THE IMPACT OF GLOBAL WARMING ON SEA-LEVEL RISE

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Summary

Global climate change is expected to become more severe over the 21st century as the world pumps more pollutants into the atmosphere. This anthropogenic climate change could have a number of impacts on different ecosystems across the globe, from tropical rainforests to marine ecosystems. One of the likely impacts of anthropogenic global climate is the effect it could have on sea-level rise. Different scenarios regarding sea-level rise during the 21st century are presented within the scientific community, from worst cases such as one meter to less than 25 cm. Distinct regions across the globe could be affected by sea-level in such a manner that likely impacts on ecosystems and human societies could have an adverse effect on the economy of states that are dependent on a number of ecosystems for economic survival. Yet, as the climate change is raging on, a great deal of uncertainty is apparent with respect to the causes and effects of global climate change and especially sea-level rise. This uncertainty is apparent in the number of scenarios that are presented by scientists on the matter.

1. Introduction

Predictions of sea-level rise due to global climate change, and in particular by global warming, are at the forefront regarding the controversy of the climate change discourse. This chapter will take a look at the event of possible global warming and the impact it could have on sea-level rise. Because most of the planet's freshwater resources are captured in ice caps and ice sheets it is expected that global warming would thaw the ice contained in the polar regions of the world to such an extent that will be brought on eustatic sea-level rise. Yet, with a great number of variables at work in the weather

patterns of the world there is also much uncertainty regarding this hypothesis. The chapter will first study the possible impacts of global warming on sea-level rise, with a number of variables at work in the equation. In the second part, a cursory glance will be given to the impacts of sea-level rise on ecosystems and human settlements. Specific reference will be made to two regions of the world that are facing likely sea-level rise, both situated within the developing spheres of the world economy. The possible impact of sea-level rise on individual countries in these two regions will be presented to show how sea-level rise could have different impacts on human societies.

2. Global Warming and Sea-level Rise

The world contains a defined amount of water. This volume of water cannot be increased or diminished, either by environmental or anthropogenic influences. Because water is found at any moment in all its different states - vapor, liquid, solid forms - a large proportion of the earth's surface is covered with ice. These surface bodies of ice are mainly located near the Polar Regions, where the temperature is low enough to keep water in its solid state. The ocean surface is mostly in liquid state but the Arctic Ocean and some parts of the ocean around Antarctica have a cover of sea ice that is often topped with snow.

Not only is water in its solid state found on the surface of the ocean, but it can also be in this state on land surfaces. Greenland and Antarctica is almost entirely covered by an ice sheet. These ice sheets are enormous plates of ice which can measure thousands of meters in thickness. For instance the Greenland ice sheet covers an area of about 1.7 million km² —almost seven-eighths of the entire island. Only a narrow strip of mountainous coast is not covered by ice. The Antarctic ice sheet, on the other hand, covers an area of around 13 million km². This ice sheet is thicker than the Greenland ice sheet and can be up to 4 000 m thick. This makes Antarctica the largest global store of freshwater. Both these ice sheets are elaborated on large, elevated land masses in high latitudes. The North Pole, like its southern counterpart is also covered by ice—floating in the vast Arctic Ocean. Sea ice does not exceed 5 m in thickness, while an iceberg may be hundreds of meters thick.

These vast areas of the earth that are covered by ice contain therefore a large volume of water. If this large amount of ice should change from solid to liquid state, this huge amount of water, or at least some part of it, could be released into the oceans. For this to take place a significant amount of energy would be needed. In other words, there should be a shift in global temperatures from the current rate to higher temperatures.

It has been mooted that, due to anthropogenic activities and mainly via industrialization, deforestation and agricultural activities, the earth's greenhouse effect is being accentuated. The assumed greenhouse effect is supposedly caused by mainly industrialization and its related emissions (77%) on the one hand, and by land use changes (23%), comprising of deforestation (9%) and agricultural methods (14%), on the other. Furthermore this could eventually lead to climate and climate related changes in the earth/atmosphere environment. The expanding intensification of greenhouse gas concentrations, most notably carbon-dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFC's), over the 20th century or so, is inducing the

atmosphere's greenhouse effect to be seriously altered, which is supposedly leading to global warming. This presumed global warming could have as one of its effects an impact on the rise of sea-levels, due to a warming of high latitude regions in which most of the world's ice is found. The change in the enhanced greenhouse effect is anthropogenic in origin. Since the start of the industrial revolution around the middle of the 18th century, industrial and other human activities have been increasing and with it the combustion of fossil fuels (such as coal, oil and natural gas), which produce greenhouse gases. The problem of an enhanced greenhouse effect was first postulated in the 1960s, when it was expressed that greenhouse gases were accumulating in the atmosphere at an ever increasing rate. The climatic response to the increased greenhouse effect is determined by ways of highly complex General Circulation Models (GCMs), assuming that there is twice as much atmospheric CO_2 concentration as there was in pre-industrial times.

The mean annual temperature of the earth/atmosphere environment has risen by about 0.5°C over the 20th century. According to reports from the Intergovernmental Panel on Climate Change (IPCC) in 1990, and confirmed in 1995, the global average temperature will rise by about 2.5°C, with a range of 1.5°C to 4.5°C, depending on which GCM is used. Although this change in the temperature is connected to increased volumes of greenhouse gas emissions, it is highly speculative at this point in time. This uncertainty is due to the natural temperature changes from location-to-location, day-to-day, and season-to-season, as well as uncertainty regarding modeling. Although there is still much speculation about the impact of an enhanced greenhouse effect on the world's climate, some scientists believe that such an influence is inevitable and that a significant warming of the world's climate will occur by the 21st century. Because the world's climate temperature rose by about 0.5°C during the 20th century, there was an appreciable rise in sea levels across the entire globe of about 10 and 15 cm. There is much controversy surrounding the impact of global warming on sea-level rise. Yet, in 1992 the IPCC forecasted a sea-level rise ranging from a low scenario of 8 cm to a high scenario of 29 cm by the year 2020. Other scientists have concluded, with much uncertainty, that a number of worst case scenarios could present themselves within the 21st century regarding sea-level rise. Some have gone so far as to suggest that eustatic sea-levels will rise by as much as 4.5 m by 2100. A more optimistic conclusion, also fraught with uncertainty, is that sea-levels could rise by about one meter by 2050 and by 1.2 m by 2100.

Evidence of an apparent rise in sea-levels and global warming is currently being extracted from a wide range of regions across the entire globe. For instance, it is said that the annual melt season of ice in Antarctica has become up to three weeks in 20 years; that Mount Kilimanjaro, in Central Africa, has lost 75% of its ice cap since 1912 (the ice of Africa's tallest mountain peak could vanish entirely within 15 years); that Lake Baikal in Siberia now freezes for the winter 11 days later than it did a century ago; that Montana will lose all its glaciers in Glacier National Park by 2070 if their retreat continues at the present rate; and that Venezuelan mountaintops had six glaciers in 1972, while today only two are remaining. Some of these geophysical changes in a number of environments, most notably ice melt, can have an impact on sea-levels. Yet, other factors are also attributed to sea-levels rising. For instance, a one meter rise in sea-level in some countries like Bangladesh would be due to a 70 cm rise because of

subsidence from land movements and removal of groundwater and 30 cm because of global climate change (global warming). In others if sea-levels would rise, most of it would be due to factors other than global warming in some regions.

Notwithstanding global warming, a great number of variables can have an influence on the level of the sea at any place, for instance glacio-isostatic rebound, tectonic uplift and subsidence. In fact some scientists claim that it is impossible at this stage to establish that sea-levels are rising or to differentiate them from local sea-level shifts due to present data and analytical tools available. For instance there are claims that sea-levels are rising in the Bangladesh delta coast at 1 mm per year. Yet, this figure is only an extrapolation of IPCC estimates of eustatic sea-level swelling. It is claimed that global warming is expected to change sea-levels essentially by glacial melting and the expansion of surface waters through the thawing of ice sheets, sea ice and Arctic and Antarctic glaciers. This seems to be a plausible and logical explanation regarding the linkage between sea-level rise and global climate change. Although the IPCC predicted a rise in sea-levels of between 8 and 29 cm before 2020, it is envisaged that by 2100 the eventual increase in sea-level is expected to vary between 0.50 m and 1.5 m, with a mean increase of 67 cm. If global warming is more severe than predicted an increase of about 5 m in sea-levels can be anticipated; however this would only be likely if the West Antarctic ice sheet thaws and slides into the ocean. There is still substantial uncertainty in the increase of sea levels, as with an expansion in global temperatures. Some of the estimates made since 1983 by a number of scientists range from 0 to 350 cm, on top of the estimates made by the IPCC.

The reason for this uncertainty in the wax of sea levels could be due to the uncertainty surrounding temperature rise, as well as to different model estimates for the amount of sea-level rise because of melting of glaciers and small ice caps. Another reason for the inherent uncertainty in sea-level rise in many locations around the world is the deficiency of accurate and reliable measurements. Sea-level rise could therefore be a by-product of a number of variables of which global warming through the mechanisms of thermal expansion of water and melting of mountainous and polar ice sheets and glaciers is but one. There is therefore also an intrinsic uncertainty attached to global warming and its impact on sea level rise, because of this great number of variables at work. This uncertainty is very significant in the global climate change debate and subsequently with respect to sea-level rise as an outflow of global warming. There is recognition that Atmosphere Ocean Global Change Models (AOGCM) are intrinsically uncertain and that regional climate change models have an additional element of uncertainty built into them. Therefore, the science of global climate change continues to be filled with uncertainty, which is the only certainty.

Yet, a number of actors in the world have started to bring what seems like scientific evidence to the table in order to prove the impacts of anthropocentric global climate change on sea-levels, amidst this high level of uncertainty. These actors range from environmental interest groups, states that would be adversely affected by sea-level rise, humanitarian agencies, the press and members from the epistemic community (scientists). The impacts of sea-levels rise are also made public by such actors. In the next section a glance will be taken at these consequences.

3. The Effects of Sea-Level Rise on the Environment and Human Society

Because of much uncertainty regarding the effects of global warming, due to a number of reasons like the inadequacy of GCMs, there is also some unpredictability with respect to the likely impacts of sea-level rise on ecosystems and human society. Notwithstanding this uncertainty, there still is considerable interest regarding the issue. The unreliable assessment of the impact of sea-level rise on ecosystems and human settlements can only go so far as to say that in the event of sea-level rise a number of socio-economic, political and environmental implications will be felt across the entire globe, especially along the coastline of the various continents.

Yet, these socio-economic, political and environmental effects will be felt differently across different spectrums of the global economy. For instance, the impacts of sea-level rise could be the same for developed and developing countries, although the capacity to deal with the problem will vary among the rich and poor states in the global political economy. For poor states the means to find financial resources to offset the likelihood of sea-level rise will be an extremely debilitating venture, for these states do not have the means to rectify even the current environmental problems. This will be the likely scenario for these states, except in the event of sea-level rise in the distant future; developing countries have developed to such an extent that mitigation strategies will be implemented without having much repercussions on their economies. Such a scenario is strengthened in a world where state power is measured by the economic output of a society. At present this seems highly unlikely especially when the debt crisis of developing countries and their weak economic status are taken into consideration.

Take Bangladesh as an example. A description of Bangladesh as a sovereign independent state usually focuses almost exclusively on the abject poverty the country is experiencing. Bangladesh is at present one of the poorest states in the world, with a gross national product (GNP) of only $ 220 or only one quarter of the average for all developing countries. Around 84 % of its 126 million people live in absolute poverty. In 1988 the 21 % of the rural population of about 100 million people were absolutely landless while 47 % of the rural inhabitants were functionally landless (less than 0.2 of a hectare per household). The state finds it ever more difficult to feed the population. In a situation like this it would be difficult to offset sea-level rise, a situation that could become very threatening for Bangladesh, a low lying country already at the mercy of cyclones and a host of other environmental concerns, like siltation of the Bengal Delta and arsenic contamination of groundwater resources. To make matters worse, if global warming sets in, accompanied by sea-level rise, Bangladesh may have a population density that will be five times that of the densest developed state, the Netherlands.

With speculation aside; what will the likely impact of sea-level rise be, in the event of global warming and subsequent sea-level changes, on human society and the natural environment? A general overview of the likely impacts of eustatic sea-level rise will be in order at this stage to come to grips with this question. Due to the uncertainty attached to anthropocentric global climate change and possible eventual sea-level rise these impacts are but mere hypotheses of what is likely to happen, and should not be seen as real events happening in the future.

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Biographical Sketch

Richard Meissner received his training as a political scientist at the Rand Afrikaans University (RAU) in Johannesburg. He obtained a Magister Artium (M.A.) degree in Political Studies from the same university in 1999 and is currently busy with a D.Phil. in International Relations at the University of Pretoria (UP). He was one of the first students in South Africa to complete a Master's thesis on water politics.

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