THE IMPACT OF EL NIÑO ON WATER RESOURCES

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Summary

El Niño - a natural weather phenomenon occurring in the Pacific Ocean when warm waters of the western coast of South America replace the colder nutrient rich waters - can cause severe impacts on the weather patterns of the world. These shifts in weather patterns can subsequently have an impact on the distribution of freshwater resources on a global scale. These impacts range from droughts in some parts to floods in others. These impacts can also have trickle down effects on the economies of society, like a lowering in agricultural production with a related stunned economic growth, especially in developing economies. However, in the developed regions of the world these natural disasters associated with El Niño can cause damage amounting to billions of dollars. To mitigate these effects governments usually put in place a number of mitigating strategies when an El Niño event is on the cards. These measures can go a long way to offset the impacts of El Niño events on economic sectors reliant on freshwater resources.

1. Introduction

Although there is much uncertainty about the long term impact of global warming on the distribution of freshwater resources around the globe, the El Niño event is one weather phenomenon that can be predicted with greater certainty. The impacts of this weather event can also be ascertained to a large extent as El Niños have occurred in the past and historical records and scientific studies have mitigated the uncertainty to a large measure. Future El Niños can be a precursor to climate change, due to the release of greenhouse gases and subsequent global warming.

In this chapter this weather phenomenon will be studied in order to find out what is El Niño and other related climatic events such as Southern Oscillation and La Niña. This will be the focus of the first part of the chapter. In the second part a closer look will be taken at what the effects of El Niño are on weather patterns around the globe. In the third section of the chapter the impacts of El Niño on the freshwater resources of the world, and the economic sectors this precious resource sustains will be scrutinized. This will be done in accordance with the world-wide impact El Niño has on weather patterns. Two major El Niño events of the twentieth century will then come under the magnifying glass: El Niño 1982-83 and El Niño 1997 with their related impacts on weather patterns, water resources and societies at large. Due to the negative impacts an El Niño event can have on weather and ultimately water resources, the last part of the chapter will be dedicated to the political responses of the South African government on El Niño 1997. This is important because there seems to be a paucity of information on the political implications of El Niños, especially on the side of the natural sciences.

2. El Niño-Southern Oscillation (ENSO) and La Niña

At the end of each year ocean surface temperatures become warmer along the coasts of Peru and Ecuador. For the local residents of these two states, and especially among the fishermen, this event is referred to as El Niño, which means “the Child”, and occurs around the end of the fishing season. The warming of sea surface temperatures is so called, because of the timing of the event - near Christmas. El Niño is therefore the word that connotes the coming of the Christ child. Every two to seven years a much stronger warming of the ocean’s waters appears. This is marked by anomalously warm ocean surface water, not only along the coast of Peru and Ecuador, but most of the tropical Pacific Ocean. This irregular, although natural event, of the abnormal warming of the sea surface temperatures has become known as the El Niño, named after the weaker warming of the sea surface. The El Niño event occurs when there is an absence of the upwelling of cold water along the coast of western South America and the overlapping of the cold Peru Current by nutrient poor warm water, a weaker South Pacific anticyclone, south-east trade winds, intensification of the Hadley cell over the Pacific Ocean and an abnormal southward shift of the intertropical convergence zone (ICZ) into the northern parts of Peru and southern Ecuador. El Niño events occurred in 1877, 1891, 1911, 1925, 1940 to 1941, 1957, 1965, 1972 to 1973, 1976, 1982-83, 1986 to 1987, 1991 to 1992, 1993, 1994 and 1997. This record shows the irregularity of the El Niño event taking place during the global weather calendar since 1877. Prediction of the event is therefore quite difficult. Yet, El Niño events have had different intensities, and evolved differently in the past. The 1982-83 and 1997 El Niño events were the most intensive on record.

El Niño was, although being a part of the global weather system for as long as there has been weather, only discovered in the 1960s by scientists. When an El Niño event does not occur, trade winds blowing west drive warm sea surface waters to collect in the western part of the equatorial Pacific Ocean. The difference in the sea-level in the Pacific Ocean in the region of Australia and Indonesia is about one meter higher than the sea surface along the coast of western South America. This causes heavy rainfall over Indonesia and northern Australia. This acts as an energy cell releasing heat, which keeps the western Pacific Ocean’s atmosphere warm. This in turn helps steer the jet stream from northern Asia to California and beyond. In the event of the El Niño rearing its head, the trade winds weaken, or may even reverse. Warm surface waters (around Indonesia and north of Australia) and the accompanying clouds move east taking the rain from some regions of the Pacific Ocean and displacing it elsewhere in the ocean. The jet stream moves further south and the result is exceptionally high rainfall over parts of Peru and Ecuador.

El Niño is intimately related to the global atmospheric oscillation, known among meteorologists as the Southern Oscillation (SO). During an El Niño event lower than normal pressure can be perceived over the eastern portion of the tropical Pacific Ocean, and higher than normal pressure is found over Indonesia and northern Australia. This pattern of pressure is associated with weaker than normal near-surface equatorial east-to-west winds. These amenities demarcate the warm phase of the SO, which is often referred to as the El Niño/Southern Oscillation (ENSO) phenomenon. The El Niño and SO are therefore in a way inextricably linked with each other when an El Niño event rears its head in the Pacific Ocean. An ENSO event is regarded as quasi-cyclical, which occurs every 2 to seven years and can last for up to 18 months. An exception to this cyclic pattern was the El Niño which began in 1991 and continued until early 1995.

The ENSO is a large-scale natural wavering of the global climate system, which is brought on by the interactions between the atmosphere and the ocean and more specifically the Pacific Ocean. El Niño is the oceanic component of the ENSO event, while the SO refers to the alterations in atmospheric pressure between the eastern and western parts of the Pacific Ocean. The SO is also in common parlance referred to as the see-saw effect. When a high pressure occurs over the Pacific Ocean there, low pressure system prevails over the Indian Ocean from Africa to Australia. Studies that have been conducted during the 20^{th} century indicated that the SO involves more than a see-saw with respect to the surface pressures between the South-east Pacific high pressure zone and the North Australia-Indonesian low pressure zone. The SO is regarded as one of the most important features of interannual climate alternation on a world-wide scale. Over the tropical Pacific Ocean the SO is related with significant variations in rainfall, sea-surface temperature, and the intensity of the trade winds blowing across the Ocean. The strength or intensity of ENSO is measured by two indicators: the Southern Oscillation Index (SOI) and sea-surface temperatures. Sea surface temperatures are observed in an area known as Niño3, where ENSO appears most strongly.

The pressure wavering that is associated with these variables in sea surface temperature is measured by changes in the SOI. The SOI is the variance in atmospheric pressure between Tahiti and Darwin, Australia, which represents the changes in pressure over the entire Pacific Ocean. An El Niño event has positive sea surface temperature anomalies in the eastern part of the Pacific Ocean and a negative SOI. La Niña events have exactly the opposite attributes.

A number of physical changes occur during the development of an El Niño event. Sea-level pressure drops in the eastern Pacific Ocean and increases in the western part over Indonesia. This is ushered by modifications in the strength of the trade winds over the equatorial Pacific Ocean, and at times in their direction. Sea surface currents of the

Pacific Ocean and their thermal configuration also change. These physical changes can be observed, but it is not certain how an ENSO ensues. Because of the close interaction between the ocean and the atmosphere, it is not known which system triggers a response for an ENSO to start.

The ENSO phenomenon has two distinct phases. The one is the El Niño event, and the other is the La Niña - the girl - event. La Niña displays opposite characteristics of the El Niño phenomena with a marked cooling of the Pacific Ocean surface along the coast of Peru and Ecuador. La Niña is therefore sometimes referred to as the cold phase of the ENSO event with El Niño being called the warm phase. La Niña does not get the same media and scientific attention that the opposite - El Niño - because this phenomenon displays extreme conditions of normal weather conditions and tends to have fewer adverse impacts on the globe's weather. Be as it may, El Niño events do have an affect on the weather patterns of the world. These effects differ from region to region and also in the intensity of the climate variability, such as droughts and floods.

El Niño is a typical example of how dynamic the earth/atmosphere environment actually is. As a large scale, global phenomena, it indicates how the circulation patterns of the ocean and atmosphere are linked and interact.

3. Impact of El Niño on the World's Weather

Because of the interaction between the sea surface and atmosphere during an ENSO event, an alteration of the climate on an almost world-wide scale occurs. The strongest influence on the climate is mostly felt in the subtropical and tropical regions of the globe. There is an increase in world-wide average temperature of a few tenths of a degree Celsius, although other regions experience a drop in temperatures. During ENSO events the normal patterns of tropical precipitation and atmospheric circulation are disrupted.

The abnormally warm waters in the equatorial region of the Pacific Ocean bring about enhanced cloudiness and rainfall in that region, especially during the boreal winter and spring seasons. Rainfall is reduced at the same time over Indonesia, Malaysia, Philippines and the northern stretches of Australia. Studies that have been conducted on ENSO events revealed that precipitation and temperature anomaly patterns are highly consistent from one ENSO to the other. With a reduction in rainfall over parts of South east Asia, drier than normal conditions are also observed over south-eastern Africa and parts of northern Brazil, during the northern winter season. During the northern summer season, the monsoon rainfall over India tends to be less than normal, especially in the north-western Indian sub-continent. Higher than normal rainfall is observed along the west coast of South America, and at sub-tropical latitudes of North America (the Gulf Coast region) and South America, particularly over southern Brazil to central Argentina.

During a warm event winter, mid-latitude low pressure systems tend to be more vigorous than normal in the region of the eastern North Pacific. The opposite takes place in the southern hemisphere where there is a tendency for high pressure systems to persist. The low pressure systems in the northern hemisphere give rise to abnormal warm air to flow into western Canada, Alaska and the extreme northern parts of the

United States. Storms tend to be more intense in the Gulf of Mexico and also along the south-east coast of the United States, which gives rise to wetter than normal conditions. In the southern hemisphere there is a tendency for drier than normal conditions because of the persistence of high pressure cells over land areas such as Southern Africa.

Rainfall is more abundant in low pressure zone with lower precipitation occurring in areas overlaid by high pressure systems. There is therefore a major impact by El Niño on precipitation patterns across almost the entire globe, with other related disruptions in wind patterns and temperature shifts.

These variables all work together in an interdependent manner to give rise to abnormal weather conditions in many regions, with the most likely impact being felt on the distribution of water in such regions.

One uncertainty that remains regarding future El Niño events is the impact global warming can have on this phenomenon. Will the increase in carbon dioxide and other greenhouse gasses have an impact on the intensity, duration and frequency of El Niño events in the future? One of the arguments put forward to support the impact of global warming on El Niño events is that since 1976, there have been seven El Niño events. Based on records of El Niños dating back about 120 years, one would have expected only five such events since 1976.

The SOI also tended to be negative for extended periods of time. This is expected to occur only one in every 1 100 years. In combination with this argument is that the El Niño of the early 1990s was longer in duration than any other in the history, and occurred three times from 1990 to 1995.

During this period global temperatures did not drop back to normal, as if it were one long El Niño. Some scientists speculated that the frequency and duration of these El Niño events were the direct cause of global warming. Yet, in 1991 Mount Pinatubo, in the Philippines erupted which released millions of tonnes of particles into the stratosphere, that could have had an impact on the global climate; this could not be ruled out as the trigger that caused the onset of this prolonged El Niño event.

One of the factors that hinders efforts to clear up the confusion with respect to the impact of global warming on El Niño, is the inadequacy of computer simulations that are used to study El Niño events and global warming. The computer simulations that are in place to predict the possible impacts on global warming are not aligned to predict changes that occur on the relatively small scales of space and time on which El Niño events operate.

The models regarding global warming also do not simulate certain important aspects of climate, such as the effect of cloud cooling and the feedbacks between the atmosphere and oceans, important variables in the operation of the El Niño phenomenon. Yet, some climate modeling results indicate that the El Niño phenomenon can change its character in accordance with an increase in carbon dioxide levels in the atmosphere. The result is that during an El Niño event moist regions get wetter, while drier areas tend to become parched.

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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.

He was employed by the Political Studies department at the Rand Afrikaans University from 1996 to 1998 as a research assistant. He is currently employed as a research associate by the African Water Issues Research Unit (AWIRU) which he joined in 1999. He was involved in a number of studies regarding the management of national and international water resources in Southern Africa and the Middle East. He has also written a number of articles which were published in accredited journals. His scope of interest lies within the field of water politics and particularly the interaction of diverse actors within the domestic and international domains regarding water resource issues. Richard Meissner is a member of the South African Political Studies Association and the South African Institute of International Affairs.