBR over the years of 1985-2012 (D'eath et al, 2012).

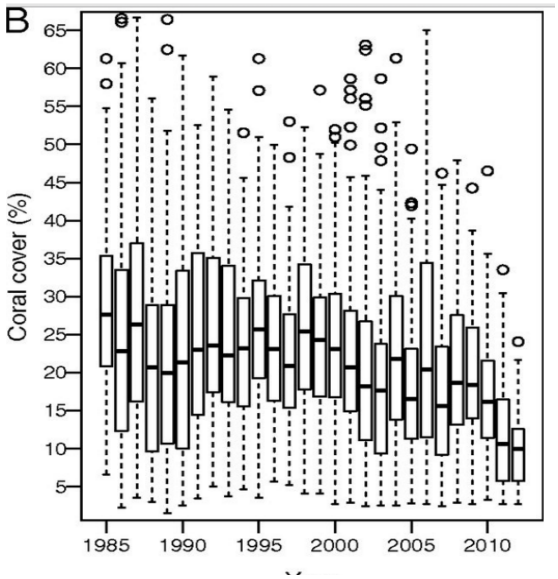

Figure 5: percentage of coral reef distributions over the years of 1985-2012, (D'eath et al, 2012).

3. Threats Obtained from GCC

Currently, "Global Climate Change (GCC)" is considered as one of the greatest risks that exposed coral reefs(Burke et al, 2011). GGC threat involves variations in storm patterns, ocean acidification, rise of sea level and higher temperatures. GCC components have different impacts on the reefs, where the acidification, bleaching and warming have

the greatest damaging impact. Further, the activities of human are largely effected on the atmosphere of earth, where the percentage of CO2 within the atmosphere and the percentage of other gases have been increased during the current years (Rogers,2013).
The quick variations within the global environment have set the coral reef within Australia and all other countries in danger. Thus, many threats face the coral reefs due to many reasons (Boruff et al, 2014):

— Varying climate: This variation in climate exposed the coral reefs into many threats such as:

— Ocean warming: which leads to increase the level of the sea and the absorption of CO_2 within the ocean.

— Mass bleaching: which led to increase the reef-building corals death percentage.

— Ocean Acidification: Which minimizes the accretion, growth and recruitment of coral reefs.

— Increasing of sea level: this threat will minimize the preservation function of the structures of the coral reefs and this will improve the energy of transmitting waves toward the coastline. Hence,the shoreline salinization, inundation and erosion will be increased and this will impact on the supplies of drinking water, agriculture and terrestrial habitats and marinehabitats.

— Stresses caused by human on the ecosystems of coral reefs: these stresses are mainly obtained from the development of coastlines that performed neighboring from the reefs. This development increases the coral reef loss, leads shoreline erosion and effects on the quality of coastal water.

— Shipping activities: the quick growth within these activities extended the harbors and ports which increased the dredging activities. Thus, the coral reefs became more affected by the deterioration that obtained from sedimentation and bleaching.

Moreover, the economy of Queensland has been greatly increased during the previous 10 years, where the shipping activities have been also enhanced and growth within the same period. Hence, the number of ships in the region of the GBR has been reached to 3583 ships in 2001. However, this number has been increased in 2010 to reach into 4487 ships. There are many factors that impact on the number of ships like the purchasing rate of international goods within Queensland, the supplying rate and the required level of Queensland exports. The figure below illustrates the growing rate of shipping within the region of the GBR (Seeney, 2012).

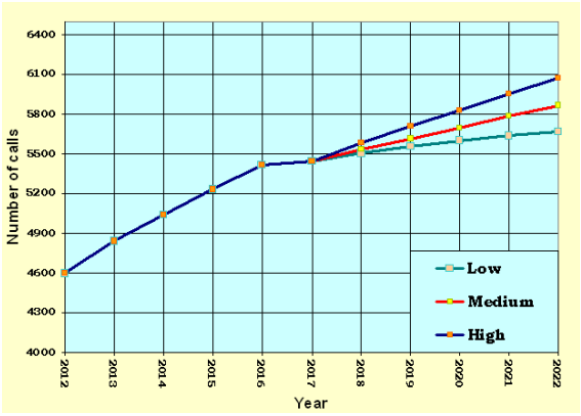

Figure 6: growing rate of shipping within the region of the GBR (Seeney, 2012).

During the previous decade, the Australian and Queensland governments utilized enhanced measures in order to reduce the shipping incident threats, reduce the environmental effects of shipping and manage the navigation safety. The "North East Shipping Management Group (NESMG)" managed the safety measures of shipping within the GBR. The plan of "North East Shipping Management (NESMG)" has been developed by this group to evaluate if the present management and safety actions will be optimal within 10 to 20 years. Many strategies have been put by this plan to manage the activities of shipping within the GBR, where the goal of this plan was to minimize the marine environment pollution and shipping incident threats. By the 2012 end, the plan will be completed (Seeney, 2012).

There are various pollutants that impact on marine and coastal environments in the region of GBRS, where sediment quality and poor water represent the most popular pollutants. Further, the report of marine environment state that established in 1995 indicated that the land-based is the key pollution that faces the marine environment and it represents about 80%. This type of pollution forms a key risk to the marine ecosystem's health that located close of the coast (Australian Government, 2013a). Hence, the Government of Australia developed the "Reef Rescue Research and Development Water Quality Program" in 2010 to enhance the knowledge and understanding about the environmental effects and management practices. Further, the program aims to enhance the quality of water through the GBR by minimizing the pesticide levels, sediments and nutrients that obtained from surrounding agricultural lands (Reef Rescue, 2013). About $200 million has been payed by the government of Australia in order to complete the program of Reef Rescue for other 5 years (Australian Government, 2013b).

4. Impact of CO2 Emission of Coral Reefs

Ocean acidification is considered as one of the significant threats that endangers the coral reefs within GBR. This threat reduced the ability of coral reefs from building their skeletons and shells. This threat also doubled the concentration of CO2 within the

atmosphere and this minimizes the calcification of coral about 30% (U.S., 2009) (Feely et al, 2008). The figure below illustrates the relations between factors reducing the resilience of coral reef and carbon emissions (Anthony and Marshall, 2009).

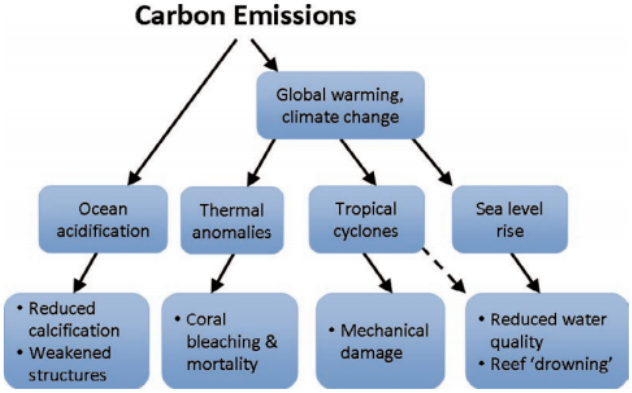

Figure 7: relation between factors impact on coral reefs and carbon emission, (Anthony and Marshall, 2009).

The historical variation within ocean acidification in Australia is shown in the figure below. The figure shows the variations in the saturation state of aragonite and pH values from 1870 to 2009. Further, the figure shows the variation in the "Sea Surface Temperature (SST)" over the same period, where a small warming in water is indicated by the figure. Further, the variations in ocean acidification are relevant to the absorption of ocean carbon that is motivated by the increasing of CO2 in the atmosphere (Lenton et al,2015).

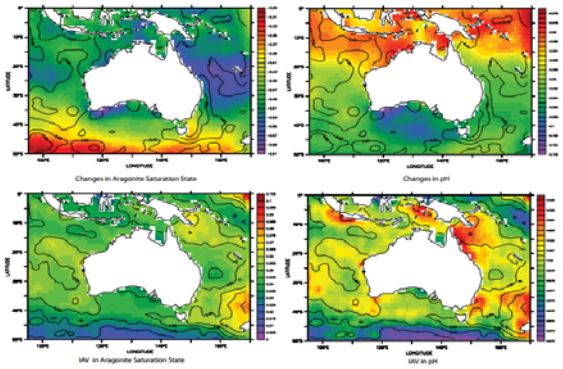

Figure 8: saturation state of aragonite and pH values from 1870 to 2009, (Lenton et al, 2015).

5. Preservation of GBR

The government of Australia performed several actions to preserve the coral reefs within GBR (United Nations, 2011). These actions are:

— The government of Australia took several steps to preserve the GBR; the first step was in 1975 by establishing the "Great Barrier Reef Marine Park Authority (GBRMPA). Further, various measures of conservation and preservation had been taken

into account, involving the building of novel plan of zoning in 2004 to increase the preservation percentage of the Marine Park.

— "Traditional Use of Marine Resource Agreements (TUMRAs)" was developed by indigenous groups and GBRMPA to manage and monitor the Parke of Marine. The agreements supported the conventional owner groups with more elastic and practical pathway to direct their interests and rights. Further, TUMRAs provided chances to preserve the cultural values and manage the significant species. Further, itaddresses the key activities that effect on the people within this area, like resource overfishing and illegal fishing.

— Other significant initiatives like "Reef Rescue" and "Reef Water Quality Protection Plan were also applied along the years from 2008 to 2013. The goals of these initiatives were tominimize the nutrients and sediment discharge by 10% and dissolved chemicals and nutrient discharge by 25%.

— Bio-regional planning of Australia's marine is established to supply the coral reefs with long-term preservation by enhancing the marine resources management, sustainable use and conservation by MPAs and MMAs.

— The Australian Government established the "Protection of Coral Reefs for Sustainable Livelihood and Development" with Pacific countries and others that impacted by coral reef loss or decline to preserve the coral reefs from this loss and decline.

6. Protection plans and policies

In 2007, the first "Great Barrier Reef Climate Change Action Plan (GBRCCAP)" was implemented by the Government of Australia. The key effects that impact on the reef and obtained from the climate variance were evaluated via a comprehensive assessment, which also provided a constituent knowledge to develop an optimal management based on the effects of climate change. By this plan, many strategies were adopted to preserve the threatened types of reefs and to raise the stewardship. The tourism operators, commercial fisher and conventional owners were utilized within those strategies to observe the health of the reefs and to establish a strong resilience for these reefs. Further, the adaptation strategy of GBRCC was aimed to aid the reefs, their communities and their industries to be adaptive and with the varying climate. The first plan was improved to be GBRCCA (2012-2017), where this extended plan aimed to enhance the reef outlook within Australia during the extended period between 2012 and 2017. This plan combined between scientific experts, conventional owners and the agencies of the Queensland Government (GBR, 2012).

One of the most popular iconic reef systems within Australia is the GBR, where it covers about 2,000 Km. However, the land-based pollution led to deteriorating this ecosystem, where the neighbor catchments represented the key reason of this decline. Hence, various policy initiatives had been applied by the Governmentsof Queensland and Australia since 2003 to minimize the impact of land-based pollution. However, the current efforts achieved by the governments to minimize the land-based pollution was

not adequate to preserve the ecosystems of GBR from water quality deterioration. Additional enhancements were identified to the recent incentives and policies and other modifications to the recent use of agricultural land to support the decisions to management for the GBR.

Several studies were performed to examine the GBR integrity and ecological health. The quality of water was one of the main elements that studied to indicate the ecosystem state. Hence,the "GBR Water Quality Protection Plans (GBRWQPP)" was established by the Australian Government to enhance the quality of water. The plan was extended between the period from 2009 to 2013. The GBRWQPP was reported via the Statements of Scientific Consenus, where it was developed via an independent and multidisciplinary scientist group. The plan showed that the reef areas within GBR exposed to deterioration and the key reasons for this deterioration were referred to the effects of changing climate, habitat destruction and modification, poor quality of water, over fishing, flooding and cyclone events (Brodie et al, 2013).

Another significant plan was established by the governments of Queensland and Australia to manage and monitor the GBR. The Plan was known as the "Reef 2050 Long-Term Sustainability Plan", which organized the key guides and actions that should be performed for management until to 2050. The goal of the plan was to address the key limitations that face the coral reef. Further, it showed the key actions that should be performed to preserve the resilience, health and values of the reef. The changing climate was the key risk addressed within this plan. Hence, enhancing ecosystem resilience to face the variation in climate was the main goal of this plan. This step was achieved by confirming the port development, keeping the biodiversity and enhancing the quality of water (Australian and Queensland Governments, 2015).

Further, in 2003 the "Reef Water Quality Protecton Plan" was established to enhance the water quality within the watersheds of reefs. The plan was also revised in 2013 and 2009. The plan aimed to minimize the distribution of source pollution involving sediment, pesticides and nutrients that obtained from the use of broad-scale land. The cards of annual reef report proved that there was an important enhancement within the quality of water. Further, the results by 2013 were better than that in 2009, where the load of nutrients was minimized by 10%, while the load of pesticides was minimized by 28%. On the other hand, the load of sediment was minimized by 11%.

7. Data Analysis

As shown from the sections above, the coral reef with Australian coasts and near areas are exposed to a large number of climatic and environmental threats. Also, as shown Australia contains a huge number of coral reefs as compared with other countries around the world. Thus, this paper based on the literature surveys to solve this problem. The paper reviewed many surveys that conducted to observe the situation of coral reefs within Australia. The surveys help to determine the main sites within Australia that contains coral reefs, the main types of coral reefs within these sites, the key threats that impacted on these sites and the percentage of coral reefs death. In addition, the main threats caused by climate change have been determined and discussed. These threats are obtained due to the coastal nature of Australia, which impacts on the area climate. Also,

the actions performed by the government to preserve the GBR and the key plans established to preserve the coral reefs within Australia have been discussed. The plans aim to show the actions should be performed to reduce the impact of natural threats in order to preserve the reefs. The paper helps to determine the volume of risk that exposed the coral reefs within Australia and the actions that should be performed to preserve the coral reef. Further, the governments and the organizations of other countries can benefit from this paper to preserve their coral reef from the death.

8. Results and Solutions

As a summary, the Australian coral reefs are largely impacted by the threats obtained from the variations in climate due to the coastal nature of this country. The impact of these threats harms the cover of coral reefs and increases the percentage of deaths. The solution of this problem can be achieved by the following recommendations (Jörgensen, 2016), (United Nations, 2011):

- ❖ Enhancing the quality of water through avoiding sediment runoff and coastal pollution.
- ❖ Preserving the habitats of mangrove which work as shoreline filters
- ❖ Minimizing the over-exploitation and habitat damaging by establishing the fishing quotas and gear restriction (McClanahan et al, 2011).
- ❖ Building MPAs to preserve coral reefs from degradation.
- ❖ Enhancing the scientific knowledge about tropical ecosystems of marine to confirm actual sustainable fishery and shoreline management.
- ❖ Reduce the global emissions of CO2, where they obtain ocean warming and ocean acidification and this will lead to damaging the coral reefs.
- ❖ Reduce watershed that based on pollution and sedimentation by enhancing the mining, livestock and agriculture practices.
- ❖ Minimize the unsustainable exercises of fishing like destructive fishing and over-fishing through sustainable management guidelines, practices and policies.
- ❖ Minimize marine-based damage and pollution through regulating and controlling the discharge of ballast.
- ❖ Enhance coastal evolutionthrough: ocean zoning, management of ecosystems, joining marine and terrestrial protected regions and integrated management of shoreline.
- ❖ Enhance the tourism sector by applying promote eco-tourism and sustainable tourism.

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