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Moustafa M. Fouda and Makram A. Gerges

Implications of Climate Change in the Red Sea and Gulf of Aden Region: An Overview

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PREFACE

The closely-related issues of greenhouse gas emissions, global warming and climate change have recently come to the top of the international environmental agenda. In particular, concerns over the problems expected to be associated with the potential impacts of climate change have grown over the past decade and captured the attention of the scientific community, the politicians, decision makers, as well as the private and public sectors. These problems may prove to be among the major environmental problems facing the marine environment and adjacent coastal ares in the near future. Therefore, and in line with UNEP Governing Council decision 14/20 on "Global Climate Change", the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of the United Nations Environment Programme (UNEP) launched and supported a number of activities designed to assess the potential impact of climate change and to assist the Governments concerned in identification and implementation of suitable response measures which may mitigate the negative consequences of the impact.

Since 1987 to date, Task Teams on Implications of Climate Change were established for eleven regions covered by the UNEP Regional Seas programme (Mediterranean, Wider Caribbean, South Pacific, East Asian Seas, South Asian Seas, South-East Pacific, Eastern Africa, West and Central Africa, the Kuwait Action Plan Region, the Red Sea and Gulf of Aden and the Black Sea). Some of these Regional Task Teams enjoy the support of the Intergovernmental Oceanographic Commission (IOC) of UNESCO and other relevant international, regional and non-governmental organizations.

The initial objective of the Task Teams was to prepare regional overviews and site-specific case studies on the possible impact of predicted climate change on the ecological systems, as well as on the socio-economic activities and structures of their respective regions based on the climate change models/scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) and widely accepted by the international scientific community.

The overviews and case studies were expected to:

- examine the possible effects of the sea-level rise on the coastal ecosystems (deltas, estuaries, wetlands, coastal plains, coral reefs, mangroves, lagoons, etc.);
- examine the possible effects of temperature elevations on the terrestrial and aquatic ecosystems, including the possible effects on economically important species;
- examine the possible effects of climatic, physiographic and ecological changes on the socio-economic structures and activities; and
- determine areas or systems which appear to be most vulnerable to the above effects.

The regional overviews were intended to cover the marine environment and adjacent coastal areas influenced by, or influencing, the marine environment. They are to be presented to intergovernmental meetings convened in the framework of the relevant Regional Seas Action Plans, in order to draw the countries' attention to the problems associated with expected climate change and to prompt their involvement in development of policy options and response measures suitable for their region.

Following the completion of the regional overviews, and based on their findings, site-specific case studies are developed by the Task Teams and are planned to be presented and discussed at national seminars. The results of these case studies and the discussions at the national seminars should provide expert advice to the national authorities concerned in defining specific policy options and suitable response measures.

The Task Team on the Implications of Climate Change in the Red Sea and Gulf of Aden Region was established and met in its first meeting at the Suez Canal University in Ismailia, Egypt, 22-25 February 1992, and in its second meeting at the Suez Canal University's Research Centre, Saint Catherin, Sinai, Egypt, 9-12 December 1992. The meetings were attended by experts from the region

invited by UNEP in their personal capacities, taking into account the need for expertise relevant to the work of the Task Team and for a balanced geographical representation. It was also attended by representatives of the Intergovernmental Oceanographic Commission (IOC) of UNESCO and the Program for the Environment of the Red Sea and Gulf of Aden (PERSGA). Each member of the Task Team was assigned a specific subject to address in detail, and the present overview is largely based on the contributions by the individual members of the Task Team.

The Task Team members who contributed to the present overview are: Dr. Moustafa M. Fouda (Coordinator),Dr. Abdel Fattah Abdel Wahab, Dr. Abdel Rahman A. Ahmed, Dr. Abdul Kader El-Hag, Dr. Ali A. Salem, Dr. Atef A. Moussa, Dr. I. El-Shamy, Dr. Girgis F. Soliman, Dr. Mohamed Ben Afif, Dr. M. Noman Noufel, Dr. Makram A. Gerges (UNEP), Dr. Amin H. Meshal (IOC), Mr. David Medio (UNESCO) and Dr. Dirar H. Nasr (PERSGA).

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I. INTRODUCTION

The natural resources of the Red Sea and Gulf of Aden are diverse, comprising a wide range of tropical marine habitats, some of considerable conservation, scientific, economic or recreation value. However, they are often impoverished, both faunastically and in the range of available microhabitats. These are due to the recent isolation of the Red Sea from the Indian Ocean, the severe environmental regime imposed by the arid zone climate, the sheltered nature and unusual geographical location of the Red Sea, and the relatively small tidal range. Consequently, there is a greater range of marine environments providing biota with both optimal and highly stressed conditions resulting in a high degree of endemism with many species capable of tolerating high water temperature and salinity. As a result, many coastal organisms appear to be close to their physiological limits.

For the above reasons, the region of the Red Sea and Gulf of Aden offers much that is of interest and importance to our understanding of diverse marine habitats and processes in general, and of responses of ecosystems to natural environmental stress (Sheppard, *et al* 1992). The current exploitation of the Red Sea and Gulf of Aden resources is causing great economic and ecological changes. Conflicting human interests are taking a toll on the region's natural resources. It is important, therefore, to note that any additional stress imposed by human activities and pollution will cause serious problem to the unique environments of the Red Sea and Gulf of Aden.

The anticipated global warming as a result of greenhouse gases emission into the atmosphere is becoming a pressing environmental problem to the extent that it encompasses many scientific and socio-economic disciplines and hence, presents major challenges of this decade and undoubtedly for the next century. Obviously, serious environmental problems are likely to rise in association with potential impacts of expected climate change in the marine and coastal areas of the Red Sea and Gulf of Aden.

The United Nations Environment Programme, in response to the above concerns, and in line with Decision 14/20 of its Fourteenth Governing Council, established Regional Task Teams on the Implications of Climate Change in all the areas covered by its Regional Seas Programme. The Task Team on the Implications of Climate Change in the Red Sea and Gulf of Aden was established in February 1992. Similar to the other Task teams, it has the following objectives:

Long-Term Objectives

a) to assess the potential impact of climatic changes on the coastal and marine environment as well as on the socio-economic structures and activities; and

b) to assist Governments in the identification and implementation of suitable policy options and response measures which may mitigate the negative consequences of the impacts.

Short-Term Objectives

a) to analyze the possible impact of expected climatic changes on the coastal and marine ecological systems, as well as on the socio-economic structures and activities; and,

b) to prepare overviews and selected case studies relevant to the Red Sea and Gulf of Aden.

This overview is expected to specifically address the following:

a) the possible effects of the sea-level changes on the coastal ecosystems (deltas, estuaries, wetlands, coastal plains, coral reefs, mangroves, lagoons, etc.)

b) the possible effects of the temperature elevations on the terrestrial and aquatic ecosystems,

including the possible effects on economically important species;

c) the possible effects of climatic, physiographic and ecological changes on the socio-economic structures and activities; and

d) areas or systems which appear to be most vulnerable to the expected impact.

In addressing the above questions, the work of the Task Team was based on:

a) the best available existing knowledge of and insight into the problems relevant to the subject of the study; and

b) assumptions accepted at the UNEP/ICSU/WMO International Conference in Vilach, 9-15 october, 1985, i.e. increased temperature of 1.5 - 4.5°C and sea-level rise of 20 -140 cm before the end of the 21st Century. However, for the purpose of this overview and the various studies by members of the Task Team, temperature elevation of 1.5°C and sea-level rise of 20 cm by the year 2025 were accepted with the understanding that these estimates may have to be revised on the basis of new scientific evidence. An IPCC (1990) scenario, for example, estimates the mean global sea rise to be between 10 - 30 cm by the year 2030, and 20 - 100 cm by the end of the next century.

2. DESCRIPTION OF THE RED SEA AND GULF OF ADEN

2.1 GEOMORPHOLOGY

2.1.1 Geological History

The Red Sea was originated, at first, in the Eocene period as a Gulf of the Mediterranean Sea which extended as far south as Qoseir. By the movements of the earth's crust, active during the subsequent geological periods, this gulf, later became separated from its father sea, but itself increased both in depth and extent and was thus transformed into a separate ditch-like depression (Gohar, 1954).

During the late Eocene, the Oligocene and the Miocene periods respectively, it separated from, rejoined and became separated again from its father sea. However, it gained in depth and length, and toward the close of the Miocene period, it was converted into a great lake separated entirely from the ocean. In this way, the Red Sea primordium was formed.

At the commencement of the Pliocene period, not only was it again connected with the Mediterranean, but through its further sinking became for the first time connected with the Indian Ocean. The Gulf of Aqaba was then also formed and connected with the Dead Sea.

This state of affairs did not last long, for toward the end of the Pleistocene period, the Red Sea was finally separated from both the Mediterranean and Dead Seas. It was left to man at successive historic eras to effect the connection with the Mediterranean Sea. Its connection with the Indian Ocean, however, has been maintained since the Pliocene period.

2.1.2 Marine Geomorphology

2.1.2.1 The Red Sea

The Red Sea is a flooded valley that can be described as a young ocean (about 70 million years), created by the pulling apart of Africa and Arabia (Fig. 1). It extends SE-NW between 12°N, 43°E and 30°N, 32°E and has a surface area of 44000 km^2. It communicates at its northern end with the Mediterranean Sea through the man-made Suez Canal and at its southern end with the Indian Ocean through the straight of Bab el Mandab. Near the latitude 28°N, the Red Sea branches into the Gulfs of Suez and Aqaba.

The Gulf of Suez extends for about 255 km with widths of 17 - 45 km and maximum depth of 83 m (U.S. Navy Charts, 1968). Throughout its geological history, the Gulf of Suez has always been a site of immense sediment accumulation (Said, 1969). Accordingly, its bottom morphology is smooth and simple, having likewise gentle submarine coastal slopes. This excessive sedimentation has also restrained the development of coral reefs.

By contrast, the Gulf of Aqaba is shorter, narrower, and much deeper. It extends for 180 km with widths varying from 25 km in its southern part to 16 km at the north. The Gulf proper is divided into three elongated deep basins striking North East. The northern deep is the shallowest (900 m deep) and is characterized by its flat bottom, while the other two deeps have irregular bottom topography and much greater depths. The maximum water depth in the Gulf reaches up to 1850 m in the central basin (Friedman, 1985). With the exception of the northernmost part of the Gulf, fringing coral reefs grow luxuriously along the entire coastline varying in width between 10 and 100 m depending on the slope gradients at the shelf edge (Friedman, 1985).

The Red Sea proper itself extends for about 2000 km. The shorelines of the sea are straight in the north but notably sinuous in its central and southern parts where they encroach vast bays. The distance between the eastern and western Red Sea coasts is 180 km at its narrowest part and double this value at the widest part at Massawa (Coleman, 1974); meanwhile its average width at Bab el Mandab is only 27 km.

The most important feature of the Red Sea is the deep, narrow axial trough cutting the medial axis of the large main trough. The main trough extends from a northern point close to Ras Muhammad southward to Zubayer islands. The southern part of the trough is straight, whereas, further north it goes in a crooked way revealing the influence of transform faults (Ross and Schelee, 1974). The axial trough, however, is well developed only in the central part and the adjacent northern areas, but missing in the extreme northern and southern parts. Yet, it is assumed that it might be covered by the thick accumulation of Pleistocene sediments in the southern part of the Red Sea (Ross and Schlee, 1974). The axial trough is only 10-30 km wide having steep-sided walls and very irregular bottom topography (Coleman, 1974). It is famous for its numerous isolated deeps, generally filled with hot brine and economically important metalliferous deposits. The water depth in the deepest pool is 2850 m (Backer and Schoell, 1972). Generally, the Red Sea rift system is characterized by extensive volcanic activity throughout the whole area (Fig. 2).

The continental shelf of the Red Sea is 15-30 km wide in the north and about 120 km wide in the south. However, in the most southern part of the sea, the Farasan and Dahlak banks are considered as parts of a shallow shelf extending to the centre of the sea. The inner part of the continental shelf is dissected by various reefs, rocky shoals, banks and islands resulting in a rough bottom topography. The outer shelf, however, slopes rather gently with a distinct break at 500-600m depth marking the edge of the main trough (Schlumberger, 1984).

Among the attractive geomorphic features in the Red Sea are the reef-island complexes forming the archipelagos of Dahlak, Farason, Suakin and Hurghada (Ghardaqa). The Red Sea islands typically range in height from less than one meter to hilly ones rising up to 300 m above sea level.