SDG14 – LIFE BELOW WATER

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SDG14 – LIFE BELOW WATER

Towards Sustainable Management of Our Oceans

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PREFACE

Oceans constitute about three-quarters of the earth's surface; they contain 97% of the earth's water and represent 99% of the living space of the planet by volume. However, about 95% of the ocean is still unexplored, around 91% of oceanic species are yet to be classified and large numbers of fish species (1,851 species as reported in 2010) are at risk of extinction. Even though human beings largely inhabit land, they have a significant dependence on oceans.

The oceanic processes and their biodiversity make the earth habitable, as they contribute many ecosystem services (CBD, 1992; Convention on Biological Diversity, n.d.). In addition, coastal and marine resources contribute US$28 trillion to the global economy every year. Importantly, oceans absorb about 40% of the carbon dioxide produced by human beings, thereby moderating the impact of global warming. They are the world's largest sources of protein, with a large proportion of the human population (over 3 billion) depending upon them as their primary source of protein. The estimated market value of such marine and coastal resources and industries is about US$3 trillion per year, which amounts to 5% of global gross domestic product (UN Web Site, n.d.-a).

So far, we know little about the importance of oceans to humans and other land species. Oceanic temperature, chemistry, currents and life regulate global systems and processes which ensure the availability of rainwater, drinking water and oxygen. Human interventions, such as pollution, depleted fisheries and loss of coastal habitats, are adversely affecting the sustainability of oceanic life. About 40% of the world's oceans are already heavily affected by such activities (UN Web Site, n.d.-a). Unmonitored fishing is also causing ocean fisheries to generate US$50 billion less per year than they could. Hence, there is increasing realisation that protecting our oceans and the lives that depend on them is a global responsibility. The global community has now committed to achieving the sustainable management of marine ecosystems by 2020 and, in a further five years, to significantly reduce marine pollution of all kinds. The Sustainable Development Goals (SDGs) of the United Nations have viewed these issues from a very broad perspective. It is clear that we need an international scientific partnership, regulation of harvesting and fishing and enhancement of our research and knowledge on issues critical to the survival of life underwater. In the context of the SDGs, the following issues need immediate attention:

(a) How does human life on earth depend on oceanic processes and biodiversity?

(b) How is marine life under threat from pollution of various kinds?

(c) What are the repercussions of the threat to oceanic life for sustainable development?

(d) How can marine biodiversity contribute to the economy of developing nations, in particular, of small island developing states and the least developed nations?

(e) What are the emerging legal issues in the conservation and sustainability of oceans and their resources?

This short book gives a glimpse into life under water, its impact on human lives and the need for sustainable management of these systems. It is primarily meant for development professionals, policy makers, university and college teachers and students. Chapter 1, the 'Introduction', describes the dependence of human beings on coastal and marine resources. It further highlights how oceanic life sustains the livelihoods of people living in coastal areas. The chapter begins with how the ocean and its ingredients, like temperature, chemistry, currents and biodiversity, play a significant role in making the earth habitable. This is followed by a discussion on human interventions and their repercussions for oceanic processes. The chapter also includes some functional links between oceans and sustainable development. Chapter 2, 'Oceans and Sustainable Development', gives a glimpse into macrolevel issues, such as oceanic acidification and warming, and their impact on oceanic life. The chapter also relates these issues to sustainable development. Chapter 3, 'Sustainable Management and Protection of Marine and Coastal Ecosystems', describes the need for sustainable management and protection of marine and coastal ecosystems. Good practices initiated in some countries are also highlighted in this chapter.

Chapter 4, 'Marine Pollution', elaborates on the impact of human interventions on oceanic life and the various ways in which the sustainability of the oceanic system is threatened. This chapter discusses the major sources of pollution adversely affecting the sustainability of oceanic processes and, consequently, the livelihoods of people. The impacts of such pollution on oceanic life are also described in this chapter. Chapter 5, 'Marine Biodiversity and Development in Small Island Developing States (SIDS)', specifically describes the contribution of marine biodiversity to the development of coastal nations, particularly to small island developing states. It discusses some examples of sustainable management and development programmes from these countries. Chapter 6, A 'Legal Framework for the Conservation and Sustainable Use of Oceans', discusses maritime laws, their historical evolution and relevance in the present-day context. The last chapter, Chapter 7, 'The Road Ahead', summarises various aspects of life under water in need of immediate attention.

Umesh Chandra Pandey, Subash Ranjan Nayak, Krishna Roka and Trilok Kumar Jain

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INTRODUCTION

Although humans are basically a land-dwelling species, they depend greatly on oceans for survival. Over 40% of the earth's population lives within or near coastal region. Oceans are connected to our existence to such an extent that with every breath we take and every drop of water we drink we owe something to them. Estimated volumes of water stored in the earth's natural reservoirs show that most is stored in oceans (about 96%); in other natural reservoirs the percentage is much less, for example, underground water (1.0%), lakes and rivers (0.025%), the atmosphere (0.001%) and plants and animals (0.00014%). Oceans cover 70% of the earth's surface, which constitutes 99% of the living space of our planet by volume. They regulate the earth's system, supply living and non-living resources and provide social and economic goods and services. A large segment of the global population depends heavily upon coastal and marine resources for their day to day needs. Oceans provide food, create opportunities for livelihoods and contribute significantly to the global economy through trade, transport, tourism, etc. This shows how intimately our existence is linked to oceans. We are now witnessing an emerging concept of the blue economy, which refers to sustainable ocean resources for economic growth, improved livelihoods and jobs and ocean ecosystem health. It is estimated by the European Commission that the blue economy creates over 5 million jobs and contributes €500 billion every year. It is increasingly relevant for coastal and island developing states, recognising that the blue economy offers an approach to sustainable development better suited to their circumstances, constraints and challenges (RIS, 2010).

However, oceans are gradually losing their potential to support our lives. Though there are several factors which have contributed directly or indirectly to declining oceanic health, there are two major categories of impacts on oceans: firstly, due to human management issues such as overfishing, habitat loss and pollution; and, secondly, greenhouse gas (GHGs) emissions, leading to ocean warming, oceanic acidification and deoxygenation. The rising levels of GHGs (especially CO_2) have brought oceanic health to the forefront of the global developmental agenda. Post-industrial societies have witnessed an extraordinary rise in levels of carbon dioxide, which is the major reason behind the rise in the earth's average temperature. The concentration of CO_2 in 1750 was 278 ppm, which had remained more or less static around this value for at least 8,000 years. However, over the past 100 years, there has been an abrupt rise, up to 400 ppm (around 44%), thereby leading to rise of average global temperatures by 0.7 °C. These trends, if they continue unabated, are likely to raise the average surface temperature of the earth by as much as 5–7 °C by 2100 (Australian Academy of Science, n.d.).

Human influence on the oceans has now become stronger, though there is widespread regional variability. We are witnessing the new era called the 'Anthropocene', so called because the human impact on oceans is now almost comparable to the impact of natural forces. In highlighting the anthropogenic influence on oceans, Roger Revelle and Hans Suess

(1957), of the Scripps Institution of Oceanography wrote as follows:

> *[…] human beings are now carrying out a large-scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years. This experiment, if adequately documented, may yield a far-reaching insight into the processes determining weather and climate. (p. 19)*

OCEANIC STRUCTURE

The ocean is immense, especially in terms of its overall volume, but it is mostly unexplored. Vast regions are more than 4,000 m (13,000 ft) deep, and the deepest depths (greater than 11,000 m) are as deep as the highest mountains are high. The ocean bottom is, for the most part, a broad, flat, featureless expanse known as the *abyssal plains*. The edges of the continents extend into the ocean as the *continental shelves*. These can extend hundreds of kilometres from the shoreline, as is the case with the entire North Sea, or only a few tens of kilometres, as along the west coast of South America. Then the continental slope plunges steeply into the deep ocean. The continental slope is a factor in guiding ocean circulation. The ocean is constantly in movement. As well as having a layered structure, there are boundary and surface currents and constant dynamic interaction with the atmosphere. The oceans are a major player in the earth's system and are in constant motion. The currents on the oceanic surface are driven by winds which work their way down into the ocean depths; this is evident from satellite data on information about heat stored in the oceans and the speed or direction of currents and helps predict global climate variations (NASA, n.d.).

These properties make oceans crucial from the point of view of climate science. The layered structure of oceans is due to a variety of reasons; for instance, due to temperature and salinity-dependant density variations, the oceanic structure is thermally and compositionally stratified. On the topmost layer is a thin, warm surface layer (known as the mixed layer); it extends about 20–200 m (66–660 ft) below the surface. The temperature in this topmost layer does not change much, primarily because this layer is subjected to waves and convection, which keeps the waters stirred. Moreover, the water in this layer is in equilibrium with the atmosphere as far as CO_2 and other components are concerned. However, as we move below this topmost layer, the temperature starts declining and salinity increases rapidly with depth. As we move still deeper, we find that salinity and temperature vary only slightly with depth. This deep zone constitutes most of the ocean (65%) and has tremendous significance from the point of view of climate change, primarily because it constitutes an enormous reservoir in which carbon can be stored for thousands of years.

WHAT MAKES OCEANS IMPORTANT

The following reasons show that oceans are important for our survival (Fleming, 2019):

The characteristics of water. Water can exist in three different phases (i.e. solid, liquid and gaseous) which are interconnected through a water cycle. The physical properties of water are vitally important for its role in oceanic processes. The typical physical atomic structure, hydrogen bonding and resulting properties of water make life possible on earth. For example, water has high specific heat capacity (about

4.2 J/g/K), heat of fusion (about 333 J/g), heat of vapourisation (2,257 J/g) and thermal conductivity (between 0.561 and 0.679 W/m/K). These exceptional properties of water are primarily a consequence of hydrogen bonding among water molecules, which are about 10 times as strong as the Vander Waals forces operating in most liquids. Each water molecule has both a positive and a negative portion, and each side is attracted towards the opposite charge. This attraction allows water to form bonds with other polar molecules around it, including other water molecules. Due to its polarity, a water molecule in the liquid or solid state can form up to four hydrogen bonds with its neighbouring molecules. The property that allows water molecules to have stronger bonds with themselves is called cohesion. It is because of cohesion that water has a high boiling point. Furthermore, the amount of energy required for turning liquid water into gas (water vapour), and similarly the amount of energy liberated when water freezes to ice, are significantly high. As a consequence, the evaporation of water from the ocean is an important mechanism of heat transfer to the atmosphere. On one hand, when heat is absorbed by water, hydrogen bonds start breaking, which sets water molecules free. On the other hand, as temperature decreases, hydrogen bonds are formed which release a considerable amount of energy. Some of these properties make water more effective at moderating the earth's climate, by storing heat and transporting it between the ocean and the atmosphere. Some major facts which prove the importance of oceans for human existence are given in NOAA (2020a).

Therefore, oceans act as a natural thermostat. The amount of energy required to raise a unit mass of water by 1 °C (specific heat) is usually very high; even a small change in water temperature releases or absorbs a relatively large amount of heat. Among the consequences of the unusual properties of water and its abundance on earth is that the ocean provides an enormous reservoir of heat, holding about 1,000 times more heat than the atmosphere. The ocean thus acts as a natural thermostat, tending to keep the planet cooler than it would otherwise be during the summer months, and warmer when it cools down.

The ocean as a carbon sink. Another important property of oceans is their capacity to act as a natural carbon sink, which helps in regulating carbon in the climate system. Oceans produce over half of the world's oxygen and absorb 50 times more carbon dioxide than our atmosphere (NOAA, 2020a). In fact, the ocean holds far more carbon than the atmosphere, biosphere and all the other surface carbon reservoirs combined. In this, the salinity of water plays an important role. On an average, it is only 96.5% water by weight. The rest of it consists of sodium chloride and relatively lesser quantities of other dissolved salts. Several processes can cause salinity to change. Evaporation removes pure water and thus increases the salinity of what remains; the influx of freshwater from rain or rivers decreases salinity by dilution; freezing removes freshwater, leaving the salt behind, while melting returns the freshwater to the ocean. These processes combine to make the ocean more or less saline in different regions and at different depths. The saltier the water, the denser it is, and consequently the lower is its freezing point. Moreover, this has implications for circulation patterns of oceanic water. Density – and thus temperature and salinity – influence how the ocean circulates and affects climate. For example, in certain polar regions, water attains a relatively high density and sinks. Having been in contact with the atmosphere at the surface, this sinking water is also CO_2-rich. This is, therefore, an important mechanism for removing CO_2 from the atmosphere and transporting it to the deep ocean, where the CO_2 typically stays for thousands of years. The atmosphere and ocean are always in constant interaction with each other. Cold water dissolves more CO_2 than warm water, so as the waters flow poleward and cool, they take up CO_2. The oceans are thus a reservoir of carbon. When carbon is added to the atmosphere through various anthropogenic activities it gets distributed to various other parts of the earth's climate system. There is a remarkable variation in the distribution of carbon dioxide in the earth's climate system: the atmosphere (829 billion metric), the ocean surface (900 gigatons), plants (550 gigatons) and soils (2,000 gigatons). However, in the deep ocean, this figure rises to 38,000 billion metric tons of carbon. It is interesting to note that most of the earth's non-geological carbon sits in **oceans;** this makes the oceans the dominant reservoir in terms of the earth's carbon. There are several reasons for the increased concentration of CO_2 in the deeper waters of oceans. As we go deeper into oceans, respiration exceeds photosynthesis, and decomposition of organic matter adds additional CO_2 to the water. Furthermore, cold bottom water can hold more dissolved gases, and high pressure enhances solubility (Roger William University, n.d.).

A source of food. Oceans and coasts are a source of rich, often fragile and largely unexplored biodiversity on earth; they are also the primary source of protein for one billion people worldwide (Unger et al., 2017, p. 4). Oceans provide essential ecosystem services, which make them indispensable for human survival and well-being. Ocean-based industries contribute roughly US$1.5 trillion to the global economy (Unger et al., 2017, p. 4). Fisheries and aquaculture operations support the livelihoods of roughly 12% of the world's population, that is, nearly a billion people depend on oceans, seas and marine resources for their survival (UN-Women, n.d.). However, the ocean is important not only from the point of view of food but also the variety of species which live in ocean is incredible; the world of different types of animal species is yet to be completely explored. About 91% of species in the ocean still await description (cited in Fleming, 2019). Such diversity is immensely important for human well-being, primarily because hundreds of millions of people rely directly on marine biodiversity for their livelihoods (Secretariat of the Convention on Biological Diversity, 2014, p. 6).

The ocean is an important source of food which constitutes fish, crustaceans, many edible creatures and a range of algae and sea plants. Fish is the biggest source of animal protein for large populations on earth: it is almost 16% of the total animal protein consumed globally (Fleming, 2019). According to the United Nations' Food and Agriculture Organisation (FAO, 2018), seaweed is an important source of nutrients including sodium, calcium, magnesium and iodine. The ocean as a source of sea food is vitally important, as other sources of animal protein have direct implications for GHG emissions and water requirements. Therefore, oceans, if properly managed and maintained, can prove to be a sustainable source to feed a growing population.

A source of oxygen. Oceans can rightly be called the lungs of our planet, as they are its largest carbon sink and play a vital role in regulating the global climate. In addition, oceans are the biggest source of oxygen on earth, which makes it even more important. Phytoplankton (i.e. microscopic organisms that live in watery environments) living in the sea are responsible for 50% of the oxygen on the earth, which they produce as a normal process of photosynthesis. These phytoplankton also transfer carbon to deep oceans when they die or are eaten by other creatures which themselves reproduce, generate waste and die. This biological carbon pump is believed to transfer about 10 gigatons of carbon from the atmosphere to the deep ocean every year.

Moderation of the climate. The ocean plays an important role in regulating the climate by absorbing a huge amount of heat from the sun and transporting heat from the equator