

Analysing the Impacts of Climate Change Using Fuzzy Associative Memories Model (Fam)

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Abstract- Debating Climate change has become unavoidable as its far reaching impacts are felt almost in all spheres of life. It has affected life on earth beyond imagination and will continue to affect in future. Therefore it becomes our primary concern to analyze its impacts through various scientific models. In this paper we do the same. Section 1 gives introduction to the impacts of climate change and section 2 describes the problem with evidence using data taken from various resources. In section 3, we list some observed impacts of climate change and in section 4, we adapt FAM model to analyses the problem. Section 5 gives conclusions and suggestions from our study.

Keywords: Climate change, Associative memories, Fuzzy associative memories, global warming, green house gas emission, species extinction, migration of species.

I. INTRODUCTION

Climate change has become a global concern now. Everyone is aware that immediate action is needed to make this globe a better place to live. The Earth is becoming rapidly warmer. Twelve of the 13 hottest years on record have occurred since 1995. The vast majority of the world's leading climate experts attribute this warming mainly to a build-up of 'greenhouse' gases (GHG) emitted by human activities, in particular the burning of fossil fuels — coal, oil and gas — and the destruction of forests. Greenhouse gases are so called because they trap the sun's heat in the atmosphere in the same way as the glass of a greenhouse. This man-made warming is causing discernible climatic and environmental changes, such as more frequent extremes of weather, rising sea levels, and melting glaciers and polar ice. In the longer term these changes threaten to cause serious damage to our economies and the environment we depend on, putting the lives of millions of people in danger and causing the extinction of animal and plant species.

The major human contributors to climate change in India can be classified into two groups. The first consists of greenhouse gases such as carbon dioxide, methane, nitrous oxide, and halocarbons. Greenhouse gases are globally mixed pollutants with long residence times in the atmosphere. Their impact on the world is not therefore determined by the source from which they are emitted. Particulate emissions constitute the second group; they do not disperse as quickly and their impacts on the climate are mainly felt in their region of origin. Thus, the climatic impacts of south Asian particulate emissions are felt mainly in south Asia. This distinction is crucial in framing appropriate policies to combat climate change because it means that particulate emissions and their effects are, to a considerable degree, under India's control. In contrast, we emit

only a small percentage of world emissions of greenhouse gases, so our direct influence on their concentrations is small, and international negotiations and agreements have an important role to play in reducing their levels. Although there is considerable uncertainty about the extent to which climate will change, even the most conservative projections lead us to expect substantial reductions in crop yields, rises in the sea level and an increased occurrence of flood and drought conditions. India's poor remain highly dependent on agriculture and, in the absence of creative policies that insure rural incomes and provide alternative livelihoods; increased poverty may well accompany changes in physical geography.

II. DESCRIPTION OF THE PROBLEM

The temperature increase is widespread over the globe and is greater at higher northern latitudes. Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Land regions have warmed faster than the oceans. Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000m and that the ocean has been taking up over 80% of the heat being added to the climate system. New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates similar to those observed in surface temperature. Increases in sea level are consistent with warming.

Global average sea level rose at an average rate of 1.8 [1.3 to 2.3]mm per year over 1961 to 2003 and at an average rate of about 3.1 [2.4 to 3.8]mm per year from 1993 to 2003. Whether this faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend is unclear. Since 1993 thermal expansion of the oceans has contributed about 57% of the sum of the estimated individual contributions to the sea level rise, with decreases in glaciers and ice caps contributing about 28% and losses from the polar ice sheets contributing the remainder. From 1993 to 2003 the sum of these climate contributions is consistent within uncertainties with the total sea level rise that is directly observed. Observed decreases in snow and ice extent are also consistent with warming. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer of 7.4 [5.0 to 9.8]% per decade. Mountain glaciers and snow cover on average have declined in both hemispheres. The maximum areal extent of seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with decreases in spring of up to 15%. Temperatures at the top of the permafrost layer have generally increased since the 1980s in the Arctic by up to 3°C.

III. SOME IMPACTS OF CLIMATE CHANGE

- The polar ice caps are melting, sea levels are rising and glaciers are retreating. Sea level rise threatens the existence of low-lying island states and coastal communities. The complete disappearance of the Greenland ice sheet would raise sea levels by a staggering seven metres. The melting of glaciers is putting people at risk of floods and will deprive them of water resources in the longer term.
- Extreme weather events such as floods, droughts and heat-waves are becoming more frequent, more severe and more costly in some parts of the world. Their impacts include reducing crop yields and thus jeopardising food production.
- Climate change has direct impacts on human health. The summer 2003 heatwave in southern Europe contributed to the premature deaths of more than 70,000 people. Global warming may encourage the spread of tropical diseases such as malaria and dengue.
- Most of the world's endangered species — some 25% of mammals and 12% of birds — may be pushed into extinction over the coming decades as global warming changes their habitats.
- In the long term climate change could threaten regional and international security by triggering conflicts, famines and refugee movements as essential resources become scarce.

IV. ADAPTATION OF FAM TO THE PROBLEM

Let us consider that there are n attributes, say x_1, \dots, x_n , where n is finite, that are associated with the causes of climate change and let y_1, \dots, y_p be the attributes associated with its effects, where p is finite. From the opinion of the experts we choose the following attributes which are causes of climate change.

C₁ – Green house gas (GHG) emissions:

The greenhouse gases are such as carbon dioxide, methane, nitrous oxide, and halocarbons. Greenhouse gases are globally mixed pollutants with long residence times in the atmosphere. Their impact on the world is not therefore determined by the source from which they are emitted. Therefore they serve as a major cause for climate change.

C₂ – Natural factors:

There are a number of natural factors responsible for climate change. Some of the more prominent ones are continental drift, volcanoes, ocean currents, the earth's tilt, and comets and meteorites. When a volcano erupts it throws out large volumes of sulphur dioxide (SO₂), water vapour, dust, and ash into the atmosphere. Although the volcanic activity may last only a few days, yet the large volumes of gases and ash can influence climatic patterns for years. Millions of tonnes of sulphur dioxide gas can reach the upper levels of the atmosphere (called the stratosphere) from a major eruption. Much of the heat that escapes from the oceans is in the form of water vapour, the most abundant greenhouse gas on Earth. Yet, water vapor also contributes to the formation of clouds, which shade the surface and have a netcooling effect. Any or all of these

phenomena can have an impact on the climate, as is believed to have happened at the end of the last Ice Age, about 14,000 years ago.

C₃ – Solid waste management:

When solid waste, from food remnants to chemical by-products from manufacturing, is not discarded properly it can have far-reaching consequences for the environment and its natural vegetation and inhabitants, as well as for public health. Ninety percent of solid waste goes straight to the landfill. If waste is not discarded properly on land, when it rains the waste is soaked and is then carried through the landfill, eventually making its way into the water you may drink. Especially dangerous chemicals are volatile organic compounds, or VOCs, which usually come from household cleaners and industrial solvents used in operations like dry cleaning. These compounds have been linked to everything from cancers to birth defects.

C₄ – Deforestation:

Trees and plants are essential to a stable climate. They help remove heat-trapping carbon dioxide gas from the air by storing it in their leaves, wood, roots and soils. But when trees and plants are destroyed, this stored carbon dioxide is released into the atmosphere, where it contributes to climate change. In fact, deforestation and land use change contributes approximately 20 to 25 percent of the carbon emissions that cause climate change.

C₅ – Water and land pollution:

“In aquatic ecosystems, effects of acidity, nitrogen, and mercury...are well documented,” states the Cary Institute. The effect on lakes is largely acidification which contributes to “eutrophication of estuaries (excess of organic and mineral nutrients causing algae and cyanobacteria to grow quickly depleting oxygen supply for plants and living organisms in water).” Coral reefs in the ocean are dying from water pollutants. Many fish store pollutants in their bodies which affect their reproduction. Fish stocks are crashing because of persistent over-fishing, too.

The following are the attributes we choose from the opinion of the experts as effects of climate change.

G₁ – Migration of species:

One of the major effects of climate change is migration of species. Every living organism defines for itself a living condition in a particular climate. When its livelihood gets affected by that change in climate it migrates from place to place searching for a suitable condition to live.

G₂ – Crop yields:

Climate change is projected to reduce net cereal production by 4% to 10% under most conservative scenario of the International Panel on climate change. Several studies have found a negative correlation between crop yields and poverty rates.

G₃ – Glacier and snowpack decline:

Glaciers the world over are thinning and shrinking as the planet warms. If the earth keeps warming at the current rate,

Himalayan glaciers are likely to disappear altogether in 25 years. More precipitation will fall as rain rather than snow and the greater water run-offs will increase flooding.

G₄ – Sea level rise:

Global warming has been raising the sea level because warm water has greater volume. This will lead to the permanent displacement of millions of people in coastal areas in India, about 3 million for a 1-metre rise.

G₅ –Species extinction:

The IPCC report predicts that 30 to 40% of all species could go extinct if the temperature were to rise by another 2 to 3 degrees Celsius. This may result in a fundamental rearrangement of ecosystems and the effects of this on agriculture are unpredictable.

G₆ –Rise in average temperature:

This is rather an evident effect of climate change. This results in an increase of humidity and creates a suitable temperature for rapid spread of diseases. This also brings about a radical change in monsoons.

G₇ –Spread of new diseases:

New diseases are the fashion now. Climate change has a role in this changing face of human health system. New diseases are discovered everyday and also they spread rapidly than ever before. Using these attributes as rows and columns, we form the characteristic matrix from the opinion of the experts. The related fuzzy matrix M formulated using the opinion of the experts is as follows:

$$M = \begin{bmatrix} 0.8 & 0.6 & 0.6 & 0.9 & 1 \\ 0.7 & 0.7 & 0.8 & 0.8 & 0.9 \\ 0.9 & 0.3 & 0.6 & 0.6 & 0.8 \\ 0.9 & 0.4 & 0.3 & 0.5 & 0.8 \\ 0.8 & 0.2 & 0.1 & 0.8 & 0.6 \\ 1 & 0.4 & 0.3 & 0.8 & 0.7 \\ 0.5 & 0.3 & 0.7 & 0.3 & 0.9 \end{bmatrix}$$

Consider a fit vector $B = (1 \ 0 \ 1 \ 0 \ 1)$

That is, the attributes Green house gas emissions, Solid waste management and Water and Land pollution are taken as ON state of the fit vector. We compute the recalled component by taking the fuzzy inner product of fit vector B with jth column of M^T for each column.

$$M_o B = A = (1 \ 0.9 \ 0.9 \ 0.9 \ 0.8 \ 1 \ 0.9)$$

According to fit vector A we see that the nodes which represent Crop yields, Glacier and snowpack decline, Sea level rise and spread of new diseases have the maximum value 0.9. Taking the resultant A as the fit vector now we calculate the inner product of A with M.

$$A_o M = (1 \ 0.7 \ 0.8 \ 0.9 \ 1)$$

Since 0.9 is the largest value it implies that the priority is given to restrict Deforestation and the next priority should be given to Solid waste management which serves as the root cause of

all pollution. Thus according to this expert the first priority should be given to C₄ and C₃. The next largest value 0.7 is given to natural factors which might lead to climate change. Now suppose we consider another fit vector B₁.

$$B_1 = (1 \ 1 \ 0 \ 1 \ 0)$$

In this fit vector we consider the attributes Green house gas emissions, Natural factors and Deforestation to be in ON state and the other two attributes Solid waste management and Water and land pollution to be in OFF state. We repeat the same procedure as above.

$$B_{1o} M = A = (0.9 \ 0.8 \ 0.9 \ 0.9 \ 0.8 \ 1 \ 0.5)$$

$$A_o M = (1 \ 0.7 \ 0.8 \ 0.9 \ 0.9)$$

The resultant vector is almost the same as that we got from the previous fit vector. This reiterates our result that priority should be given to stop Deforestation, Water and land pollution and also to solid waste management.

V. CONCLUSION

Using the model we suggest that the priority should be given to stop deforestation and immediate steps are needed to protect forests. The model also suggests that priority should be given to effective solid waste management which results in polluting agricultural lands which has direct impacts on the livelihood of all living organisms. We also suggest that blindfolded view toward industrialization has to be rejected to protect our land and water from pollution. Importance should also be given to analyzing the factors which facilitate natural calamities like volcanic eruption.

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