GLOBAL CLIMATE CHANGE AND ITS IMPACT ON SOUTH ASIA

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CERTIFICATE

Certified that the dissertation entitled **"GLOBAL CLIMATE CHANGE AND ITS IMPACT ON SOUTH ASIA"**, submitted by **Ms. PREETY KANOJIA** in fulfilment of nine credits out of the total requirements of twenty four credits for the award of the degree of **MASTER OF PHILOSOPHY (M. Phil)** of this University, is her original work and may be placed before the examiners for evaluation. This dissertation has not been submitted for the award of any other degree of this University or any other University to the best of our knowledge.

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PREFACE

Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations. A worsening of poverty, hunger, ill health and illiteracy and the continuing deterioration of the eco-systems on which we depend for our well being. For two centuries since the age of Englightenment it was assumed that whatever the advance of science, whatever the economic development, whatever the increase in human numbers, the world would go on much the same. It was progress. And that was wanted. Now it is known that this is no longer true. The world has become more and more aware of the growing imbalance between human species and other species, between population and resources, between human kind and the natural order of which they are a part.

In recent years man has been playing with the conditions of the life as he knows on the surface of earth. He has treated the air and the oceans like a dust-bin. He has come to realise that his own activities and numbers threaten to upset the biological balance which he has taken for granted and on which human life depends.

It can be easily paid that the threat to our world comes not only from tyrants and tanks, it can be more insidious through less visible. The danger of global warming is real enough for us to make changes and sacrifices

so that we do not live at the expense of the future generations.

What cannot be denied is the physical evidence of a change in the global climate which alongwith brings about other definite changes on the ecology of this planet and on human beings. Because of the increase in the global temperature there will be a full change of practically everything on the face of this earth which is changeable. The rise in the earth's temperature is brought about through many related factors and this raised temperature gives the earth what is called the Green House Effect.

The climate of the Earth depends on the global radiation balance, that is how solar radiation is scattered and absorbed and thermal infrared radiation is scattered and absorbed and thermal infrared radiation is emitted and absorbed by the Earth's surface and atmosphere. Of particular importance for the radiation budget are radiatively active gases (green house gases) and aerosols. There is a natural green house effect which already keeps the Earth's surface warmer by about $33^{o}C$ than it would otherwise be. Due to human activities the concentrations of these gases have changed in the past decades and centuries to a degree that threatens to seriously perturb the balance between incoming solar and emitted infrared radiation and thus cause to change the global climate. The atmospheric concentration of several green house gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) has

increased since the industrial revolution. Furthermore, Chlorofluoro Carbons (CFCs) which did not exist in the the unperturbed atmosphere have been industrially produced and emitted to the atmosphere in the last few decades contributing to the growing green house effect. Many of these gases have long life times in the atmosphere so that even after a complete stop of man made emissions their concentrations, would decrease only slowly over decades to centuries towards their pre industrial values. From scientific researches it is evident that the earth's atmosphere could warm by anywhere from 1.5 to 4.5 degrees centigrade by the middle of the next century. With unchanged policy it can be assumed that this will lead to a sea level rise of 30 cm to 1.00 m in the coming century. The speed of these changes is two to six times greater than the rate of change of climate in the past ten thousand year. And we can be sure that the ecosystems like forests and coastal regions cannot adapt without large scale damage and socio economic disruption.

The implications of this kind of a change would be that around 8 to 10 million people will have to be moved from coastal regions. There will be serious flooding intense storms and damage to agriculture. Malaria and other tropical diseases will invade parts of northern Europe and cause epidencies there. Mediterranean countries could become semi-desert with severe shortages. Economies will be severely affected millions may face starvation and their

life style may be recked. Africa will be the worst affected with wood supplies for cooking disappearing and deserts advancing. The U.S., Central America and S.E. Asia will suffer droughts. Drinking water supplies will be disrupted. Air pollution in cities will get worse, adversely affecting human health. Northern forests are going to be severely, affected with trees unable to cope with small increases in temperatures and rainfall. Mammals under stress will become extinct as are many plants with small economic niche. Many rivers will dry up or shrink. Activities of the coastal communities will be thoroughly affected, migration will become increasly prevalent bringing with it threats of civil unrest, societal problems,disruption of the economies of the coastal areas. There effects are seen in a much greater effect in the South Asian Region where the countries are more vulnerable because of their low lying surfaces. Their beaches will be more prone to disappearing, their shorelines would receede at an alarming rate. Their economies which as it is are under developed or developing will have more serious threats of getting disrupted. Their occupation of fisheries etc. will suffer and the divide between the rich and the poor area will widen all the more.

In the present study efforts have been made to study the issue of global climate change in context of its magnitude. Attempt has been made to assess the exact magnitude of the climate change, to understand the past present and future of the world in wake of this changing

climate. The causes for the climate change can be understood as mainly the Green House effect which has also been dealt with in this study. The Green house gases, their role in raising the temperatures of the atmosphere and the hydrosphere simultaneously. The ozone depletion which again is a manifestation of the green house effect,the emission of green houses gases which are responsible for the depletion and at some areas a total loss of the ozone layer which protects the Earth's surface from excessive ultra violet radiations of the sun. Another problem and an important issue in the context of the global climate change is that of the Acid Rain. The acid deposition is a major hazard which has created a lot of physical imbalances and which naturally will create a desruption of the balance between man and the physical nature of the earth. Deforestation is a major problem which has led a helping hand to the global warming especially in the tropical areas - An issue which has been made part of the study. The global warming also leads to the reduction and at times extinction of some species of plants and animals which are found in such a great variety on the face of the Earth. This issue of global warming and bio diversity has also been made a part of the study. Floods caused by a rise in the sea level, agriculture which accelerates the emission of green houses gases, are also a part of the work done.

Global climate change is an issue which is not bound by any nation or any individual. it is a common

problem of every one who breathes the air lives on this earth and drinks its water. An international perspective has been taken into view in this context and study has been done to understand what exactly is the world community doing today to understand the threat, to curb it and find out means of combating it, so that an international cooperation be made to work releventessly on cleaning and stabilizing our planet.

One of the biggest manifestations of the global warming is that of the rise in the sea level. An assessment of the global situation is an integral part of any study which is done in this context. Sea level rise has been brought about by the melting of Antarctic and Greenland Ice, the thermal expansion of water and many such reasons. Because of this there has been a major threat of the submergence of coastal areas a threat which if becomes true may bring about a total submergence of small islands under the surface of the water as the increase is said to be between 20 - 140 cm by the end of the 21st century on the basis of scientific experiments and their subsequent predictions.

South Asia is one of the those areas which are under major threat from the rise of the sea level. Efforts have been made in the present work to understand the impact of the rising sea level on the coastal areas of South Asia. An assessment of the risk to the coastal communities - in

the context of their survival threat to their society, their economy, as well as their whole existence. the physical and ecological impacts have been studied in detail and so have their later impact on the human population living in those areas, and which are directly related to the sea as their existence is regulated by the sea in toto.

Sea level rise is predicted to have a lasting effect on the human beings. It will effect their settlement especially in the coastal areas, will lead to migration, extra investments for protections against flooding and storms which is a part and parcel of the rise in the sea level. The Urbanization, the coastal landuse is also a part of the performed study. Sea level rise also raises the question of the survival of ports and tourisms.

When talking of environment and its international regime. One cannot ignore the fact that it will entail the study of the present political arenas of the global community. It has been a major interest for the UN and other governmental, non-governmental and inter-governmental agencies to make effects to understand the causes and the impacts of sea level rise and ways of combating and preventing it. Another aspect of international politics which has been dealt with in this study is that of the fear of scientific colonization. Efforts have been made to assess the reasons for the North South divide on issues concerning every body and also areas where effort for a compromise can be reached.

The study has been concluded with an assessment of the prospects for South Asia. Which needs the maximum amount of attention. A special effort has been made to understand why an unusual amount of stress is being made while talking of South Asia. The prospects include the programms which have already started or are going to be implemented in the very near future for South Asia to also remain on the face of globe as it is.

Education is the key to improving the environment. We must educate people that we have to create a sustainable economy in which we all live off the interest and not the capital. We have to create a conservation as without it a life a humans and other species is not envisaged in later future because the earth cannot provide infinite natural resources or endlessly assimilate our coasts.

However integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystem and a safer, more prosperous future. No nation can achieve this on its own but together we can, in a global partnership for sustainable development.

CHAPTER I

GLOBAL CLIMATE CHANGE ;

AN INTERNATIONAL PERSPECTIVE

Man is as closely related to Nature as he is to himself, because he is a part of it. An outright dependence on nature has been a striking feature of Man's progress through the centuries of his struggle. Since Man himself is a part of Nature he is effected and inturn effects the other constituents, which are as much a part of Nature as man himself.

Climate has from the very beginning regulated Man in practically every aspect of life and has played a very important role in the development of civilizations all around the world. Man's impact on climate began 5000 to 9000 years ago as he was able to alter the environment by burning and felling forest and tilling the Earth[1]. Also in those river valleys - the cradles of ancient civilizations - in arid regions where he learnt to irrigate the soil and produce crops, i.e. vegetation, where previously all but the river was dry, the climate was in some measure altered. But the increase in windspeed in the little forest clearings and the lowering of albedo and raising of relative humidity where crops replaced desert would hardly have any significance beyond the fields. Over irrigated land the incoming energy from the sun and sky is partly used in evaporation, and the air temperature rises less in

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1. H.H. LAMB, Climate: Past, Present and Future, Vol 2, London, 1977, p. 654.

consequence. The latent heat passed into the air in localities is later released as feelable heat when condensation occurs, in cloud and precipitation processes commonly after the air has traveled some thousands of kilometeres.[2] Thus there is a moderating effect on maximum temperatures just over the fields, but little effect concentrated enough to be significant elsewhere.

The most extensive change wrought by man prior to our own times was the gradual conversion of most of the temperate forest zone to crops that is an artificial steppe or savanna. But, although increased windiness and changed evaporation, over deforested ground changes the precipitation regime slightly, according to DROZDOV and GRIGORIEVA (1963), the effect is relatively small where the forest is replaced by other types of vegetation.[3]

Thus until the industrial revolution and probably until the present century, Man had little effect on the climate except on a very local scale. And up to the middle of the present century, outside the limits of urbanised and industrialised areas and away from artificial lakes and irrigated areas. Man's effect on the climate have probably in no case - apart from the output of carbon dioxide been significant in comparison with the magnitude of the natural fluctuations of climate.

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2. Ibid. p. 654.

3. Budyko, M.I., **Climate and Life** (English Edition by D.H. Miller). New York, 1974. p. 508.

Anxieties are, however, reasonably felt, and widely expressed, about the possible imminence of global effects owing to the increasing energy at Man's disposal, the increasing variety of pollutants and his rapidly increasing technical power. Certain grandiose schemes for modifying world climate deliberately, e.g. inducing a permanent warming by abolishing the Arctic ice, with the aim of increasing the total cultivable area of the globe.

Thus a change which has been underway on Planet Earth for billions of years, has accelerated during the last hundred years. And this is because, a single species of life has emerged and multiplied in numbers and activity to a level that has enabled it to acquire the capacity to influence global change - and do so within the lifetime of a single member of the species. A major acceleration in this process has taken place within the last few hundred years as a result of the impact of the explosive development in the understanding and use of matter, energy, life processes and information - and their interaction - on the growth of population and the economy. This development is the handiwork of the scientific and technological enterprise, imposing major responsibilities on those communities to address the consequences of their handiwork.

It is appropriate to examine the phenomenon of global change from a contemporary point of view. The facts are challenging. Population growth in developing countries is stressing environmental carrying capacity, with a

consequent deterioration in the capacity to enhance - or even sustain - a desirable quality of life. Economic growth in developed countries degrades environmental quality, thereby also stressing environmental carrying capacity. In both instances, these stresses are beginning to affect the "global commons" of air and water, with consequences that adversely affect both developing and developed countries.[4] Thus in the industrialised nations when economic production is high, the flow of energy and materials through the manufacturing process had leaks and residues which contaminate the environment. In the developing countries where economic production is correlatively low, the stock of environmental resources is being eroded to meet the needs of a rapidly growing population.

A very strange and important aspect is that of the vast difference in the perspective of the developed and the developing world as far as the responsibility to own up for the dramatic increase in the pace of the Global Climate Change and measures to be adopted to restrain as well as curb it. A fact that must be understood is that The Global Climate Change is global in impact, not in sources.[5] A

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4. Thomas F. Malone, **Global Change in the 1990s Imperatives for Action Global Environmental Change** NATO ASI Series Vol. 1, Ed. by R.W. Corell and P.A. Anderson, Berlin, 1991, p. 9.

5. P. Sudha Rani, **Global Warming and The Emerging Legal Controls,**, Dissertation Submitted to the Jawaharlal Nehru Univ. in partial fulfilment of the requirements for the award of the degree of Master of Philosophy, New Delhi, 1991, p. 4.

problem that is absolutely impossible for either a single nation or a single area to resolve, it seems unreasonable to blame and expect only a few nations and regions to take up the responsibility for wroughting the change and then finding means of restraining and wiping it totally from the face of the Earth, as is expected by the developing world from the developed world and vice-versa. As for example, the Report of the World Resources Institute on emissions of carbon dioxide from various countries pointing to India and China as the major share holders of the responsibility came under criticism in recent times.[6] The questioning of the World Resources Institute figures the authenticity of research do leads one to believe that politics could be a major hurdle in the quest for saving the Earth from a disaster which is as imminent as tomorrow's sun if the present conditions prevail. These climate changes in the wake of the already depleting world resources will naturally lead to magnifying the already prevailing North-South tensions. In fact, environmental tensions are said to be both a cause and consequence of political tensions and international disputes!

A subject that holds the interests of public, policy makers and scientists together and which holds a lot of significance as regards the future of our home planet, is

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6. Anil Agarwal and Sunita Narain, **Global Warming in an unequal world - A Case of Environmental Colonialism**, The centre for science and Environment, New Delhi, 1991, p. 1.

a topic that needs to be studied thoroughly so that the gloomy forecast predicted for the Earth can be changed as much as possible. A constant cleansing by the nature is as much a part of nature as its creations, but because of the overburdening of the earth with ever increasing population and the over exploitation of the natural resources, nature's recycling machinery is showing a definite stress. This has brought many dangerous changes in our surroundings, environment and climate. A few such manifestations of nature's wrath are global warming, rise in the sea level all over the world, green house effect, ozone layer depletion, acid rain, bio-diversity, water shortages, land floods in the most unlikely places, spread of all the diseases, especially the tropical ones to the temperate areas, adverse effects in all possible ways to the human health, many species of animals may become extinct and many other such consequences are a part of the change in the global climate.

All this has set in a flurry of activity in every possible way and has lead to a wide awakening amongst every body, right from the common man to world leaders, and has practically absorbed every possible avenue of research and a through work is underway to save the earth from this imminent disaster which is standing in way of its destruction and simultaneously the destruction of the whole of mankind in years to come.

The idea that Earth and its environment are presently undergoing a change on a time and space scale not previously experienced has recently become the object of great attention by the scientific community, policy makers and the public in general. However, many climate experts think that the atmospheric processes may contribute significantly to this change, few are ready to make categorical predictions about future change. World leaders are putting strong emphasis on the economic and social consequences of altered climatic patterns, making environmental change a major issue in the international organisations.

The need for immediate action is stressed by some who consider that the threats have been sufficiently proved. Others assume a more cautious position, refusing to embark on the adoption of expensive mitigating measures before seeking clear evidence of the menace. In this context, one aspect does, however, draw general agreement, this being the need to expand greatly the scientific knowledge of the basic process that control the global earth system. Scientists' response to this need has been encouraging, as proved by the numerous programmes and other initiatives taken at national level or headed by international organizations.[7] It has become necessary to review the existing international policy

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7. Luis V. Chunha, **International Activity Related to Global Environmental Change** in R.W. Corell and P.A. Anderson, eds., Global Environmental change, NATO ASI Series Vol. 1, Berlin, 1991, p. 17.

framework related to global climate change, as well as the ongoing scientific activities origanised by international organisations, to help in clarifying the role of a work like this.

Several conferences in the recent years have taken place which have provided international policy framework to be considered when dealing with the science of the global climate change. A brief reference is being made below to the initiatives considered most relevant.[8]

a) **VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER (VIENNA, AUSTRIA, MARCH 22, 1985)**

This convention was signed by 20 states and the EEC at a conference convened by the UNEP. The object of the convention was the protection of human health and the environment against adverse effect resulting or likely to result from human activities which modify or are likely to modify the ozone layer.

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8. Ibid. pp. 18-28.

b) **INTERNATIONAL CONFERENCE ON THE ASSESSMENT OF THE ROLE OF CO_2 AND OTHER GREEN HOUSE GASES IN CLIMATE VARIATIONS AND ASSOCIATED IMPACTS (VILLACH, AUSTRIA, OCTOBER 9-15, 1985) AND FOLLOW UP WORKSHOPS (VILLACH, AUSTRIA, SEPTEMBER 28, OCTOBER 2, 1987 BELLAGIO, ITALY NOVEMBER 9-13, 1987)**

The Villach conference held with 29 countries recommended that the governments and inter-governmental organisations should take into account the results of the assessment made in their policies of social and economic development and in their environmental programmes, and should favour the increase of public information effects on the global change issues. This meet was in regard with the assessment of the presence of carbon dioxide in the atmosphere.

c) **MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER (MONTREAL, CANADA, SEPTEMBER 16, 1987)**

This protocol signed by 24 of the 46 countries attending a conference in Montreal seeks to inhibit the production, consumption and trade of ozone-depleting compounds. The compounds are divided into two groups: Group I (certain CFCs) and Group II (specific halons), each subject to different limitations. The protocol also distinguishes between two groups of countries, the more developed with relatively high levels of consumption of the

controlled ozone depleting substances, and the developing countries with relatively low levels of consumption.

d) **CONFERENCE ON THE CHANGING ATMOSPHERE: IMPLICATIONS FOR GLOBAL SECURITY (TORONTO, CANADA, JUNE 27-30, 1988)**

The conference was organized at the initiative of the Canadian government and gathered together more than 300 scientists and decision makers from 45 countries and international organisations. The conference called for urgent work on an "Action Plan for the Protection of the Atmosphere." This Action Plan,. complemented by national actions, had addressed the problems of climate warming, ozone layer depletion, long-range transport of toxic chemicals and acidification.

e) **RESOLUTION OF THE UNITED NATIONS GENERAL ASSEMBLY ON PROTECTION OF GLOBAL CLIMATE FOR PRESENT AND FUTURE GENERATIONS OF MANKIND (RESOLUTIONS 45/53 OF DECEMBER 1988 AND 44/207 OF DECEMBER 1989)**

The resolution urged governments, inter-governmental and non-governmental organizations and scientific institutions to treat climate change as a priority issue, to undertake and promote specific, co-operative action oriented programmes and research so as to increase understanding on all sources and causes of climate change including its regional aspects and specific time frame as well as the cause and effect relationship of human

activities and climate and to contribute as appropriate, with human and financial resources to protect the global climate.

F) INTERNATIONAL CONFERENCE ON SAVING THE OZONE LAYER (LONDON, UK., MARCH 5-7 1989)

This conference was held at the initiative of the United Kingdom in association with UNEP, with the participation of 123 countries and the European Community. The conference was aimed at strengthening support for the Vienna convention and the Montreal Protocol and at the examination of more radical proposals than were contained in those treaties. The conference was meant primarily as an awareness raising exercise, no negotiations having taken place during the event.

e) INTERNATIONAL CONFERENCE ON THE PROTECTION OF THE GLOBAL ATMOSPHERE (THE HAGUE, THE NETHERLANDS, MARCH 11, 1989)

This conference held at the initiative of the French Prime Minister and co-sponsored by the French, Dutch, and the Norwegian governments, produced "The Hague Declaration" which called for the development within the UN framework of a new institutional authority, either by strengthening existing institutions or by creating new institutions. The declaration also called for the creation of an "Atmospheric Fund" to provide "fair and equitable

assistance to compensate countries bearing an abnormal or special burden as a result of decisions taken to protect the atmosphere."

h) **FIRST MEETING OF THE PARTIES TO THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER (HELSINKY, FINLAND, MAY 1-5, 1989)**

The conference issued a declaration of intent for the complete elimination of the production and use of CFCs by the year 2000. The declaration also called for a transfer of technology and of financial aid to Third World countries to enable them to institute alternatives to CFCs.

i) **SUMMIT OF THE GROUP OF SEVEN INDUSTRIALISED COUNTRIES (PARIS, FRANCE, JULY 14-15, 1989)**

By including in its final statement related to environmental issues, the Summit clearly expressed a strong interest in the environment, with particular attention being devoted to global climate change issues.

j) **INTERNATIONAL CONFERENCE ON GLOBAL WARMING (NOORDWIJK, THE NETHERLANDS, NOVEMBER 6-7, 1989)**

The conference issued a declaration calling for a freeze in the CO_2 emissions as soon as possible and to be set at levels to be considered by the IPCC and the Second World Climate Conference.

k) **WHITE HOUSE CONFERENCE ON SCIENCE AND ECONOMICS RESEARCH RELATED TO GLOBAL CHANGE (WASHINGTON DC, USA, APRIL 16-18, 1990).**

This conference which was initiated by the US President sought to add an integrating focus for international thought on global change, by introducing the concept of "Global Stewardship." It also emphasized a new dimension of the international dialogue on global change: that economic analysis and research on broad global change policies and on the consequences of such policies must be integrated with the science of global change.

l) **CONFERENCE ON ACTION FOR A COMMON FUTURE (BERGEN, NORWAY, MAY, 14-16, 1990)**

In this conference was prepared the "Bergen Ministerial Declaration on Sustainable Development in the Economic Commission for Europe Region" covering policies, objective, principles and commitments in support of sustainable development and with particular emphasis on the global aspects.

m) **LONDON SUMMIT (LONDON, UK, JUNE 1990)**

This was basically an amendment of the Montreal Protocol and aimed at establishing a funding mechanism to assist the developing countries into the transition period. Developed countries agreed at London to take all practical steps to transfer technology to the developing countries.

n) **MADRID AGREEMENT ON ANTARCTICA (MADRID, SPAIN, OCTOBER 5, 1991)**

A landmark agreement on Antarctica was signed by member nations of the Antarctica Treaty which banned the exploitation for oil and other minerals on the icy continents to protect the eco-system and also regulates the marine pollution and waste disposal. The agreement bans mining indefinitely and says this cannot be altered until at least 50 years have passed.

o) **EARTH SUMMIT - UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT (RIO de JANEIRO 3-14 JUNE, 1992)**

The historic Earth Summit held form June 3-14, 1992 in Rio de Janeiro was attended by over 115 heads of states or governments. The major achievement was the adoption of Agenda 21, a voluminous 800 pages document that details how countries would go about achieving sustainable development with detailed chapters on the financial principle and mechanisms involved. There are also chapter on technology transfers.

There was also a declaration know as the Rio Declaration) on principles on general rights and obligations on environment protection, initiated by heads of governments at the United Nations conference on Environment and Development.[9]

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9. Darryl D'Monte and Agencies, "Rio declaration adopted," The Times of India. June 15, 1992, pp.1 & 5.

SCORECARD OF THE HISTORIC MEET[10]

During the Earth Summit, success in a limited form was seen in the different treaties signed by the attending nations. Two key treaties were signed by over 150 nations - the treaty on bio diversity and climate change. An agreement signed by the countries on the statement of principles of forestry has been regarded as a major achievement and so has the setting up of the high level commission on sustainable development to monitor the implementation of Agenda 21 by the countries.

As for the funding of the cleaning up of the environment, Japan during the Summit said, it will increase its development aid by 400 million a year to 1.4 billion Germany and France promised to raise their contributions to 30.7% of their gross national products by the year 2000. Some 150 nations signed a treaty that might - if carried out decrease the emissions that contribute to the global warming phenomenon. The nation European community and Japan went further. They promised to limit carbon dioxide emissions which contribute to global warming at the 1990 level by the year 2000.

Although as Pakistan Prime Minister Nawaz Sharrif who is also the chairman of the G-77 nations, said the world

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10. "Score card of the Historic Meet ", The Times of India, June 15, 1992, p. 5.

will never be the same again after the conference, the conference was a giant step towards sustainable development and creation of an ecological and social environment which is safe, harmonious, and clean, it cannot be denied that some stumbling blocks during the conference, left the world to wonder, whether the world really will change for better after the conference. There were serious examples of non-cooperation and lack of unanimity on serious issues like Bio-diversity, a treaty which was to save. Species of plants and animals from extinction which the US refused to sign, even though there was heavy pressure on it from all over the world, and also the global warming treaty to decrease the emissions that contribute to the global warming phenomenon was watering down by the U.S.

The section on atmosphere appeared no close to solution with Saudi Arabia insisting on dropping of world non-renewable source of energy being kept out of the final text. Indian objected to the use of the word safe in clean and sage technologies in the atmosphere chapter in Agenda 21.

The Summit did not take up many relevant issues including toxic wastes, nuclear energy, over population. There was another major stumbling block at the Rio Summit, at the question of funding of Agenda 21[11], the ambitious

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11. Darryl D'Monte, **"Hitch over Agenda 21 funding"** The Times of India, June 8, 1992, pp. 1 & 7.

check-list of environmental measures that need to be taken in the next century. The G-77 group of developing countries has proposed 2000 A.D. as the deadline for the North to pay 0.7% of its gross domestic product as overseas development. The U.S. which now pays 0.23% of its GDP, has opposed any such deadline. There also was a lack of consensus, as to when the funding will be organized. The G-77 wants that the funding should be done according to the wants and needs to the developing countries, as they are the ones who are suffering the precent of the global environmental crisis created by the developed nations, whereas the developed nations have asked for the IMF to regulate the funding. This was then settled over by a midway agreement of the IMF handling the funding in accordance to the committee set up for the purpose, so that the demands of both sides be met.

Expectations from UNCED may not have been fully met but there is a renewed urgency and purpose and determination to work for a more equitable and environmentally sound world order.

SCIENTIFIC PROGRAMMES AND OTHER ACTIVITIES OF INTERNATIONAL ORGANISATIONS

The need for extensive research is understood by all the scientific community and to bring out solid results and methods of curbing the accelerated climate change. Many

governmental and non-governmental organisations have been set up and have made efforts in this regard. The UNEP (United Nations Environment Programme), UNDP (United Nations Development Programme) are some of the environment programmes which are making active efforts and are doing research in this field. Apart from them, Economic Commission for Europe (ECE), the European Economic Community (EEC), the European Science Foundation (ESF), The Food and Agricultural Organisation (FAO), International Social Science Council (ISSC), World Meteorological Organisation (WMO), The Inter-governmental Oceanographic Commission (IOC) -this a part of UNESO, the Scientific Committee on Ocean Research (SCOR) and many other such organisations. Apart from them there are other scientific activities underway which are funded by different organisations such as the World Weather Watch (WWW), World Climate Research Programme (WCRP), World Climate Programme (WCP), World Climate Impact Studies Programme (WCIP) Past Global Changes (PAGES), Integrated Global Ocean Station System (IGOSS), Human Dimension of Global Change (HDGG), Global Environment Monitoring System (GEMS), Global Change and Terrestrial Eco-System (GCTE), European Programme on Climatology and Natural Hazards (EPOCH) and many such activities which have really helped in our understanding the intensity of the accelerated Climate Change and ways and methods to work in our fight against the imminent disaster facing our planet.

CHAPTER II

ISSUES INVOLVED

Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to nuclear war. The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes are already having harmful consequences over many parts of the globe.[1]

This analogy between the consequences of a nuclear war was not made by idealistic, scientifically innocent environmentalists, but by the more than 300 policy makers and scientists from 46 countries, United Nations Organisations, other International bodies, and non-governmental organisations who attended a major international conference sponsored by the government of Canada, which came out with a statement to the effect that it is clearly within our power not only to alter the planet beyond comprehension within a few hours by using nuclear weapons, but also within a few decades by destroying the Earth's life support systems and radically changing the climate by contamination of the air and water with the residuals of production.

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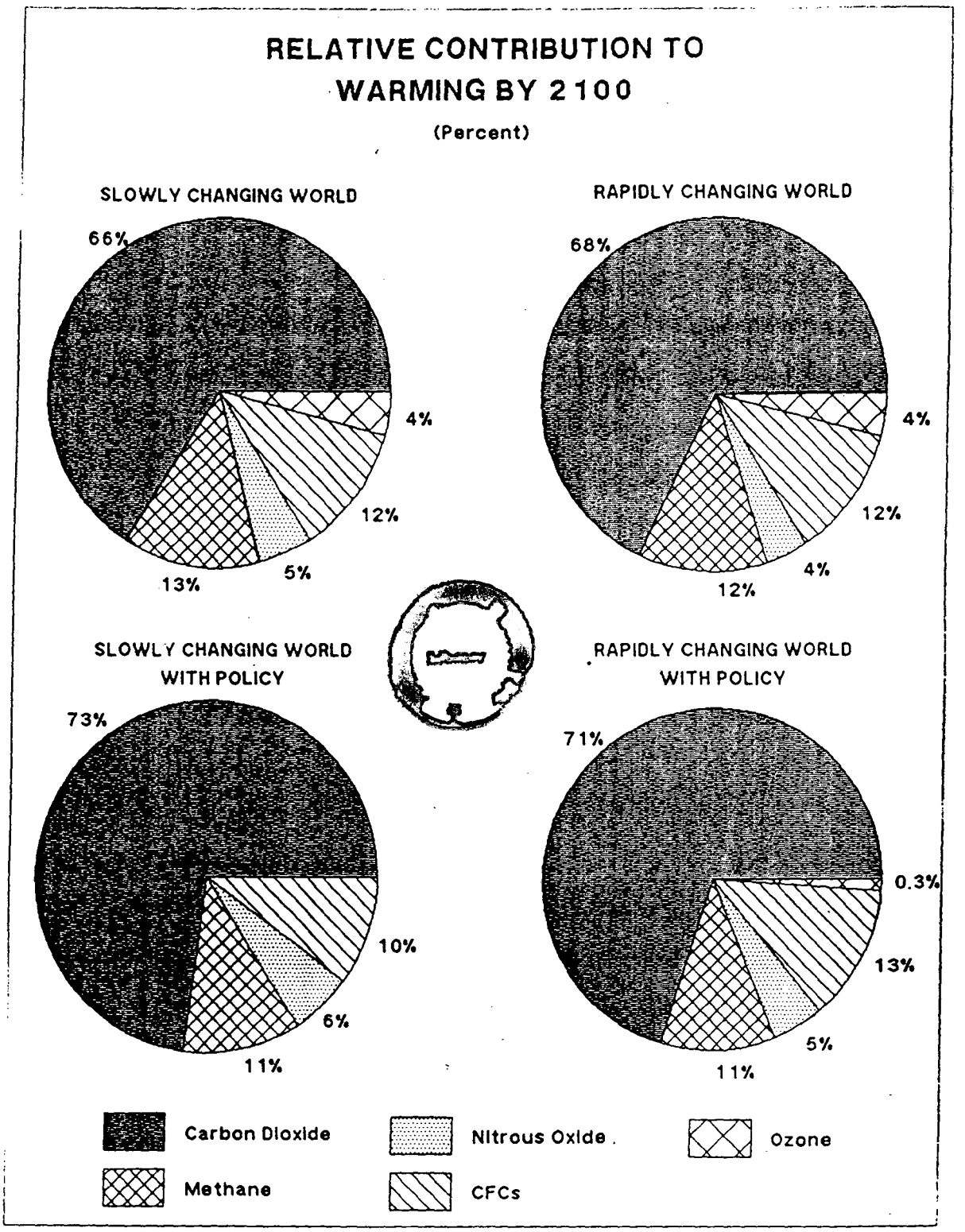
1. Toronto Conference Statement, in Dean Edwin Abrahamson, Ed., The Challenge of Global Warming. p.3. (1989).

Global climate is changing because of the buildup in the atmosphere of Carbon di oxide, methane, nitrous oxide, the CFCs (powerful greenhouse gases as well as destroyers of stratospheric ozone), and other greenhouse gases produced by fossil fuel burning, by deforestation and by producing food for the rapidly increasing population at a global level. Some of the major issues involved in the study of the Global Climate Change are the depletion of the ozone layer, the green-house effect in total, acid rain, deforestation, especially in the tropical regions, biodiversity, floods and many of these kinds of related issues which are directly or indirectly involved in bringing out a climate change of such a high magnitude.

1) Magnitude of the Change

The composition of the Earth's atmosphere is changing. Detailed background atmospheric concentration measurements combined with analyses of ancient air trapped in Antartica and Greenland ice, now give a compelling picture, and also of major changes that have occurred in preindustrial times. Mounting evidence that the atmosphere is changing has increased the urgency of understanding the processess that control atmospheric composition and the significance of the changes, that are taking place.

The first analysis of the effect of increasing Carbon-di-oxide concentrations on global warming was conducted by the Swedish Chemist, Svante Arrhennius (1896).


RELATIVE CONTRIBUTION TO WARMING BY 2100
(Percent)
SLOWLY CHANGING WORLD
66%
4%
12%
5%
13%
RAPIDLY CHANGING WORLD
68%
4%
12%
4%
12%
SLOWLY CHANGING WORLD WITH POLICY
73%
10%
6%
11%
RAPIDLY CHANGING WORLD WITH POLICY
71%
0.3%
13%
5%
11%
Carbon Dioxide
Methane
Nitrous Oxide
CFCs
Ozone

Arrhenius, concerned about the rapidly increasing rate of fossil-fuel use in Europe, recognised that the resulting increase in the atmospheric concentration of Carbon-di-oxide would alter the balance of the atmosphere. Using a one dimensional model, Arrhenius estimated that if the atmospheric concentration of CO_2 doubled, the surface of the planet would warm by about $5^{o}C$.[2]

After Arrhennius many studies were done in order to understand the reasons for the changing global climate and its future repercussions. In 1979, a study by the U.S. National Academy of Sciences (NAS) evaluated the impact on global climate of doubling the concentration of CO_2 relative to the preindustrial atmosphere (NAS, 1979). Dickinson also in his work in 1986 suggests that the effects of a greenhouse gas buildup radiatively equivalent to doubling the preindustrial concentration of CO_2 might warm the planet to a great extent than had previously been expected.

Apart from the studies of the Climate effects of greenhouse gas buildup there have been various studies to the effect of the future Carbon-di-oxide emissions. By the mid-seventies, measurements of atmospheric CO_2 concentrations at Manua Loa begun by Keeling during the

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2. Arrhennius, S. 1896. 'On the Influence of Carbonic acid in the air upon the temperature on the ground'. Phil Mag 41, p. 237.

International Geophysical Year (1967-1958) provided indisputable evidence of a long term increasing trend while the oil embargo of 1973 and the nuclear power debate focused attention on future energy supplies. Thus from then on, many studies were done to the understanding of the subject, like the one done on future energy use conducted by the International Institute for Applied Systems Analysis (IIASA 1981 and 1983). In 1983 two economists Edmonds and Reilley developed a detailed partial equilibrium model to investigate the effects of alternative energy policies and their implications for future CO_2 emissions.[3] In 1983 the National Academy of Sciences completed a Congressionally-mandated study to evaluate, among other things the effects of fossil-fuel development activities authorised by the Energy Security Act of 1980 (NAS, 1983).

In the last few years a number of analysis have investigated the combined effects on global surface temperature of a buildup of CO_2 and other trace gases. The studies related to this effect have been performed by Lacis, (1981), Seidel and Keyes (1983), Ramnathan (1985), Dickinson and Cicerone(1986), Mintzer (1987). More recently, Rotman have performed their study in 1988 in the understanding of the greenhouse warming.

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3. Edmonds, J.A., and Reilley J.M., "A long-term global energy-economic model of carbon-d-oxide release from fossil fuel use". Energy Economics 5, pp.74-88.

All these studies have tried to put before humanity the actual extent and the magnitude of the global climate change which is occurring at such a rapid pace, and which is having so many extra side effects, on the human life. From various studies performed, with various methods as a medium, the magnitude of the climate change has been assessed. Not only will there be a direct change of the climate, but also the magnitude of the effects of that climate change.

The consequences of the global heating which would result if the present release rate of the major greenhouse gases are maintained for only a few decades more, would be catastrophic if our present scientific understanding is even approximately correct, and the resulting climatic change would be irreversible. It is now known that a warming of several degrees, greater than previously experienced in human history, could now occur in a few decades-a time which is short compared with the life-span of a tree or a man. Major changes will result in ecological, economic, and social systems, as all are in delicate balance with the environments which in turn are dependent on the climate. There is scientific consensus that the increase in greenhouse gas emissions will result in climate change. The Council On Environmental Quality, concluded in 1981, that the potential long-term risks of social disruption caused by increased atmospheric concentrations of CO_2 (aside from the other greenhouse gases) are significant. However,

considerable uncertainty exists with regard to the ultimate magnitude of the warming, its timing, and the regional patterns of change. In addition, there is great uncertainty about changes in climate variability and regional impacts. No one can describe the precise nature of these changes in part, because of the technical demands of climate modeling and in part because of the impossibility of predicting the choices which will be made within the next fifty or so years-but change there will be. Although the crystal ball is too cloudy to reveal the details, the general course of climatic change is well understood.[4]

If we allow emissions of CO_2 and the other greenhouse gases to continue unabated, the earth will warm five to ten times faster than it did during the retreat of the last ice age. Many trees cannot migrate much faster than they did as the last ice age. By the time a tree matures enough to produce seeds, the climate will be unfavourable for those seeds to take hold and produce the next generation.

As go the forests, so go the other species, animal and plant, supported by them. The most likely outcome is the extinction of species.[5]

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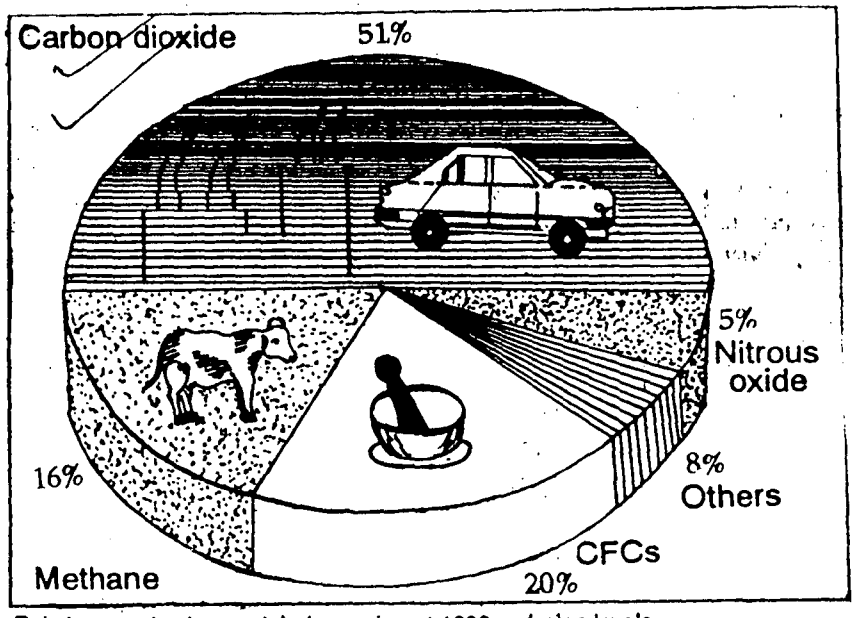
4. Dean Edwin Abrahamson, Global Warming : The issue, impacts, responses, in Dean Edwin Abrahamson, Ed., The Challenge of Global Warming, 1989, p.4.

5. Robert L. Peters, Effects of global warming on biological diversity, in Dean Edwin Abrahamson, Ed., The Challenge of global warming, 1989, p.88.

Contribution to
Relative n Global warming at
1990 emission levels.

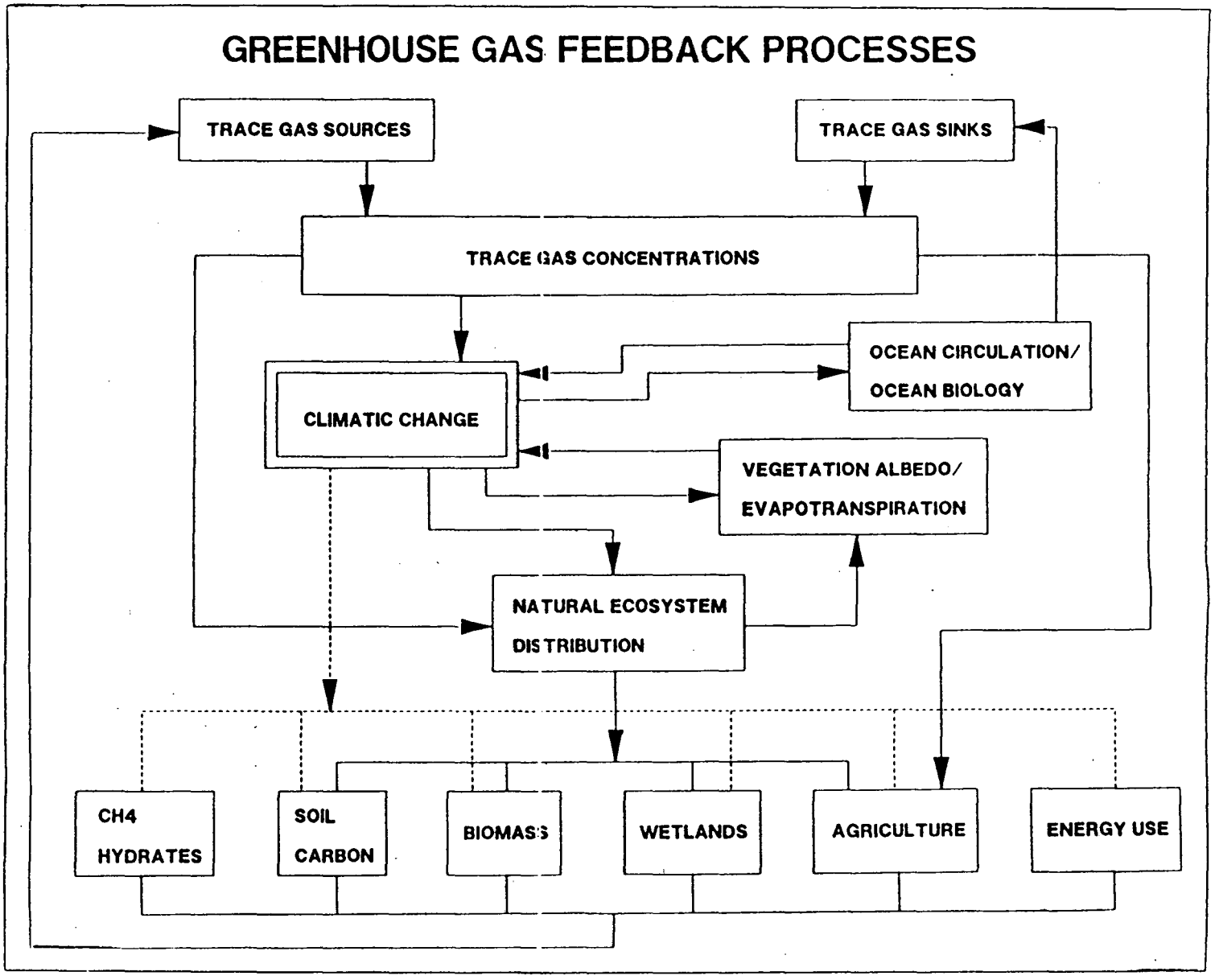


Relative contribution to global warming at 1990 emission levels

Each $1^{o}C$ of global warming will shift temperature zone by about 100 miles. A continuation of present trends in the emission of CO_2 and the other greenhouse gases, is expected to result in the additional global heating of atleast $2^{o}C$ by the 2030. All parks, refuges, and wilderness will affected by warming, by changes in water balance, or by saltwater intrusion.

Continued global heating will also increase sea level by 1 to possible 3 meters within the next hundred years. This sea-level rise would be sufficient to inundate most salt marshes and coastal wetlands, change the character of the Everglades, push barrier islands further towards the present coast, and contaminate coastal aquifers. Reduced summer soil moisture would result in the loss of freshwater wetlands, reduced stream flows, and further lowering of aquifers. The consequences would include loss of wetlands habitat, reduced water quality, and increased concentrations of toxic wastes.

When having the uncertainity of the exact magnitude of the climate change it becomes very necessary to understand the precise nature and magnitude of the factors which bring about this drastic change. Some of these factors have been dealt with in detail below.


GREENHOUSE GAS FEEDBACK PROCESSES
TRACE GAS SOURCES
TRACE GAS SINKS
TRACE GAS CONCENTRATIONS
OCEAN CIRCULATION/
OCEAN BIOLOGY
CLIMATIC CHANGE
VEGETATION ALBEDO/
EVAPOTRANSPIRATION
NATURAL ECOSYSTEM
DISTRIBUTION
CH4
HYDRATES
SOIL
CARBON
BIOMASS
WETLANDS
AGRICULTURE
ENERGY USE

THE GREENHOUSE EFFECT

The 'greenhouse effect', is a natural phenomenon that plays a central role, in determining the Earth's climate. The hot surface of the sun radiates as a body having the equivalent temperature of 5800^{O}K. The bulk of the radiation is in the visible wavelength region, 0.4-1.0m, where the earth's atmospheric gases absorb only weakly. In contrast, the low temperature earth emits radiation at infrared wavelengths for the atmosphere is highly absorbing. In an over simplified description, the atmosphere lets shorter-wavelength radiation in, but does not let the larger-wave length radiation out. By supposed analogy with the behaviour of panes of glass, the effect is called the 'green house effect.' In reality, greenhouses do not depend an trapping radiation for their warmth, but rather inhibit cooling of the plants due to moving air; thus, thin plastic works about just as well as glass.[6]

Although technological advancement in industry and agriculture, have provided extraordinary wealth to a portion of the global population of over 5 billion people, these technologies have the potential to dramatically alter the Earth's climate by causing changes in the composition of the atmosphere. Myriad human activities and continued population and economic growth, raises the prospect of

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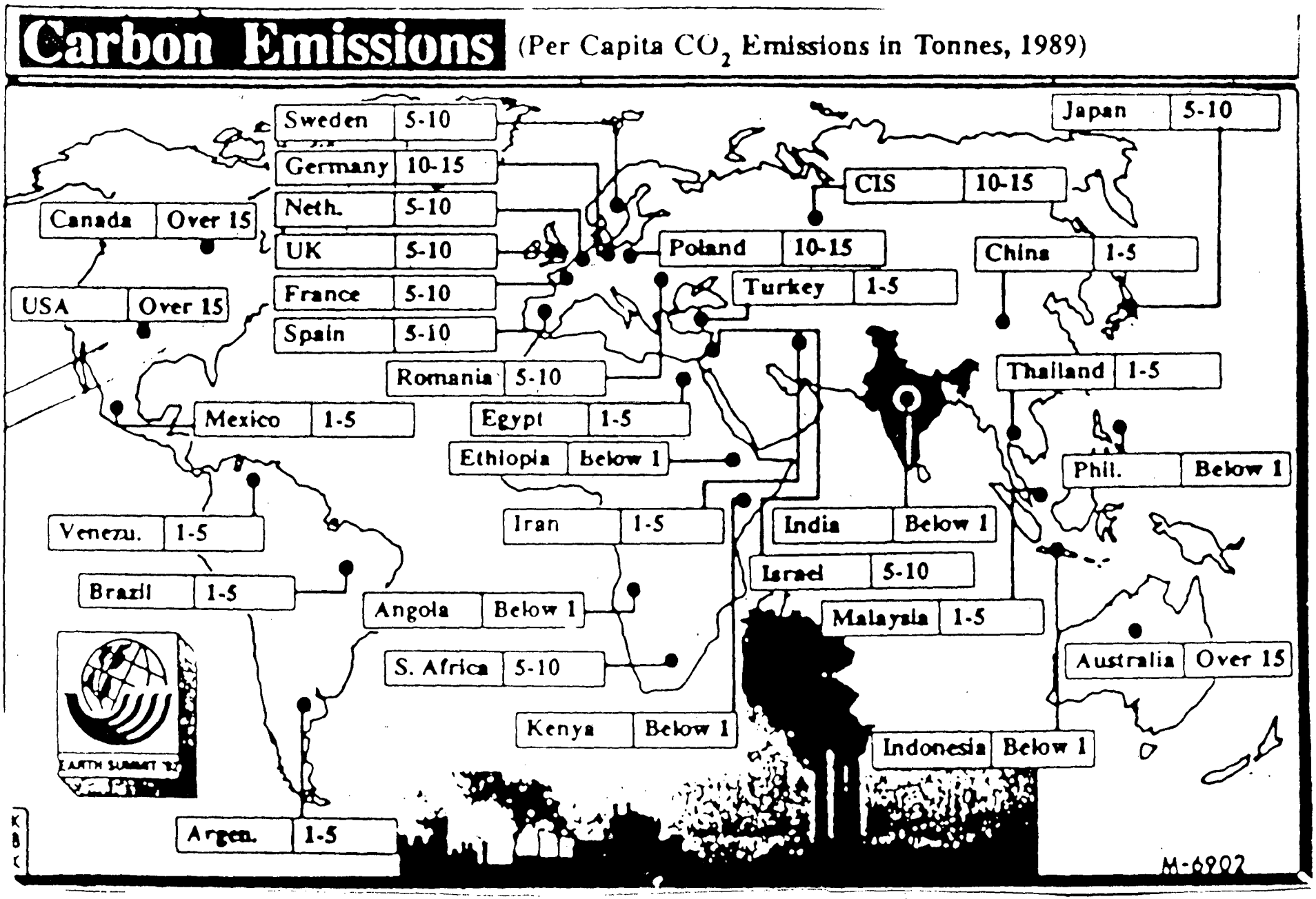
6. Gordon MacDonald, Scientific Basis for the Greenhouse Effect, in Dean Edwin Abrahamson, Ed., The Challenge of Global Warmings, 1989, p.126.


Carbon Emissions
(Per Capita CO_2 Emissions in Tonnes, 1989)
Sweden 5-10
Germany 10-15
Neth. 5-10
UK 5-10
France 5-10
Spain 5-10
Canada Over 15
USA Over 15
Romania 5-10
Mexico 1-5
Egypt 1-5
Ethiopia below 1
Venezu. 1-5
Brazil 1-5
Iran 1-5
Angola Below 1
S. Africa 5-10
Kenya Below 1
Argen. 1-5
Poland 10-15
Turkey 1-5
CIS 10-15
Japan 5-10
China 1-5
Thailand 1-5
India Below 1
Israel 5-10
Malaysia 1-5
Phil. Below 1
Australia Over 15
Indonesia Below 1
EARTH SUMMIT '92
KBC
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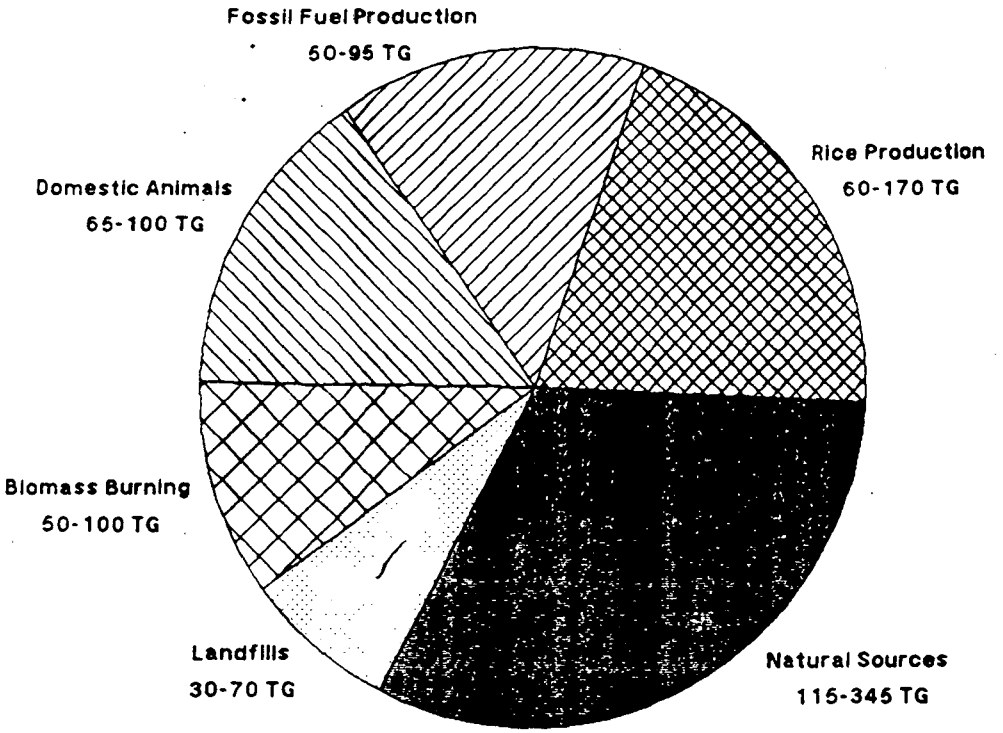
accelerated greenhouse gas building in the future. Global increases in the atmosphere concentrations of Carbon di-oxide,nitrous oxide, methane and chlorofloro carbons are now well documented, perhaps already committing the Earth to significant climate change. In addition to all these changes, tropospheric and stratospheric chemistry are being modified due to the addition of these gases as well as emission of carbon monoxide, nitrogen oxides, and other compound. The increase of the different greenhouse gases have been documented by the United States Environmental Protection Agency, Office of Policy, Planning and Evaluation, in 1989.

- The concentration of carbon dioxide into the atmosphere has increased by 25% since the industrial revolution Detailed measurements since 1958 show an increase of about 35 parts per million by volume. Both land clearing and fossil fuel combustion have contributed to this rise, but the fossil fuel has dominated in recent years. Carbon-di-oxide is increasing at a rate of about 0.4% per year and is responsible for about half of the current increases in the greenhouse effect.

- The concentration of methane has more than doubled during the last three centuries. There is considerable uncertainity about the total emissions from specific sources of methane, but the observed increase is probably due to increases in a number of sources, as

CURRENT EMISSIONS OF METHANE BY SOURCE

(Teragrams)



TOP THREE PRODUCERS

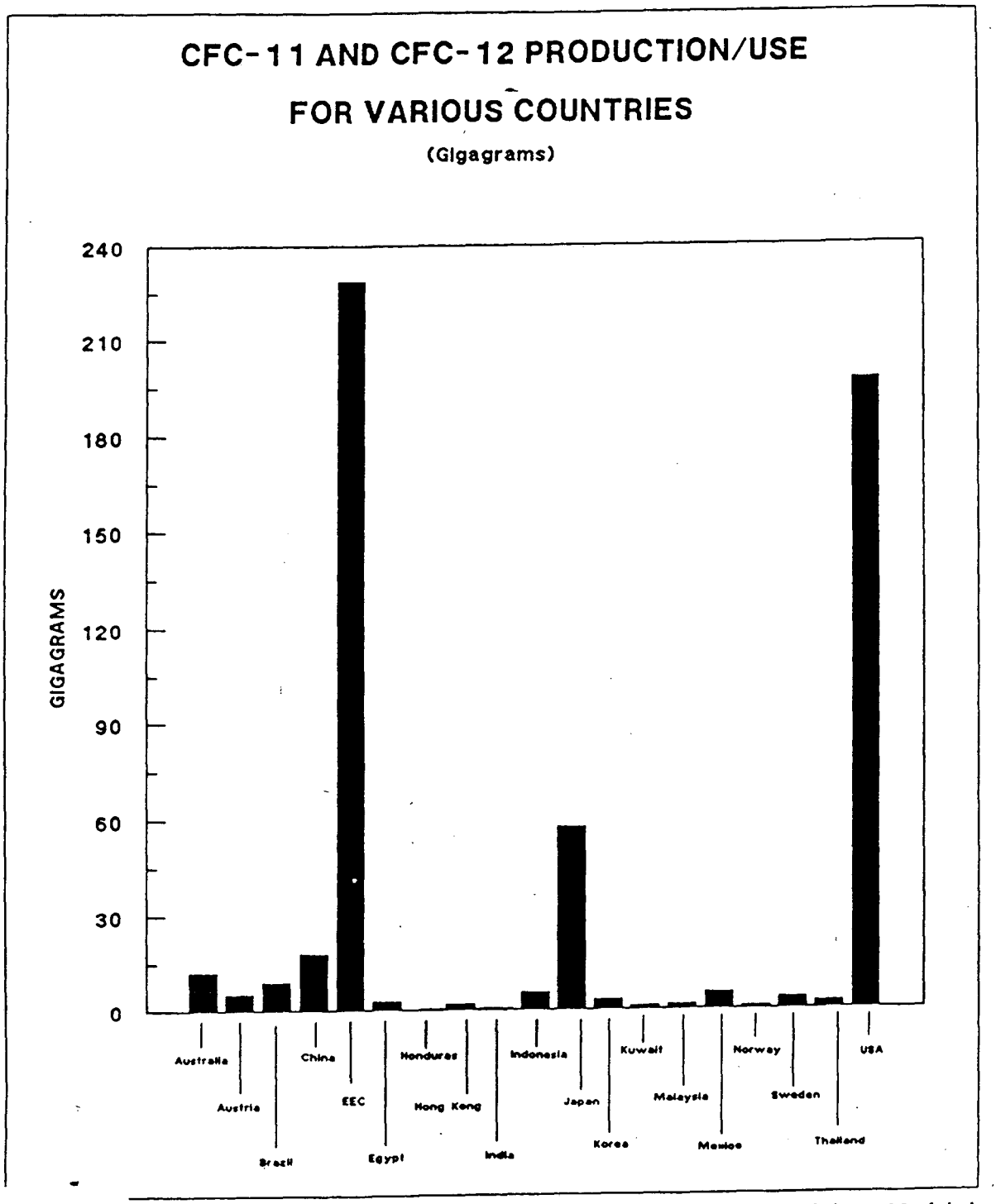
Rice Production	Domestic Animals	Fossil Fuel Production
1. India	1. India	1. United States
2. China	2. USSR	2. USSR
3. Bangladesh	3. Brazil	3. China

Human activities in the agricultural sector (domestic animals, rice production and biomass burning) and the energy sector (fossil fuel production) are the major sources of atmospheric CH_4. Natural sources, from wetlands, oceans, and lakes, may contribute less than 25% of total emissions. (Sources: Cicerone and Oremland, 1988; Crutzen et al., 1986; Lerner et al., 1988; United Nations, 1987; IRRI, 1986.)

well as changes in tropospheric chemistry Agricultural sources, particularly rice cultivation and animal husbandry, have probably been the most significant contributors to historical increase in concentrations. But there is the potential for rapid growth in emissions from landfills, coal seams, permafrost, natural gas exploration and pipeline leakage, and biomass burning associated with forest clearings in the future. Methane is increasing at a rate of 1% per year and is responsible for about 20% of the current increases in the greenhouse effect.

- The concentration of nitrous oxide has increased by 5-10%, since preindustrial times. The cause of this increase is highly uncertain, but it has been understood that the use of nitrogenous fertilizer, land clearing, biomass burning, and fossil fuel combustion have all contributed. Nitrous oxide is over 200 times more powerful, on a per molecule basis, than carbon-di-oxide as a greenhouse gas, and can also contribute to stratospheric ozone depletion. Mitrous oxide is currently increasing at a rate of about 0.25% per year, which represents an imbalance between sources and sinks of about 30%. Nitrous oxide is responsible for about 6% of the current increases in the greenhouse effect.

- CFCs were introduced into the atmosphere for the first time during the century; the most common species are



The EEC, the United States, and Japan accounted for almost 70% of the 1985 global production of CFC-11 and CFC-12. (Source: U.S. EPA, 1988a.)

CFC-12 and CFC-11, which had atmospheric concentrations in 1985 of 380 and 220 parts per trillion by volume respectively. While these concentrations, are tiny compared with that of carbon-de-oxide, these compounds are about 30,000 times more powerful, on a per molecule basis, than carbon-di-oxide as a greenhouse gas and are increasing very rapidly-5% per year from 1978 to 1983. Of major concern because of their potential to deplete stratospheric ozone, the CFCs also represent about 15% of the current increases in the greenhouse effect.

- The chemistry of the atmosphere is changing due to emission of carbon monoxide, nitrogen oxides, and volatile organic compounds, among other species, in addition to the changes in the greenhouse gases already described. This alters the amount and distribution of ozone and the oxidizing power of the atmosphere, which changes the lifetimes of methane and other greenhouse gases. Changes in global ozone are quite uncertain, and may have contributed to an increase or decrease in the warming commitment during the last decade.

THE GREEN-HOUSE EFFECT AND THE STRATOSPHERIC OZONE DEPLETION

An important relationship exists between the causes of the global greenhouse effect and the depletion of stratospheric ozone: the key greenhouse gases fluorocarbons -12 and -11, nitrous oxide, and methane also affect

stratospheric ozone strongly. These gases have atmospheric survival times, long enough to permit them to make the upward journey into the stratospheric ozone layer. In the harsh ultraviolet light there, the flurocarbons are decomposed, yielding chlorine atoms that destroy ozone. Nitrous oxide decomposition yields nitric oxide that acts similarly. Methane acts to slow the attack on ozone, but it also decomposes to yield molecular fragments that are involved in ozone destruction. Interestingly, present models say that chlorine attack on ozone is slowed, somewhat if in the future nitrous oxide and methane continue to increase along with the flurocarbons. The slower decrease of total ozone will result in a redistribution of ozone towards lower altitudes.

Carbon-di-oxide is not involved chemically but once in the upper atmosphere it acts to cool the air by radiating energy to space. This cooling should also act to slow the chlorine attack on ozone a little.

Another connection arises because stratospheric ozone itself can affect temperatures at the surface of the Earth. If, for example, the flurocarbons, nitrous oxide, and methane all increase in the future there should be more ozone present in the lower stratosphere and a warming should occur.

More complicated phenomenon may be occuring over the Antarctica, where spring-time ozone concentrations have decreased greatly in the past fifteen years or so. The same ozone destroying chemicals just mentioned are probably at play but through a more complex pathways. Of all the gases relevant today, the flurocarbons stand out in several ways. Their concentrations in the atmosphere are the smallest, the annual percentage rates of increases are the largest, and their sources are the simplest to understand; they are manmade.[7]

What is so terrible about the depletion of ozone layer is the fact that the increased levels of ultraviolet radiation, while the strtospheric ozone shield thins, will cause a significant rise in the occurance of skin cancer and eye damage and will be harmful to many biological species. Each 1% decline in ozone so expected to cause a 4 to 6% increase in certain kinds of skin cancer. A particular concern is the possible combined effects on unmanaged ecosystems of both increased ultraviolet radiation and climate changes.

Over the last decade, a decline of 3% in the ozone layer has occured at mid latitudes in the southern Hemisphere, possibly accompanying the appearance of the Antarctic ozone hole; although there is more meteorological

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7. Ralph Cicerone, Global Warming, Acid Rain, and Ozone Depletion, in Dean Edwin Abrahamson, The Challenge of Global Warming, pp.236-237. (1989).

variability, there are indications that a smaller decline has occured in the Northern Menisphere. Changes of the ozone layer will also change the climate and circulation of the atmosphere.[8]

ACID RAIN AND THE CHANGING GLOBAL CLIMATE

Although the phenomenon of "acid rain" (more correctly acid deposition) was identified in Manchester, England, as long ago as 1852,[9], and described more thoroughly in 1872, modern scientific research has been going on only since the mid-1950s.[10] Public concern about the problem began in the late 1960s, and arose in North America 10 years ago.[11] Acid precipitation is a mixture of strong mineral acids sulphuric, nitric and in some locations, hydrochloric - in rain and snow, and is usually defined as having a ph of less than 5.6, the value of

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8. The Changing Atmosphere : Implications for Global Security. Toronto Conference Statement, Toronto, Omtario, Canada, 27-30 June, 1988 in Dean Edwin Abrahamson, The Challenge of Global Warming, 1989, p.49.

9. R. A. Smith, "On the Air and Rain of Manchester", Mem. Manchester Lit. Phil. Soc., Ser. 2, 10:207-217 (1852) in Eville Gorham, "Acid Rain : An Overview", in Chandrakant M. Bhumralkar, Ed., "Meteorological Aspects of Acid Rain", 1984, p.1.

10. E. B. Cowling, An Historical Resume of Progress in Scientific and Public Understanding of Acid Precipitation and its consequences, Research Report F R 18180 SNSF Project, Oslo, Norway (1981), p.29.

11. G. E. Likens, F.H. Borman and N. M. Johnson, "Acid Rain", Environment 14:33-40 (1972).

distilled water in equilibrium with atmospheric carbon-di-oxide.[12]

The primary reason for concern is that acid deposition acidifies streams, and takes on coarse, sandy soils low in lime. The effect is seen particularly in headwater areas and in wet montane environments, wherever sulfate loading from anthropogenic sources is strong. In Northern England, several lakes on soils poor in lime were very acid by the 1950s.[13] In southern Scandanavia thousands of lakes and streams in the Adirondacks, Maine, Ontario and Nova Scotia have likewise shown acid stress in recent years and thousands more are threatened, particularly in Canada.

The chemical and physical consequences of lake acidification include, increased leaching of calcium from terrestrial soils, mobalisation of heavy metals such as aluminium, zinc, and manganese, and an increase in the transparency of lakewaters.[14] The biological consequences

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12. E . Gorham, "Atmospheric Pollution by Hydrochloric Acid", Quart. J. Roy. Meterol. Soc., 84:274-276 (1958).

13. E. Gorham, The Ionic Composition of Some Lowland Lake Waters From Cheshire, England, Limnol Oceans g.2:22-27 (1957) in Eville Gorham, "Acid Rain : An overview in Chandrakant M. Bhumralkar, Ed., "Meteorological Aspects of Acid Rain", 1984. p.2.

14. D. W. Schindler, Experimental Acidification of a Whole Lake : A Test of the Oligotrophication Process in Ecological Impact of Acid Precipitation, D. Drablos and A. Tollan Eds. (Oslo, Norway : SNSF Project, 1980) pp. 370-374.

include market changes in communities of aquatic plants and animals, with a progressive lessening of their diversity.[15] In a few extreme cases, a lessening of primary productivity is observed, and there is a progressive elimination of sensitive species of plants and animals, including fish which are completely exterminated under severe acidification.

Many ecologists, believe that over the long term, several decades to a few centuries - acid deposition may further impoverish forests soils, developed on sandy substrata poor in lime. As a consequence of accelerated leaching of nutrients, such as phosphorous, potassium, magnesium and calcium from these soils, forest productivity would eventually be reduced.[16] Acid precipitation can also mobilize heavy metals from pipes into supplies of potable water. Some ground waters have known to become acidified in Sweden.

Moreover, the acid sulfate particles that contribute to acid precipitation are in the size range that penetrates deep into the lung, and they may well exacerbate lung diseases and increase mortality rates.[17]

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15. ibid.

16. G. Abrahamson, Acid Precipitation, Plant Nutrients and Forrest Growth, in Ecological Impact of Acid Precipitation, D. Drabios and A Tollan, Eds., (Oslo, Norway: SNSF Project, 1980), pp 58-63.

17. L.D. Hamilton, "Health Issues", Canada-U.S. Law, J.5:47-50(1982).

DEFORESTATION AND CLIMATE CHANGE

Forests, which store 20-100 times more carbon per unit area than croplands, play a critical role in the terristrial carbon cycle.[18] Each year at least 11.3 million (and perhaps as high as 15 million) hectares of forest are cleared in the tropics.[19] The rate of deforestation combined with the exalting growth in demand for forest products--is such that while 33 tropical countries are currently net exporters of wood products, this no may decline to fewer than 10 by the end of the century. [20] If this trend could be halted and reversed, tropical forests could serve as a vast carbon sink, reducing CO_2 levels.

The causes of deforstation are will known. They include population pressure for agricultural land, the demand for industrial timber production and export, and inappropriate government policies regarding land tenure, economic incentives, forest settlement, and other population issues.

In tropical Africa and in South and Southeast Asia, rapid population growth appears to be the critical

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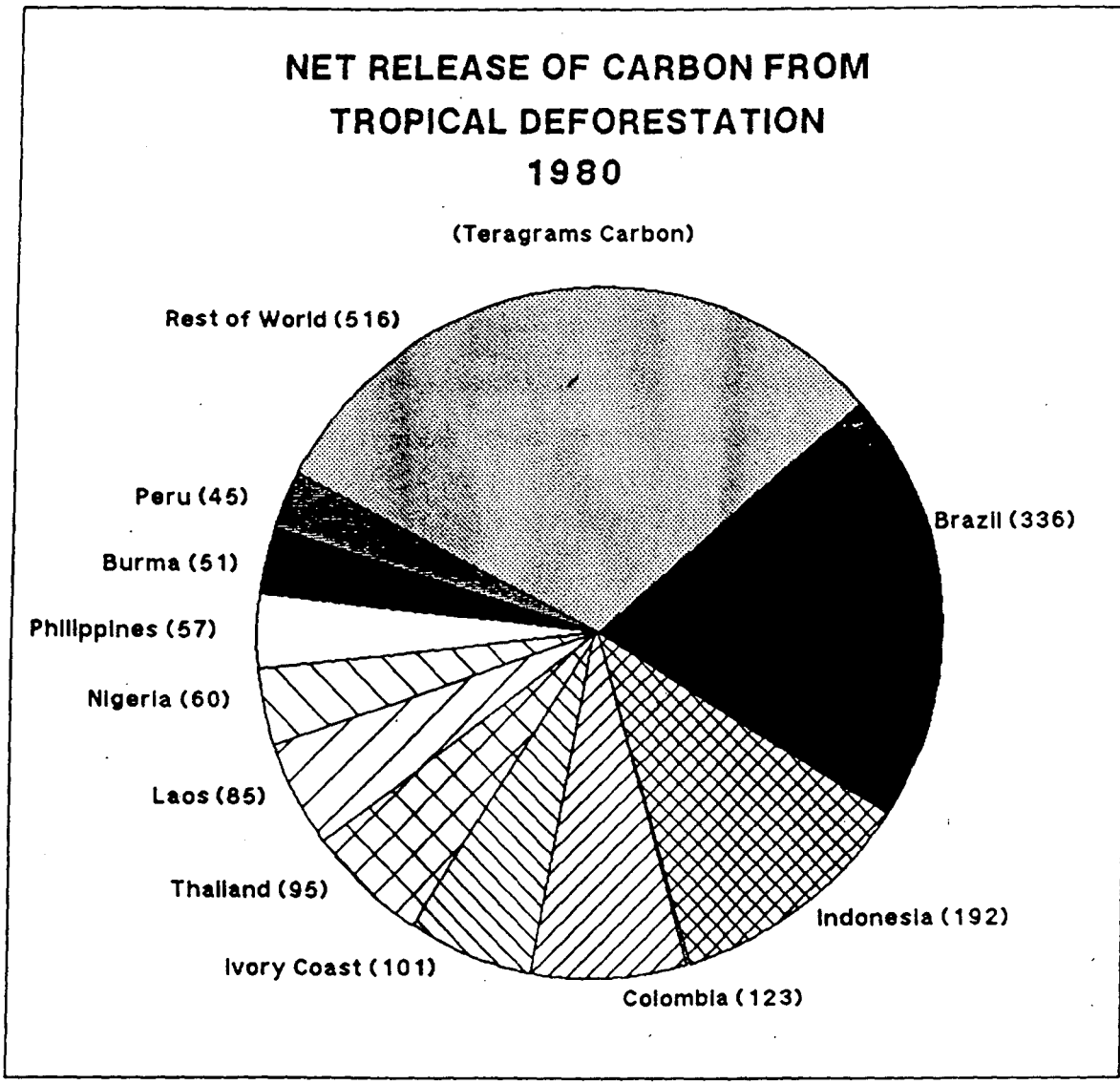
18. R. Noughton, "The Global Carbon Cycle : Letters in Response to Detwiler and Hall, 1988 Science 241 : 1736. (1988).

19. J. Lanly, Tropical Forest Resources, FAO Forestry Paper No. 30, UN Food and Agricultural Organisation, Rome (1982).

20. R. Repetto, The Forest For the Trees? Government Policies and Misuse of Forest Resources, (WRI, 1988).



Tropical deforestation accounts for approximately 10-30% of the annual anthropogenic CO_2 emissions to the atmosphere. Over half of the 1980 CO_2 emissions from deforestation was produced by six countries: Brazil, Indonesia, Columbia, the Ivory Coast, Thailand, and Laos. (Source: Houghton et al., 1987.)

factor affecting deforestation. The majority of the population practices agriculture, and most of the increases in agricultural production necessary to sustain high birth ratio have come from increases in the area under cultivation through deforstation. The Amazon region in Brzil is experiencing one of the highest rates of tropical deforestation in the world.[21] As a consequence, Amazonia is emitting greenhouse gases, at rates and quantities high enough to affect global Co_2 and climate cycles.

GLOBAL WORMING AND AGRICULTURE.

Agriculture contributes to the emission of greenhouses gases through three primary means rice cultivation, nitrogenous fertilizer use, and enteric fermentation in domestic animals. Estimates place the annual contribution of the cultivation and domestic animals at approximately 20 and 15%, respectively of global methane production.

Both the magnitude of agricultural source emissions themselves and the potential effectiveness and costs of possible reduction measures are very uncertain. While considerable research has been done on the agricultural activities of interest, relatively little attention has been focused on agricultural related emissions

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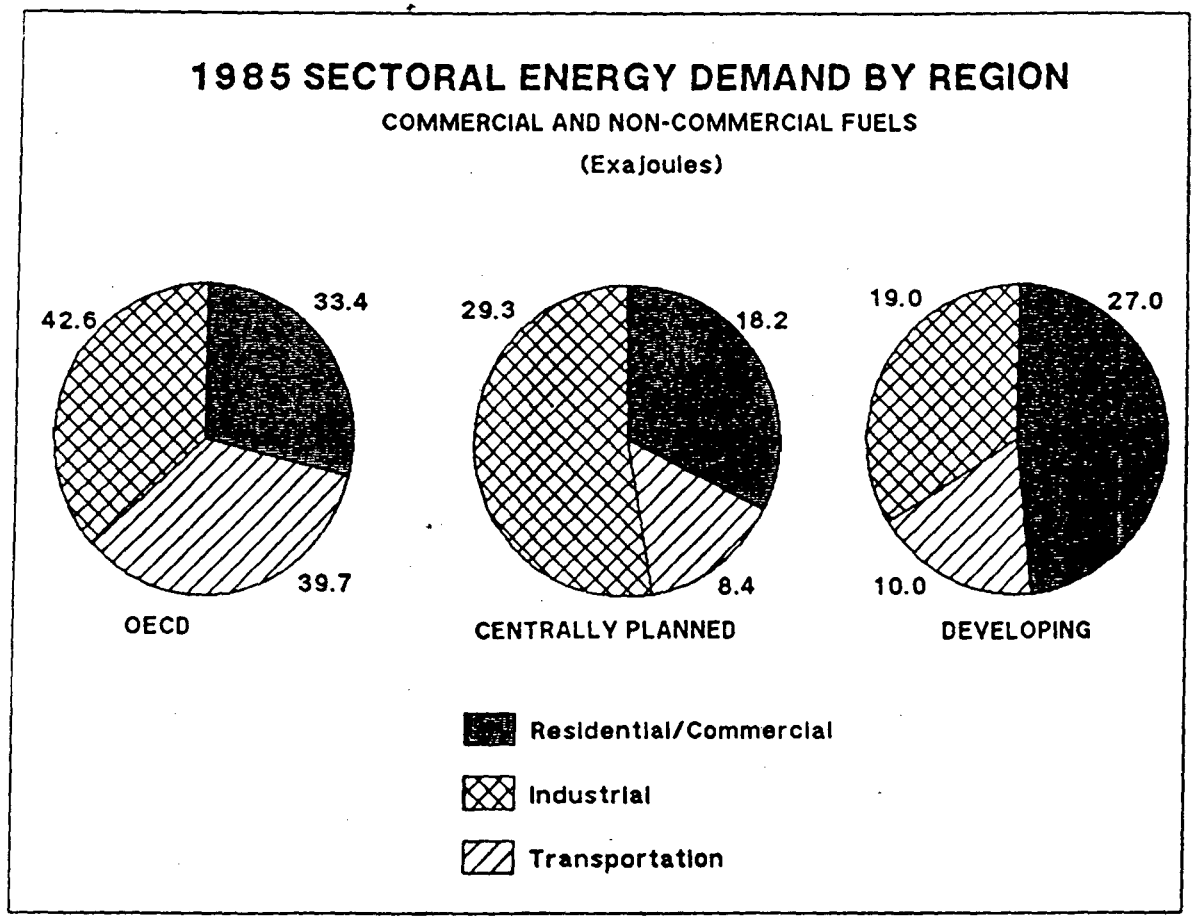
21. P.M. Fearnside, Causes of Deforestation in the Brazilian Amazon, In R. Dickinson, ed., The Geophysiology of Amazonia (1987).



End-use energy demand by sector for three global regions. While energy demand in the OECD countries is split almost equally between the three sectors, over 50% of the energy in the centrally planned countries is consumed by the industrial sector, and almost 50% of the energy in the developing countries is consumed by the residential/commercial sector. (Sources: Sathaye et al., 1988; Mintzer, 1988.)

of greenhouse gases and how various changes in agricultural practices affect these emissions.

It has been found out that emission from all three categories of agricultural practices are expected to increase over 1985 levels: Global CH_4 emissions from rice and enteric fermentation increase abut 35% and 65% respectively, by 20-25; and N_2O emission from fertilizer use are projected to increase by 133% by 2025. By 2100, emissions from rice, enteric fermentation, and nitrogenous fertilizer increase by approximately 40%, 125% and 175%, respectively.[22]

THE GLOBAL CLIMATE CHANGE AND BIOLOGICAL DIVERSITY

Previous natural climate changes have caused large-scale geographical shifts, changes in species composition and extinctions among biological communities. If the widely predicted greenhouse effect occurs, communities would respond in similar ways. Moreover, population reduction and habitat destruction due to other human activities would make it difficult for species to shift ranges in response to changing climate conditions. Human encroachment and climate change could jointly threaten many more species than either alone.

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22. I. Fung, Agricultural emission coefficients estimates, Presented U.S. EPS Workshop on Agriculture and Climate Change, Washington D.C. (February 1988).

It can be inferred, how the biota might respond by observing the world as it is to day. By observing present distributions of plants and animals, which are determined in large part by temperature and moisture patterns, it is possible to hypothesize what would happen if these underlying temperature and moisture changed.

For example, if it is known that one race of the dwarf birch, 'Betula nana' can only grow where the temperature never exceeds $22^{o}C$,[23] then a hypothesis could be made, that it would disappear from those areas where global warning causes temperatures to exceed $22^{o}C$

Observations have led to believe, that, plants and animals are very sensitive to climate. Their range move when the climate patterns change - species die out in areas where they were once found and colonize new areas where the climate becomes newly suitable. It is also known from the fossil records that some species have become completely extinct because they were unable to find suitable habitat when climate change made their old homes unlivable.

Geological stress would not be caused by temperature rise alone. Changes in global temperature patterns would trigger widespread alteration in rainfall patterns,[24] and for many species, precipitation is a more

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23. M.J. Ford. The Changing Climate, (1982).

24. J. Mansen, D. Johnson, A. Lacis, S. Lebedeff, P. Lee, D. Rind, and G. Russell, "Climate Impact of Increasing Atmospheric Carbon-di-Oxide", Science 213:957-966.

important determinant of survival than temperature. Some regions would see dramatic increases in rainfall, and others would lose their present vegetation because of drought.

Other environmental factors would change because of global warming: soil chemistry would change.[25] Increased carbon-di-oxide concentration may accelerate the growth of some plants at the expense of others, possibly destabilizing natural ecosystems. And rises in sea level may inundate coastal biological communities.

One important pattern of global warming, generally concluded by a variety of computer projections, is that warming will be relatively greater at higher latitudes. This suggests that although tropical systems may be more diverse and are currently under great threat because of habitat destruction, temperate zone and arctic species may ultimately be in greater jeopardy from climate change. Also a recent attempt to map, climate-induced changes, in, world biotic communities projects, that high-altitude communities

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25. R. C. Kellison, and R. J. Weir, Selection and breeding strategies in tree improvement programs for elevated carbon-di-oxide levels,In Shands, W.E., and Hoffman, J.S., eds., CO_2, Climate Change, and Forest Management in the United States". Conservation Foundation : Washington D.C. (1986).

could be particularly stressed.[26] Boreal forest for example was projected to decrease by 37% in response to warming of $3^{o}C$.

An issue that was heavily debated in the recently held UNCED in Rio de Janerio, Blo-diversity is one of the major problems that the world faces to-day, that of either a heavy reduction in some of the plant and animal species, or a total extinction of some other plant and animal species, which cannot adapt to this rapid change.

All the issues discussed and many others like them will bring abut many drastic changes on the face of the earth. They would impril human health and well being, diminish global food security, through increases in soil erosion and greater shifts and uncertainties in agricultural production, particularly for many vulnerable regions. They would also change the distribution and seasonal availability of fresh water resources, increase political instability and the potential for international conflict, jeopardize prospects for sustainable development and the reduction of poverty, accelerate the extinction of animal and plant species upon which human survival depends, alter yield,

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26. W. R. Emanuel, H. H. Shugart, M.P. Stevenson, Response to Comment Climate Change and the broad-scale distribution of territorial eco system complexes. Climate Change 7 : 457-460.

productivity, and biological diversity of natural and managed ecosystems, particularly forests.

If rapid action is not taken now by the countries of the world, these problems will become progressively more serious, more difficult to reverse and more costly to adress.

CHAPTER III

SEA LEVEL RISE

For the last several thousand years, sea level has risen so slowly that for most practical purposes it has been constant. As a result, people and other maritime species have had the opportunity to extensively develop the shorelines of the world. Whether one is talking about a vacation sport in Rio de Janerio, swamps in Bangladesh, farmland in the Nile Delta, marshes along the Chesapeake Bay, or the merchants of Venice, life along the coast is in a sensitive balance with the level of sea.[1]

This balance would be upset by the rise in sea level that could result in global warming, which could raise sea level by one meter or more in the next century, by expanding ocean water, melting mountain glaciers, and perhaps eventually causing polar ice sheets to melt, or slide down into the oceans.[2] Sea level rise would inundate low-lying areas, drown coastal marshes and swamps of rivers, bays, and aquifers throughout the world.

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1. James G. Titus. The causes and Effects of sea level rise in Dean Edwin Abrahamson, "The challenge of Global Warming" (1989) pp. 161-162.

2. J. Hansen, A. Zacis, D. Rind, G. Russel, I. Fung., and S. Lebedeff, Evidence for Future Warming: How large and When (1987). in W.E. Shands, and I.S. Hoffman, eds., Co_2, Climate change and Forest Management in the United States. Conservaation Foundation. Washington D.C. (1987).

Causes of Sea-Level Rise.

Past Trends in Sea Level

The world wide average of sea level depends primarily on (a) the shape and size of ocean basins, (b) the amount of water in the oceans, (c) the average density of seawater. Subsidence, emergence, and other locals can cause trends in 'relative sea level' at particular locations to differ from trends in "global sea level".[3]

Hays and Pitman analyzed fossil records and concluded that over the last 100 million years, changes in mid-ocean ridge systems have caused sea level to rise and fall over 300 meters.[4] However Clark et al have accounted for sea level a changes of less than one millimeter per century.[5]

The impact of climate on sea level has been more pronounced. Geologists generally recognize that during ice ages the glaciation of substantial positions of the Northern Hemisphere has removed enough water from the oceans to lower

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3. Titus, n.1, p. 163.

4. S.D. Ways. and W.C. Pitman III, "Lithosphere plate motion, Sea Level changes and climate ecological consequences". Nature, 246: 18-22. (1973).

5. J. A. Clark, W. E. Farrell, and W. R. Peltier, "Global Changes in Post Glacial Sea level: Numerical calculation" Quarternary Research, 9: 265-287. (1978).

sea level one hundred meters below present levels during the last (18,000 years ago) and previous ice ages.[6]

Although, that once covered much of the Northern Hemisphere have retreated, the world's remaining ice covers contains enough water to raise sea level over seventy-five meters.[7] Estimates show that existing alpine glaciers contain enough water to raise sea level 30 or 60 centimeters, respectively. The Greenland and west Antarctica ice sheets each contain enough water to raise sea level about seven meters, while East Antarctica has enough ice to raise the sea level over 60 meters.[8]

There is no evidence that either the Greenland or East Antarctica ice sheets have completely disintegrated in the last two million years. However, it is generally recognised that sea level was about seven meters higher than to day during the last interglacial period, which was one to two degrees warmer.[9]

Tidal gauges have been available to measure the change in sea level at particular locations over the last

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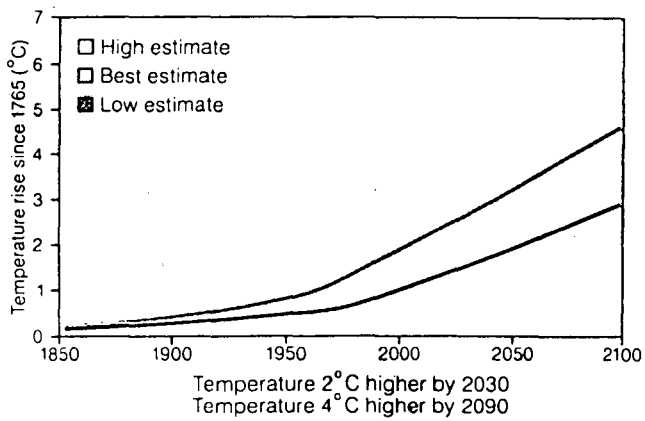
6. Kennette, Marine geology, (1989).

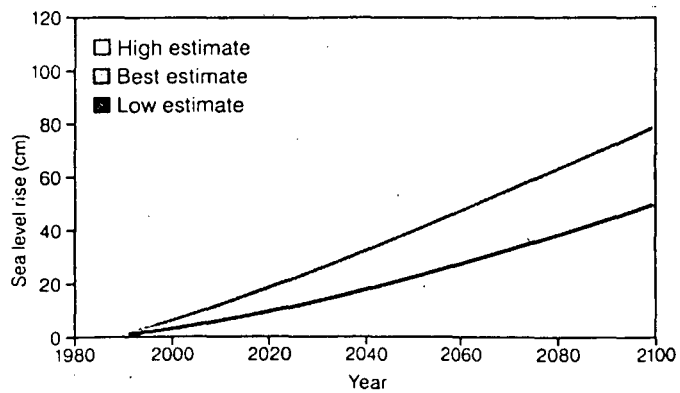
7. J. T. Mollin, and R. G. Barry, "Empirical and theoritical evidence concerning the response of the earth's ice and snow cover to a gloabl temperature increase". Environmental international 2: 437-444. (1979)

8. Ibid.

9. J. H. Mercer, "Antarctic ice and Sangamon sea level", Geological society of American Bulletin, 79: 471. (1968).



Temperature Rise, IPCC Business as Usual Scenario



Sea Level rise, IPCC Business as Usual Scenario

century. Studies combining these measurements to estimate global trends have concluded that sea level has risen 1.0 to 1.5 mm/yr. during the last century.[10] It was found that the rate of sea level rise for the last fifty years would be between 2.0 and 2.5 mm/yr, while in the previous fifty years there was little change; however, the acceleration of the rate of sea level rise was not statistically significant.[11]

Several researchers have attempted to explain the source of current trends in sea level. Barnett[12] and Gornitz, Labedeff and Hansen[13], estimate that thermal expansion of the upper layers of the oceans resulting from the observed global warming of 0.4°C in the last century could be responsible for a rise of 0.4 to 0.5 mm per year. Roemmich and Wunsch[14] examined temperature and salinity measurements at Bermuda, and found, that the 4°C isotherm had migrated 100 meters downward, and concluded, that the resulting expansion of ocean water could be responsible for some or all of the observed rise in relative sea level.

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10. T. P. Barnett, "The estimation of global sea level change: A problem of Uniqueness". Journal of Geophysical Research 89(C5): 7980-7988 (1984).

11. Ibid.

12. Ibid.

13. V. S. Gornitz, S. Lebedeff, and J. Hansen, J. "Global Sea Level trend in the Past Century" Science 215: 1611-1614. (1982).

14. D. Roemmich, and C. Wunsch, "Apparent Changes in the climatic statte of the deep North Atlantic Ocean" Nature 307 : 47-450.

Meier[15] estimates that retreat of alpine glaciers and small ice caps could be responsible for a current contribution to a sea level of between 0.2 and 0.72 mm per year.

Impact of Future Global Warming on Sea Level

Concern about a substantial rize in sea level as a result of the projected global warming stemmed originally from Mercer,[16] who suggested that the Ross and Filchner-Ronne ice shelves might disintegrate, causing a deglaciation of the west Antarctic ice sheet and a resulting six to seven meters rise in the sea level in possibly 40 years.

Subsequent investigations have concluded that such a rapid rise is unlikely-Hughes[17] estimated that such a disintegration would take at least 200 years, and Bentley estimated that it would take 500 years.

Researchers have turned their attention to the magnitude of sea level rise that might occur. The best understood factors are the thermal expansion of ocean water and the melting of alpine glaciers. In the National Academy of Sciences report 'Changing Climate', Revelle estimated

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15. M. F. Meier, "Contributions of Small graciers to global sea leve" Science 226 (4681): 1418-1421.

16. Mercer, n. 9.

17. T. Hughes, The stability of the West Antarctic Ice Sheet : what has happeed and what will happen Conference 820970. Washington D.C. Department of energy. (1983).

Estimated Sea Level Rise (in cm) Through 21st Century

Year	Low	Mid-range low	Mid-range high	High
2000	4.8	8.8	13.2	17.1
2025	13.0	26.2	39.3	54.9
2050	23.8	52.3	78.6	116.7
2075	38.0	91.2	136.8	212.7
2100	56.2	144.4	216.6	345.0

temperature increases at various depths and latitudes resulting from a 4.2°C warming by 2050-2060.[18]

Hoffman, Wells and Titus[19] estimated in 1985, that a warming of between 1° and 2.6°C could result in a thermal expansion of contribution to sea level of between 12 and 26 cm. by 2050. They also estimated that a global warming would result in a thermal expansion of 28-83 cm. by that year. In 1984 Meier[20] estimated that a 2.8mm rise had resulted from warming of 0.5°C and concluded that a 1.5° to 4.5°C warming would result in a rise of 8-25cm in the next century.

Available estimates of the Greenland contribution assume that all meltwater flows into the oceans and that the ice dynamics of the glaciers do not change. The NAS polar Board in 1985 suggested that some of the water would refreeze, decreasing the contribution to sea level rise. Although a change in the dynamics might imply additional deglaciation and increase the rate of sea level rise, the panel assumed that such changes were unlikely to occur in the next century. The potential impact of a global warming on Antarctica in the next century is the least certain of

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18. R. Revelle, Probable future changes in sea level resulting from increased atmospheric Co_2 In changing climate. Washington D.C. (1983)

19. J. S. Hoffman, J. Wells,, and Titus J.G., Future Global Warming and Sea level rise (1986)

20. M. F. Meier, "Contribution of Small Glaciers to Global Sea level" Science, 226 (4681: 1418-1421.

all the factors by which a global warming might contribute to sea level rise. Meltwater from East Antarctica might make a significant contribution by the year 2100.

Future Trends in Local Sea Level

Although most attention has focused on projections of global sea level, impacts on particular areas would depend on local relative sea level. Tidal gauge measurements suggest that relative sea level has risen 10 to 20 cm per century more rapidly than the worldwide average along much of the U.S coast.[21] Local subsidence and emergence are caused by a variety of factors. Rebound from the retreat of glaciers after the last ice age has resulted in the emergence of Alaska and parts of Scandinavia. Groundwater pumping has caused rapid subsidence around Houston, Texas, Taipai, Taiwan, and Bangkok, Thailand, among other areas. River deltas and other newly created land subside as the unconsolidated materials compact.[22]

Although subsidence and emergence trends may change in the future, particularly where anthropogenic causes are curtailed, no one has linked these causes to future climate change in the next century. However, the

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21. S. D. Hicks, H. A. DeBaugh, L. H. Wickman, Sea level variations for the United States, 1955-1980 (1983).

22. S. P. Leatherman, Costal geomorphic responses to sea level rise: Galveston Bay Texus In Barth and Titus (eds) (1984).

removal of ice from Greenland and Antarctica would deform the ocean floors. Other influences on local sea level that might change as a result of a global warming include currents, winds, and freshwater flow into estuaries. None of these impacts, however, has been estimated.

Effect of Sea Level Rise

A rise in sea level of 1 or 2 m would permanently inundate wetlands and lowlands, accelerate coastal erosion, exacerbate coastal flooding, threaten coastal structures, and increase the salinity of estuaries and aquifers.

Submergence of Coastal Wetlands

The most direct impact of a rise in sea level is the inundation of areas that had been just above the water level before the sea rose. Coastal wetlands are generally found at elevations below the highest tide of the year and above mean sea level. Because of common means of estimating past sea level rise has been the analysis of marsh peats, the impacts of sea level rise on wetlands are fairy well understood. For the rates of sea level rise of the last several thousand years, marshes have generally kept pace with sea level through sedimentation and peat formation.[23] As sea level rose, new wetlands formed inland while the

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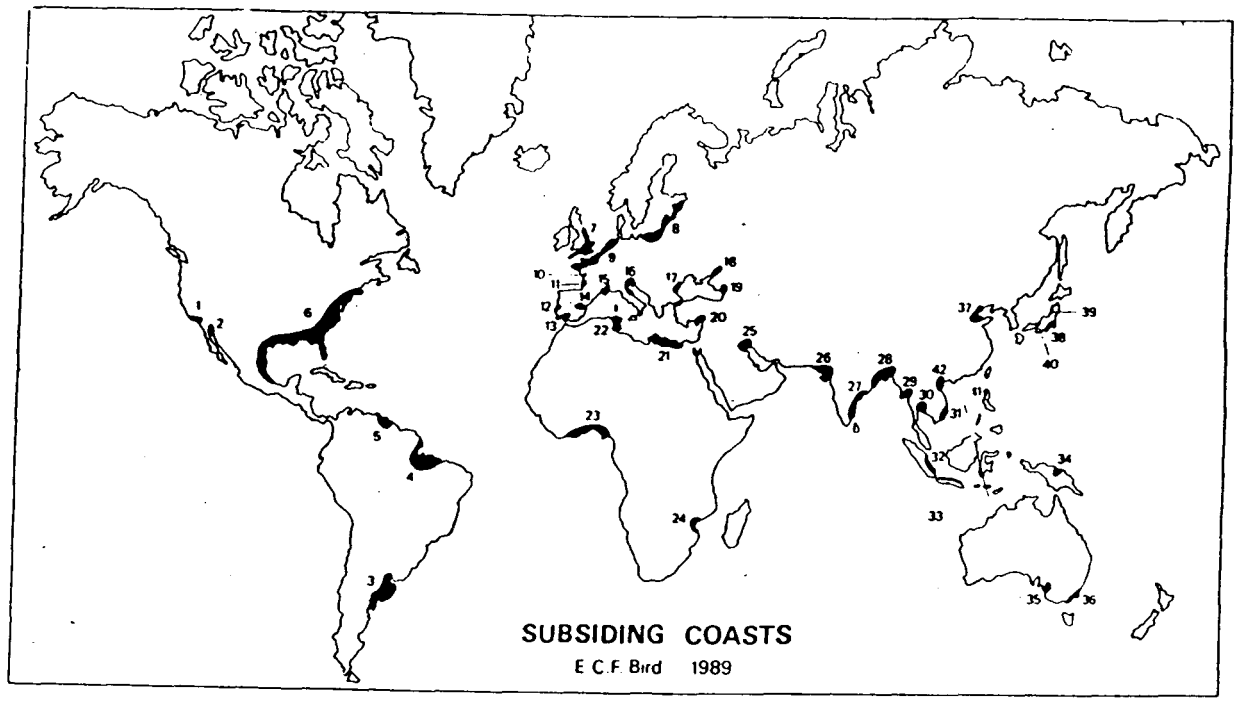
23. K. O. Emery, and E. Uchupi, Western North Atlantic Ocean Memoir, 17 Tulsa. Okla (1972).



Sectors of the world's coastline thought to have been subsiding in recent decades: 1, Long Beach area, southern California; 2, Columbia River delta, head of Gulf of California; 3, Gulf of La Plata, Argentina; 4, Amazon delta; 5, Orinoco delta; 6, Gulf/Atlantic coast, Mexico and United States; 7, Southern and Eastern England; 8 The southern Baltic from Estonia to Poland; 9, North Germany, the Netherlands, Belgium and northern France; 10, Loire estuary, western France; 11, Vendee, western France; 12, Lisbon region, Portugal; 13, Guadalquavir delta, Spain; 14, Ebro delta, Spain; 15, Rhone delta, France; 16, Northern Adriatic from Rimini to Venice and Grado; 17, Danube delta, Rumania; 18, Eastern Sea of Azov; 19, Poti Swamp, Soviet Black Sea coast; 20, South-east Turkey; 21, Nile delta to Libya; 22, Tunisia; 23, Nigerian coast; 24, Zambezi delta; 25, Tigris-Euphrates delta; 26, Rann of Kutch; 27, Eastern India; 28, Ganges-Brahmaputra delta; 29, Irrawaddy delta; 30, Bangkok coastal region; 31, Mekong delta; 32, Eastern Sumatra; 33, Northern java deltaic coast; 34, Sepik delta; 35, Port Adelaide region; 36, Corner inlet region; 37, Hwang-ho delta; 38, Tokyo Bay; 39, Niigata, Japan; 40, Maizuru, Japan; 41, Northern Taiwan; 42, Red River delta, North Vietnam.

seaward boundary was maintained. Because the wetland area has expanded, Titus, Henderson, and Teal (1984)[24] hypothesised that one would expect a concave marsh profile, that there is more marsh area than the area found immediately above the marsh. Thus, if sea level rose more rapidly than the marsh's ability to keep pace, there would be a net loss of wetlands. Moreover, a complete loss might occur if protection of developed areas prevented the inland formation of new wetlands.

Throughout the world, people have dammed, leveed, and channelized major rivers, curtailing the amount of sediment that reaches river deltas. According to Milliman and Meade in 1983.[25] Even at today rate of sea level rise, substantial amounts of land are converting to open water in Egypt and Mexico. Other deltas, such as the Ganges in Bangladesh and India are currently expanding seaward. These areas would require increased sediment, however, to keep pace with an accelerated rise in sea level. Additional projects to divert the natural flow of river water would increase the vulnerability of these areas to a rise in sea level. Several options have been identified for reducing wetland loss due to sea level rise. Abandonment of

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24. T. Titus, Henderson, J. M. Teal, "Sea level rise and wetlands loss in the United States" National wetlands News letters 6:4 (1984).

25. J. D. Milliman and R. H. Meade. "World wide delivery of river sediment to the oceans" Journal of Geology 91(1): 1-21.

developed area inland of today's wetlands could permit new wetlands to form inland. In some cases it might be possible to enhance the ability of wetlands to accrete vertically by spraying sediment on them or restoring the natural processes that would provide sediment to the wetlands.

Inundation

Although coastal wetlands are found at the lowest elevations, inundation of lowland could also be important in some areas, particularly if sea level rises at least one meter. Unfortunately the convention of ten foot contours in the mapping of most coastal areas has prevented a general assessment of land loss. Kana et al in 1984 used data from aerial photographs to assess elevations in the area around Charleston. They concluded that 160 and 230 cn rises would result in 30 and 46% losses of the areas dry land, respectively. Leatherman in 1984 estimated that such rises would result in 9 and 12% losses of the land in the area of Galveston and Texas city. Texas, assuming that the elaborate network of seawalls and levees were maintained.

As with wetlands loss the responses to inundation fall broadly into the categories of retreat and holding back the sea. Levees are used extensively in the Netherlands and New Orleans to prevent the flooding of areas below sea level and could be similarly constructed around other major cities. In sparsely developed areas, however, the cost of a level might be greater than the value of the

property being protected. Moreover even where levees prove to be cost effective the environmental implications of replacing natural shorelines with man-made structures would need to be considered.

Coastal Erosion

Sea level rise can also result in the loss of land above sea level through erosion. Brun in 1962[26] showed that the erosion resulting from a rise in sea level would depend upon the average slope of the entire beach profile extending from the dunes out to the point where the water is too deep for waves to have a significant impact on the bottom (generally a depth of about 10 meters). By comparison, inundation depends only on the slope immediately above the original sea level. Because beach profiles are generally flatter than the portion of the beach just above sea level, the "Brunn Rule" generally implies that the erosion from a rise in sea level is several times greater than the amount of land directly inundated.

As Bird emphasizes,[27] processes other than sea level rise also contribute to erosion including storms, structures currents and alongshore transport. Because sea level has risen slowly in recent centuries, verification of

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26. P. Brunn, "Sea level rise as a couse of shore erosion" Journal of waterways and Harbours Division. (ASCE) 1: 116-130.

27. Bird in J. G. Titus,(ed) Greenhouse effects, sea level rise and wetland loss In impacts of sea level rise on coastal wetlands of United States. (1986).

the Brunn Rule on the open coast has been difficult. However, water levels along the great lakes can fluctuate over one meter in a decade.

Geologists basically believe[28] that coastal barriers can maintain themselves in the face of slowly rising sea level through the landward transport of sand which washes over the island during storms, building the island upward and landward. The potential erosion from a rise in sea level could be particularly important to recreational beach resorts, which include some of the world's most economically valuable and intensively used land. Relatively few of the most densely developed resorts have beaches wider than about 30 m at high tide. Thus the rise in relative sea level of 30 centimeters projected in the next 40 to 50 years could erode most recreational beaches in developed areas, unless additional erosion response measures are taken.

Bird in 1986[29] has stated that in many undeveloped countries, small relatively inexpensive houses are found very close to the shore. Because the value of these houses is less than the cost of protecting them, they must be moved as the shore erodes. An accelerated rise in sea level would speed this process of shoreline retreat.

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28. R. G. Dean and E. M. Maurmeyer, Models for beach profile response In Handbook of coastal processes and erosion. (1983).

29. Bird (n.27).

Flooding and Storm Damage

A rise in sea level could increase flooding and storm damages in coastal areas for three reasons, erosion caused by sea level rise would increase the vulnerability of communities, higher water levels would provide storm surges with a higher base to build upon, and higher water levels would decrease natural and artificial drainage.

In 1984 Leatherman[30] conducted an analysis of Galveston Island, Texas. He estimated that the area within the 100 year flood plain would increase from 58% to 94% for an 88 cm rise in seal level and that for a rise greater than one meter. The Galveston seawall would be overtopped during a 100 year storm. A wide variety of shore protection measures would be available for communities to protect themselves from increased storm surge and wave damage due to sea level rise.[31] Many of the measures used to address erosion and inundation including seawalls, breakwaters, levees and beach restoration also provide protection against storms. In the case of Galveston which is already protected on the ocean side by the seawall might be necessary to completely encircle the developed areas with a level to

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30. S. P. Leatherman. Coastal geomorphic responses to sea level rise : Galveston Bay, Texas In Barth and Titus (eds) (1984).

31. R. M. Sorensen, R. N. Weisman, and G. P. lennon, Control of erosion, inundation and salinity intrusion. In Barth and Titus (eds). 1984.

prevent flooding from the bay side, upgrading the existing seawall might also be necessary.

Increased Salinity in Estuaries and Aquifers

Although most researchers and general public have focused on the increased flooding and shoreline retreat associated with a rise in sea level, the inland penetration of salt water could be important in come areas. In 1986 de de Sylva said that a rise in sea level increases the salinity of an estuary represents the outcome of (1) the tendency for the ocean salt water to completely mix with the estuarine water and (2) the tendency of fresh water flowing into the estuary to dilute the saline water and push it back toward the ocean. During the rainy season low salinity levels prevail. A rise in sea level has an impact similar to decreasing the freshwater inflow. By widening and deepening the estuary, sea level rise increases the ability of salt water to penetrate upstream.

Hull, Thatcher and Tortoriello in 1986[32] examined the potential impacts of an accelerated rise in sea level due to the greenhouse warming. They estimated that 73 cm and 250 cm rises would result in the salt front migrating an additional 15 and 40 kilometers, respectively.

Thus the causes and effects of seal level rise are a matter of grave concern and it is now understood that if

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32. C. G. J. Hull, R. C. Torloriello, and M.L. Thatcher, Salinity in the Delaware Estuary Staff report. (1986).

proper steps to restrict the rise are not taken, then dangerous consequences would result in a magnified way and effect the human life in a very horrific manner. Because it is to be clearly understood that human life would also be affected by the rising sea level, especially of the people in the coastal areas.

Thus it can be concluded that the problems of future sea level rise are important not only to geomorphologists, ecologists, geographers and social scientists, but also to governments and their agencies concerned with planning and management of the coastal regions that will be modified by the changes.

CHAPTER IV

SEA LEVEL RISE AND ITS IMPACT ON SOUTH ASIA

Of late, it has become increasingly clear that man has acquired the power and capability to alter the ecology of this planet adversely. Researchers in the past few decades have clearly demonstrated that urgent attention is needed to reverse this trend. The influence of the oceans, which cover nearly 71% of the earth surface, is of much importance for regulating the climate of this planet. The last decade has witnessed a sudden increase in man's awareness of the oceanic environment, and the slow and progressive deterioration of our seas due to human activity. Any change in this equilibrium of the sea, however, minor it may be, is bound to affect the human population, as 1/5 of the total population is living in the coastal belt of the land mass. Therefore, it is a matter of utmost importance to develop an understanding of the ocean and coastal environment. Moreover, the changes in the sea level is a subject which deserves our immediate attention. The global warming, an important factor for sea level rise, is caused by the release of carbon dioxide, chloroflorocarbon, nitrous oxide and methane in the atmosphere due to human activity. The consequences of sea level rise are far reaching and these result in increased coastal erosion, submergence of coastal wetland, increased damage due to storm surges, shifting of the river mouths and deltas, salt water intrusion into the rivers, etc. In addition, ecological damages include loss of coastal neglalation, loss of

commercial fisheries, destruction of important nursery grounds like the mangroves and extinction of valuable coastal funna and flora.

The most severe impacts are likely to stem directly from inundation. SE Asia would be most affected because of the extreme vulnerability of several large and heavily populated deltaic regions. For example, with a 1.5 m sea-level rise, about 15 per cent of all land (and about one fifth of all farmland) in Bangladesh would be inundated and a further 6 pr cent would become more prone to frequent flooding (UNEP 1989)[1]. Altogether 21 per cent of agricultural production could be lost. In Egypt, it is estimated that 17 per cent of National agricultural production and 20 per cent of all farmland, especially the most productive farmland, would be lost as a result of 1.5 m sea-level rise. Island nations, particularly low-lying coral atolls, have the most to lose. The Maldive Islands in the Indian Ocean would have one-half of their land area inundated with a 2 in. rise in seal-level (UNEP,1989).[2] In addition to direct farmland loss from inundation, it is likely that agriculture would experience increased costs

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1. UNEP, Critieria for assessing vulnerability to sea level rise: a global inventory of high risk areas. United National Environment Programme and the Government of Netherlands Draft. Report. (1989).

2. Ibid.

from saltwater intrusion into surface water and groundwater in coastal regions. Deeper tidal penetration would increase the risk of flooding and rates of abstraction of ground water might need to be reduced to prevent recharge of aquifers with sea water. Further indirect impacts would be likely as a result of the need to relocate both farming populations and production in other regions. In Bangladesh, for example, about one-fifth of the nations population would be displaced as a result of the farmland loss estimated for a 1.5 m sea-level rise.

Historically, the coastal regions around the world, particularly areas near the mouth and along the great rivers have been centres of population concentrations. Trade, commerce and industry have flourished as well because of easy access to the resources of the hinterland and reach of the markets across the oceans. Thus, it is not surprising that a significant portion of the world's population lives within the coastal zone, with many of the cultural artifacts, built at elevations less than 3 m (10 ft) above mean high-tide level along the shore line, even without a change in the height of mean sea level or the height of the land, the elevations of settlements and other artifacts are not adequate to provide safety in the event of extreme storm-surges, etc. The hazard of flooding, erosion, intrusion of saline water in the underground aquifers has grown increasingly apparent and serious along may of the world's coastline as local mean sea level has risen during

the twentieth century at a rate ranging from 1 to 5 mm/yr. The scientific and engineering community has focused their attention on the problems of accelerated beach erosion and the rising level of "green house gases in the atmosphere."[3] As a first approximation, the effects of one metre sea level rise on a coastline in South Asia may be determined by surveying the contour one metre above present high spring tide line, but allowance must then be made for the effects of erosion and deposition as submergence proceeds. Submergence will result in recession of the coastline, except where there is vertical cliff, or where deposition of sediment continues at a sufficient rate may continue in the vicinity of the mounts of major sediment-yielding rivers, such as the Ganges, which have built large deltas.[4]

Submergence is likely to accelerate the recession of cliffed coasts, except where the rock outer crops are resistant, and high and low tide lines simply move up the cliff face. In the tropics cliffs are mainly on headlands, such as Cape Comorin in India and Condra Head in Srilanka, and the rock outcrops are usually deeply weathered and easily eroded. Many are vegetated bluffs rather than actively receeding cliffs, and a sea level rise is likely to underent them, producing slumping and eventually steep,

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3. V.K. Asthana, "Past changes in Relative Mean Sea Level and the Future Trends" in Victor Rajamanickam, G. (ed.) Sea Level Variation and Its Impact on Coastal Environment. p. 7 (1990).

4. E.C.F. Bird and M.L. Scwartz (Eds) "The World's coastline." (1985).

active cliffs. Cliffs that are already receding, as on the coast near Chittagong and cox's Bazar in Bangladesh, will show an acceleration of cliff retreat as sea level rises, and larger waves move in through deepening water. where shore platforms have developed, they will disappear beneath the rising sea. Some will be builtup by nearshore deposition, or the growth of organisms such as algae and corals. Submergence of low-lying river deltas and coastal plains will cause extensive retreat of the coastline, accompanied by marine erosion, but a few sectors may be maintained by sedimentation, especially in the vicinity of the mouths of large rivers. On the north coast of Java there is already erosion on deltaic sectors where former river mouths have been diverted, naturally or artificially, but this is largely compensated by the progradation that continues around the present river mouths (Bird and Ongkosongo, 1980)[5]. With a rising sea level, the proportion of eroding coastline will greatly increase on these and other deltas. In India, Ahmad (1972)[6] estimated that a quarter of the coastline was prograding as the result of delta growth, but this proportion will be much reduced.

As sea level rises, beaches will become narrower, and beach erosion will become more extensive and severe than it is now. An exception may be found locally where beaches

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5. E.C.F. Bird and O.S.R. Ongkosongo, "Environmental Changes on the coasts of Indonesis". (1980).

6. E. Ahmad, "Coastal Geomorphology of India". (1972).

are nourished with a larger supply of sediment derived from rivers draining areas of increasing rainfall, or from accelerating cliff erosion, but some of the sediment supplied to the coast by rivers will be retained within submerging river mouth areas.[7]

As submergence proceeds, coastal inlets, embayments, and estuaries will enlarge and deepen, and salinity penetration from the rising sea will increase. Tidal regimes will be modified. and intertidal shoals, mangroves and marsh islands (as at the mouths of the Ganges) will show extensive erosion as these features disappear beneath the sea. Depositional terraces built up by mangroves and salt marshes during the Holocene slitsand will only be maintained if sedimentation continues at a sufficient rate, but generally their seaward margins will be cut back. Coastal lagoons of the kind found in Southern India and around Srilanka will also become larger and deeper, and the rising sea will erode their enclosing barriers. In some cases submergence and erosion of barriers will reopen lagoons as coastal inlets or embayments. Fringing and nearshore coral reefs will be submerged in the same way as rocky shore platforms fronting cliffed coasts, but the rising sea level may stimulate the upward growth of corals and associated organisms, which could maintain the reef structure if they keep pace with the marine transgression. This will be critical for the future of low

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7. Bird, n. 4

sandy islands (cays) which have formed on coral reef flats as in the Maldives and the Andaman islands.[8]

Low-lying coastal areas will show migrations of vegetation and faunal zones as submergence proceeds. Mangroves are extensive in such areas as the Sunderbans and the tidal shoals off the Ganges delta, but mangrove fringed coastlines have become less extensive in South - east Asia in recent decades because of the impacts of land reclamation, fishpond construction, mineral dredging, and waste disposal. In Thailand, for example, these impacts have already reduced the mangrove area by more than one-third (Bird, Kunstadter and Sabhasri, 1987)[9].

Where mangroves persist, they typically stand in front of zones of salt marsh and freshwater vegetation (fer, scrub or swamp forest) where there has been coastal progradation, the advance of the mangroves (often arranged in species zones) has been followed by salt marsh and freshwater communities in succession as sedimentation builds up the substrate to appropriate levels, forming an intertidal depositional terrace.

A sea level rise will reverse this sequence, unless sedimentation continues at a sufficient rate to maintain or prograde the coastline. Submergence will kill

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8. Ibid.

9. Eric C.F. Bird, P. Kunstadter, and S. Sabhasri, (Eds), Man in the Mangroves. (1987).

the seaward mangroves, and initiate erosion of the previously prograded terrace. As the coastline retreats, the mangrove zone will migrate landward to displace the salt marsh, which in turn, will invade the freshwater hinterland. Mangroves regenerate quickly in areas that have been cleared, then abandoned, and it is likely that they will spread back on to suitable low-lying hinterlands as the sea rises, but where the hinterland is steep or rugged the mangrove zone will be extinguished by submergence.

In South and South-East Asia, the land immediately behind the magroves is commonly used intensively for fish ponds or rice fields and these would be invalid by the retrogressing mangroves if local people permit. In drier areas, such as the Rann of Kutch where mangroves, are backed by base, hypersaline plains, a sea level rise will result in the colonisation of presently unvegetated tracts by mangroves as the coastline retreats.

Coastal lagoons typically show salinity gradients from fresh river inflow through backish to sea water at their marine entrances, this is true for example in the chain of lagoons that opens to the sea at Songhkla in South Eastern Thailand. A sea level rise of a metre over the next century is likely to increase marine inflow through deepened and sidened marine entrances. Where this occurs areas that were previously fresh water will become brackish with die-back of existing vegetation and replacement by mangroves,

salt marsh and other salt tolerant hydrophytes. There will also be displacement of freshwater fauna by estuarine and marine species.

In these various ways ecosystems in coastal regions will change as sea level rises but on the coasts of South and South East Asia. The natural vegetation and fauna have already been extensively modified and what actually happens will depend very much on human responses to ecological change.

The ways in which modern coastal societies will respond to be a relatively rapid tise in sea level will vary with political and economic factors. Nations that have the organisation, technology and resources to counter the effects of a sea level rise by means of artificial structures will do so others will,in general have to choose between evacuation of submerging areas or adaptation to changing coastal environments.

On coast lines close to urban and industrial centres it is likely that a sea level rise of about a meter over the next century will stimulate expenditure on structures designed to prevent submergence and erosion. It is very likely that where land has recently been reclaimed from the sea for use by large coastal population (as in Singapore), strenuous efforts will be made to retain it, by building sea walls and introducing pumping systems using

techniques familiar from the history of the Netherlands coast. Where eroding beaches are valued for there creation or tourism, as in sea side resorts such as Pattaya in Thailand it is possible that they will be maintained by beach renourishment programmes of the kind already used in the US and Australia. More generally beach erosion will continue to be met by the spread of artificial structures: already more than 260 kms of the Kerala Coastline in South India are fringed by granite boulders walls (Ahmed, 1985).[10]

Away from highly developed centres there may have to be abandonment of coastal fringes as submergence proceeds and modification of developed land and water uses as the water table rises and soil and water salinity increase.

A sea level rise of a metre over the next century will accenturate such problems on the intensively ..... utilised and density populated coastal plains of South and South East Asia, causing coastline recession of up to several kilometeres, displacing coastal villages and depriving many people of their land and resources.

Tide range in bight of Bankok, is upto 2.3 metres and a sea level rise of a metre on this gently sloping coastal plain would submerge the whole of the reclaimed mangrove area and an additional zone upto five kilometers to

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10. E. Ahmad, "India, in Eric C.F. Bird and M.L. Schwartz (Eds) The World's Coastline", pp. 741-748.

landward (Bird, 1989)[11] Existing fish ponds, shrimp ponds and salt pans are thus likely to be submerged and destroyed by marine erosion unless they are protected by even larger and more elaborate sea walls.

The predicted sea level rise of a metre during the coming century will greatly modify the geomorphology and ecology of the coastlines of South and South East Asia, and generate a whole new range of problems for the communities that occupy and utilise these coastal areas. The effects of a sea level rise can be deduced theoretically or inferred from studies of coastlines where submergence is already in progress, but there is a need for site specific predictive studies of the physical and ecological consequences of a sea level rise on the various types of coastline, especially those that are low lying, densily populated and intensively utilised.

The human response to sea level rise may be counter measures. Where resources and technology are capable of these but elsewhere there will have to be evaluation or come kind of adaptation to the changing coastal environment. On the coastlines of South and South east Asia, the most likely outcome is an intensification of use and occupance of nearshore sea areas.

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11. Eric. C.F. Bird, "The Effects of A rising sea level on the Coasts of Thailand" ASEAM Journal on Science and Technology for Development., V. 6. pp. 1-13.

CHAPTER V

HUMAN DIMENSION AND SEA LEVEL RISE

Global Climate change when talked of brings about many such changes, which directly or indirectly affect human activities, their social, economic and political set up. The same has happened in the case of sea level size. The causes of which have been discussed in the previous chapter. This sea level size directly effects the life of human beings, especially those, who live in coastal areas. Their economics and politics is very much dependent on the sea, and any changes in the sea, will naturally bring about changes in their lifestyles, economics and politics, equally, as all three are inter-related.

Ecologically, sea level size, brings about, consequences like the changing of that area's biosphere, which would naturally effect human activities, as the people living near the sea, would be very much dependent on the biotic resources, especially those obtained directly from the sea, like fish, and other such sea food, pearls ecetra. Submergence of coastal weltands, inundation, coastal erosion, flooding and storm damage, especially in the costal areas, increased salinity in estuaries and aquifers, and all these factors would effect the human life to such a degree that, especial efforts are required to fight these consequences, brought about by the increasing sea level. As a consequence, the coastal zone is to be regarded as one of the most important and critical parts of the planet,

particularly as far as global change, is concerned. On the one hand, the physical context is transforming because of changing sea level and progressive coastal erosion; on the other hand human communities concentrating along the sea and exploiting its coastal resources. There is a growing awareness today that human activities are beginning to affect our planet on a global scale. Sea level rise and other potential consequences of climate change create problems that can be solved only by international cooperation. Humanity would do well to increase its sense of stewardship for the planet it inhabits. An increasing body of evidence suggests that in the coming decades a global warning due to the greenhouse effect will lead to a substantial rise in sea level. Estimates for the next century range from 0.5 to 2 meters.[1] Because a large part of the world's population lives in low lying areas near the sea such a rise will have an important impact on society. Unlike most issues involving air pollution, an effective solution to the greenhouse effect will require action decades before the impacts occur, because of time lags in natural processes. Even if all emissions were stopped, temperatures

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1. UNEP-ICSU-WMO, **International conference on the assesment of the role of carbon dioxide and of other greenhouse gases in climate variations and associated impacts**. Villach, Austria. 1985, in Cees, B., Vreugdenhil and Wind, G., Herman. Impact of sea level rise on society - Framework of analysis and recommendations. p. 1, (1986).

would continue to rise for a few decades and sea level could rise for an even longer period of time. Coastal infrastructure and coastal protection works take decades to implement and can last for centuries. Therefore, to ensure an effective and timely response, scientists, engineers and policy makers must join forces to consider the consequences for today's activities.

There is an interaction between social conditions and the impacts of sea level rise. On the one hand, particularly if coastal defence is impossible there could be a large social impact in the form of the abandoning coastal areas and the migration of population whether or not this is considered acceptable, depends on the values and norms of the society. On the other hand, the way in which a society responds to threats from a rising sea level depends very much on the social structure. Seventy percent of the human population lives within 60 km of the sea, and the percentage is increasing. Human settlements, industry and agriculture in coastal lowlands are vulnerable to rising sea level or changes in storminess or storm surges.[2]

Some nations are particularly vulnerable. Eight to ten million people live within one meter of high tide in each of the unprotected river deltas of Bangladesh, Egypt

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2. **Oceans, Fisheries and Coastal Zones.** Task Group 3. Report in J. Jager, and H.L., Ferguson, **Climate change: Science, Impacts and Policy** - Proceedings of the Second World Climate Conference. p. 443, (1991).

and Vietnam. Half a million people live in archipelagos and coral atoll nations, that lie almost entirely within three metres of sea levels, such as the Maldives, the Marshall Islands, Tuvalu, Kiribati and Tokelan. Other archipelagoes and island nations in the Pacific and Indian oceans and Caribbean could lose much of their beaches and arable lands, which would cause severe economic and social disruption. Even in nations that are not, on the whole, particularly vulnerable to sea level rise, some areas could be seriously threatened.[3] Examples include Sydney, Shanghai, coastal Louisiana and other areas economically dependent on fisheries or sensitive to change in estuarine habitats. As a result of present population growth and development, coastal areas world wide are under increasing stress. In addition, increased exploitation of non-renewable resources is degrading the functions and values of Coastal Zones in many parts of the world. Consequently, populated coastal areas are becoming more and more vulnerable to sea level rise and other impacts of climate change. Even a small rise in sea level could have serious adverse effects.

A substantial rise in sea level would permanently imundate wetlands and low lands, accelerate coastal erosion, exacerabate coastal flooding and increase the salinity in

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3. Eid, El-Mohamady and Hulsbergen, Cornelis, J., **Sea Level Rise and Coastal Zone Management**, in J. Jagger, and Ferguson H.L., Climate change: Science, Impacts and Policy - Proceedings of the Second World Climate conference p. 305. (1991).

estuaries and aquifers. The human response may very between complete abandonment of the land and adequate protection, depending on the physical and socio-economic conditions. Bangladesh, and Egypt appear to be among the nations most vulnerable to the rise of sea level. Up to 20% of their usable, and densely populated, land could be flooded with a 2 m rise in sea level. A large fraction of the world's coastal wetlands may be cost, threatening fish breeding grounds. A rise of 1 to 2 m by 2100 could destroy 50-80 % of the coastal wetlands in the United states. No estimate of the world wide impact is available but the U.S. figure may be representative.[4] Coastal erosion could threaten recreational beaches throughout the world. Case studies have concluded that a 0.3 m sea level rise would result in beaches eroding 2-0-60 m or more. Only major beach preservation works can avoid unacceptable narrowing of the beaches and damage to property. Sea level rise will increase the frequency of high floods, thus causing more damage and requiring more flood protection and more flood insurance. Increased salinity from sea level rise would convert swamps into open water and threaten water supplies.

A rapid rise of the mean sea level of 1 to 2 metres in 100 years will have a considerable impact on all environmental conditions in low deltaic areas, coastal

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4. J.G., Titus, **The Causes and Effects of Sea Leve Rise** in Wind Herman G., (Ed) Impact of Sea Level Rise on Society Report of a project planning session/Delft 27-29 August 1986. p. 79.

marshes and embayments in coastal lowlands. They are often densely populated, and highly productive in the agricultural sector. The impacts on morphology and water quality will lead to countermeasures in the fields of flood protection and water management.[5]

A common situation is that of a growing delta. The land areas are built up by sediments from the river and the sea, to an elevation slightly above high tide in the coastal strip and to the level of the 1 to 5 years flood along the rivers. So the land level rises and the delta aceretes into the sea. The whole process is strongly related to the local relative change of mean sea level. A rapid increase of the global rise of mean sea level will upset the present dynamic equilibrium. The process will adapt to the new rate of rise which generally means a slowing down of the rate of accretion, even recession and drowning may be the result. A rise in mean sea level will also influence the propagation of the tides and the generation of storm surges. Sea dikes will have to be heightend, often even more than the rise of mean sea level. In some cases a shortening of the coastline by enclosure of embayments may be feasible. The rise of sea level and the related backwater effects increase the water levels in the estuary and, with some time lag, in the lower

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5. Volker, A., **Impacts of Rapid Rise of the Sea Level on Flood Protection and Water Management of Low Lying Coastal Areas** in Wind, Herman G., (Ed); Impact of sea Level Rise on Society. Report of a project planning session/Delft 27-29 August 1986. pp. 87-89.

part of a river. In these areas also the flood protection has to be adapted.

A rise of mean sea level will cause the heavier saline sea water to intrude more upstream in estuaries. The salt renders the water unsuitable for many purposes, especially during periods of low discharge when the need for fresh water is high. The eco-system will also be affected. The seepage of sale water from the sea and from estuaries into the coastal aquifers will increase considerably as a consequence of the increased head as well as the increased penetration in the estuaries. In much larger areas in (especially arid) coastal zones, the ground water will become brackish and will require countermeasures.[6] In many humid tropical areas without storm surges, rice is grown on land with little protection against floods by fresh river water. A rise of sea level of 1 m or more will upset these conditions and require measures to maintain the present levels of productivity. In embanked areas with artificial drainage the lifting capacity of the devices has to be increased. In some cases, gravity drainage will have to be replaced by pump-lifting. Although salt intrusion may adversely influence the availability of water for irrigation, and require intakes more upstream, the resulting increase in head may be beneficial. Cities, harbours and other industrial areas will have to be protected from

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6. Ibid.

flooding by water from the sea or the river by embankments and from precipitation by pump lift drainage. The drainage of coastal storage reservoirs to the sea will be hampered by a substantial rise of sea level and their operation may require considerable adaptation.

MORPHOLOGIC PROCESSES AND HUMAN INTERFERENCE.

From a geological point of view deltas belong to the most rapidly changing parts of the crust of the earth. A common situation in cases where man has not yet interfered or only to a limited extent is that of a growing delta. This is a delta which is extending into the sea entailing a rise of the riverbed and hence of the levels of the river floods. The land areas are built up by sediments from the river and from the sea. Under normal conditions the land in the coastal strip is built up to an elevation slightly above high tide level. Beyond the tidal reach the river builds up the natural level to approximately the level of the 1 to 5 years, flood.[7] The annual rates of extension vary widely but often amount to a few tens of metres horizontally and to some centimeters vertically, actual rise is a fraction of this figure because of compaction and subsidence. A rapid rise of the sea level within a certain period will upset the present dynamic equilibrium. There will be a gradual adoption of the morphology to the new sea level. Because of

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7. Ibid. p. 168

the time lag the water depths of the river channel and the sea floor will initially increase slowing down the rate of building up. The tidal currents in the shallow coastal waters will increase and cause erosion of sandy costs. The mangrove belt which exists along the coasts of most tropical deltas will deteriorate or even disappear. This belt has a high commercial value and effectively protects the landward banks against wave attack. In the case of Bangladesh-West Bengal the mangrove forest (some 12,000 Km^2) reduces the cyclove levels from the sea at inland Khulna. In deltas where flooding has been excluded by the construction of embankments the natural building up of the land areas has been arrested. Agricultural drainage has caused a land subsidence. The effect of a rapid rise of the sea level will be a still lower land elevation with respect to the tidal levels when the river bed has adapted itself to the new situation the flood levels will be accordingly higher. In deltas where the distribution of the upland discharge over the tributaries has not been stabilised by hydraulic works, a river branch may be cut off from the supply of sediments (moribund river). The part of the delta which was supplied with sediments by that branch will be exposed to erosion in the case of a rapid rise of the sea level (parts of the delta of the Mississippi River). An extreme case is that of the drowning delta like the (former) delta of the Rhine and the Meuse in the Netherlands. Low supply of sediments, natural and man-induced subsidence and a rise of the sea

level have led to an artificial situation where man is constantly fighting the destructive forces of the sea. Man has learned how to cope in this area with a continuing relative rise of the sea level which, if man-induced subsidence is included, amounts to some 3 metres during the past 1000 years.[8]

IMPACTS ON FLOOD PROTECTION[9]

PROTECTION IN THE COASTAL ZONE

Costals embankments are exposed to high water levels and, depending on the situation, to impact of waves. High sea levels are caused by astronomical spring tides and along a number of coasts, by wind-induced set-up of the sea level (storm surges, cyclones, typhoones and hurricares). A rise of the sea level will affect these conditions in different ways. The propagation of the astronomical tides in shallow coastal waters will be modified, increasing, in general, the tidal range. The set-up will decrease but, in general, this effect will be small. The wave uprush may substantially increase, especially in those cases where under the original conditions, the depths in front of sea dites are small or where tidal foreland exists. The result is that the sea dikes will have to be raised to a greater height than the rise of the sea level to maintain the same

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8. Ibid. p. 169.

9. Ibid.

degree of safety. In many deltas embankments have been raised periodically to cope with the relative sea level rise. The motive has often been not so much for this rise but the desire to ensure a greater degree of safety, especially after disasters (1953 in the Netherlands and 1959 in Japan). This was also the motive for the implementation of schemes aiming at shortening the lines of defence by enclosure near the mouth of estuaries and other tidal embayments (Japan, the Netherlands and, on a smaller scale, Bangladesh).

PROTECTION UPSTREAM

In a delta three zones can be distinguished with respect to flood levels. In the coastal strip the extreme levels are governed by the storm surge levels at sea. In the river reach the effect of the river floods is predominant. In the intermediate zone the highest floods occur when sea and river floods coincide. A rise of the sea level will affect the levels in all three reaches with different time-scales. The rise of the sea level and the related back-water effects increase the depths of the lower river reach and facilitates the propagation of the storm surges in this reach. In a later stage the effect of the rise of the river bed will be felt, firstly downstream and then propagatging in upstream direction. This will be most pronounced in deltas and lower river reaches with very small slopes (10^5) like the Parava and the Mekong rivers.

SEA WATER INTRUSION INTO OPEN ESTUARIES[10]

In all estuaries where a freshwater river debauches into a basin with saline water the heavier saline water will penetrate into the estuary and more in an upstream direction in spite of the flow of freshwater in the opposite direction. Depending on various factors, in the first place the tidal range in the basin, the estuary will show a distinct interface between the fresh water near the surface and the saline water near the bottom or a situation will occur where there is partial or complete mixing. The saline intrusion renders the water unsuitable for various purposes and is a maximum when the riverflow is a minimum during dry periods when the need for freshwater is high. An extreme case in the Gambia river in west Africa where at minimum flow the saline effect is felt up to 235 Km upstream from the sea. A rise of the sea level will increase the intrusion of saline water because of the increase in water depths, at least in a first phase, and the increase in tidal flood volumes. The shift of the saline reach in the upstream direction will affect the intake of water from the river for irrigation and water supply and the ecological conditions of the channel and the adjacent land. It should be noted that this process is already taking place in a number of

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10. Rijkswaterstaat, Salt Water Distribution In Estuaries The Hague:

estuaries where because of dredging in connection with post development the saline effect has moved further upstream. A classical example is the Rotterdam waterway giving access to the port of Rotterdam where the saline reach moved over 35 Km in a period of about 60 years.

SEEPAGE[11]

In the subsoil of most large deltas pervious strata are found through which groundwater can move under the effect of differences in elevation of the surface waters. As a result of marine transgressions in the geological history the groundwater under deltas is often brackish or saline so that when seepage occurs water with a high salinity will ooze at the surface--In many cases, however, the seepage in deltas is not a salient feature because of small differences between the level of the land and the level of the sea. This changes with a rising sea level. Seepage of water with a high salinity (ultimately seawater) will occur where the semi-pervious top layers are absent or poorly developed. This is often the case under the sea and in the land areas at the location of increased rivers , filled-in tidal creeks and abandoned natural levels. The presence of a sandy ridge (e.g. dures) with fresh water pockets will not prevent seepage from the sea because of the deformation of the pocket resulting from a

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11. ESCAP "The Development of Ground Water Resources with Special Reference to Deltaic Areas". **Water Resources Series** 24. (1963).

rise of the sea level. Seepage water has to be drained from land areas by pump-lift and this involves additional coasts. The saline water causes considerable problems especially in deltas in the arid zone like the delta of the Nile and the delta of the Indus.

IMPACTS ON WATER MANAGEMENT SYSTEMS

DRAINAGE OF AGRICULTURAL LANDS[12]

Non-embanked areas

Lowland rice is grown in many deltas in the humid tropical zone where storm surges occur and where there is no protection against river floods. In these areas, often there are only low coastal embankments to protect the coastal strip from flooding with saline water during high astronomical spring tides. Local rice varieties are grown which are adapted to the depth of flooding caused by river. Near the coastal strip the depths of flooding are small and relatively high yields are obtained. Further upstream the depth of flooding may be as much as 3-4 m and 'floating rice' is grown with low yields. These condition occur in many parts of the large deltas of South-East Asia and especially in the delta of the Mekong river. A rise of the sea level of, say 1 m or more, would upset these conditions. the sea-dikes will have to be raised and in the tidal reach the depth of flooding will increase affecting the productivity. To maintain the present productivity

levels protection against flooding will become necessary and embankments will have to be created. although, in itself, this is a simple operation, it will change the environment profoundly and will entail many hydrological and morphological side effects (rise of the flood levels, rise of the river bed and increased meandering). Embanking makes it necessary to lay out a system of drainage canals and outfalls. Because of the elimination of the beneficial effects of the floods (supplemental irrigation and flushing) it may become necessary to provide irrigation facilities. Under the present conditions with the continuing relative sea level rise and the desire to increase the yields and to grow other crops than rice there is a tendency to carry out development schemes in the deltas aiming at flood protection, drainage and irrigation. An uncertain economic feasibility often hampers actual implementation. A rise of sea level which far exceeds that occuring at the present will either ruin many agricultural areas or accelerate the developments which are already taking place.

EMBANKED AREAS

Depending on the land elevation, relative to tidal levels, and on the drainage requirements (lowland rice or dry food crops) either gravity drainage or pump lift

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12. International Commission on Irrigation and Drainage. **Development of Deltaic Areas**. International Commission on Irrigation and Drainage 6th Congress, New Delhi. (1966).

drainage can be applied. In the coastal zone of many deltas all over the world tidal drainages is applied on a large scale when the land is not too low. The system often consists of simple wooden box slies with flap gates. If there is a significant rise of the sea level this system will have to be replaced by pump-lift. This will entail high installation and operation costs in deltas in the humid tropical lone with their high amounts of rainfall. Where pump-lift drainage is applied like in the Netherlands, Italy, Japan, USA and India the pumps will operate at lower efficiency if there is a substantial rise of the sea level and the structures may have to be modified or redesigned.

IRRIGATION[13]

The sea level rise will increase the salt water intrusion threatening the intake points of irrigation water along the river. Unless the drastic solution of enclosure of the estuaries near the mouth is applied, the intake points will have to be shifted upstream beyond the salinity limit during periods of low river flow. New canals will have to convey the irrigation water from the new locations of these intales to the downstream areas and when the stopes are small booster pumping stations in the canals will be necessary. A benefit of the sea level rise will be the increase in head for the flow of irrigation water from the river to the land.

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13. Ibid.

URBAN AREAS AND HARBOURS

If there is a rapid rise of sea level cities in low-lying coastal areas will have to be protected from flooding by encircling embankments (pocket dikes) and in any case, will have to be drained by pump lift. This is an operation which is already under way in a number of large cities mainly as a consequence of man induced land subidence. Typical examples are New Orleans and Osaka, Banglok as a recent case. In Osaka a (local) maximum subsidence of 2.8 m occurred in a period of about 30 years. This probably is a greater rate than any conceivable rate of rise of the sea level. The walls along the city canals and the entrances from the sea have been raised by 1 to 3 m. check-sluices (some with vizor gates with a span of 60 m) have been built which can be closed when high typhoon levels occur on the pacific Ocean. The city area is then isolated from the surrounding waters and excess water from local typhoon rainfall has to be removed by pumping. The Kema pumping station, probably the largest of the world, with a capacity of 330 m^3/s (6 pumps of 55 m^3/s) and a head of 3-4 m in has been constructed for this purpose.[14] The response of the Japanese to this challenge has been immediate and vigorous. Because of financial and organisational problems this however would probably not be possible for cities like Shanghai and Calcutta, should a

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14. Volker, A., (n.5) pp 172-17

rapid relative rise of the sea level occur which would be similar in effect to the subsidence of Osaka.

The case of Osaka demonstrates that, from the technical point of view, a of the sea level of say 2 to 4 m within a period of 100 years would not cause unsurmountable problems. The coses have been justified because of the high economic value of an urban place like Osaka.

In tidal harbour basins it will be necessary to raise the heights of quay walls and landing stages. Attention should also be paid to ensure that there is sufficient headway under bridges. In the case of dock harbours the access locks may have to be adapted to a rise of sea level.

COASTAL STORAGE RESERVOIRS[15]

In a number of coastal areas in France, India, Japan, the Netherlands and to a lesser extent Bangladesh and the Mekong-delta coastal or estuarine reservoirs have been farmed by damming off tidal embayments or estuaries. Excess water from the rivers is discharged into the sea through sluices and the enclosed basins have keen transformed into reservoirs with freshwater by the inflow of river water.

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15. ESCAP, Proceeding of the fourth session of the Committee on Natural Resources. **Flasibility of Utilizing Coastal And Estuarine Storage For Resh Water Supplies"** water Resources Service 48. (1978).

The discharge of to the sea in effectuated by tidal drainage. The low lying areas around the reservoirs can abstract water from these reservoirs during dry periods.; generally they also drain to these reservoirs during rainy periods, either by gravity or by pump lift.

A rise of the sea level of around 0.5 m or more will completely upset the present operation of these reservoirs, since gravity drainage into the sea will no longer be possible. There are two basically different solutions which could be considered. The one could be, that the reservoir levels would be maintained at the original level. This implies that excess water from the reservoir would have to be removed by pumping and that the sluices would be closed. Since the volume of flood waters from the river may be quite high, this could be an expensive solution.

In the second solution operational level of the reservoir could be raised, so that gravity drainage to the sea remain possible. This would require modification or redesign of the existing sluices. The drainage of the surrounding low lying areas on the reservoir would be hampered and pump-lift may be necessary> Embankments would have to be raised not only along the reservoir but, because of back-water effects, also along the rivers debouching into the reservoir. Indeed in a delta, with its system of interconnected water courses, the side of the reservoir

level would propogate in the entire system unless partitions are made.

There would also be a seepage flow from the reservoir with its high level to the surrounding low-lying areas, but after a long period of time this seepage water would have the same composition of the water in the reservoir.

A large position of the world population lives in coastal areas and on islands. These areas have several assets, including some of the largest cities of the world, ports, industries, fertile lands, fisheries and tourism facilities. A sea level rize of one meter by 2100 would have severe impact on all costal areas particularly in the developing countries.[16] More frequent recurrence of storm surges would pose an intolerable burden on the coastal populations the impacts on shorelines erosion, inundation of wetlands, and mangroves, increases in the salinity of aquifers, and drowning of coral reefs would cause severe ecological damage. The small islands are particularly vulnerable.

Human beings in their responses would naturally try to adapt to these changes and the rising sea level especially in the coastal areas where the effect will be

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16. Sarma, K., Madhava, **"Adaptation Measeures"**, in Jager, J., and Ferguson, H.L., Climate Change. Science, Impacts and Policy"- Proceedings of The second world climate conference. p. 137 (1991).

much higher. This adaptation will be brought about, because of the severe stress on the economics of those effected areas. Agriculture will be effected as sea level area could inundate low lying coastal plains with fertile alluvial soils where a high proportion of rice production is located. Fisheries could be effected. Two thirds of the world's fish catch and many marine species, depend on costal wetlands for their survival. Without human interference eco-systems would migrate landward as sea level rises and then could remain largely intact, although the total area of wetlands would decline and so would the fish catch. If human intervention is followed then there are chances, that a large portion of these ecosystems would be lost which again would reduce or finish the fisheries.

Thus a gentle coherence is needed and to understand the human response, they can be put into three categories.[17]

* Retreat i.e., abandon unlnerable areas and resettle inhabitants
* Accommodation - adjust to sea level rize.
* Protection - for vulnerable areas particularly those with high population density economic value or precious natural resources.

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17. Ibid.

(a) Retreat

Preventing development can reduce future expenditure for adaptation. India, Sri Lanka, USA, Australia and a number of island nations have already such regulations. Where the area that could be immundated is high, the timing of such regulations would be difficult. Spreading of awareness among all the occupants of vulnerable areas could encourage private initatiaives and solutions. This is no solution, however for small island states and poorer countries. Also under this option, resettlement could create major problems. Resettled people our not always well recieved. They often face language problems, racial and religious discrimination and difficulties in obtaining employment. Even when they feel welcome, the disruption of families, friendships and traditions can be stressful.[18]

Although the impacts of accommodation and protection would be less, they may still be important. The loss of traditional environments which normally sustain economics and cultures and provide recreational needs could disrupt family life and create social instability regardless of the response eventually chosen. Community participation in the decision making process is the best way to ensure that these implications are recognized.

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18. Eid and Pulsbergen. (n. 3) p. 306

(b) ACCOMMODATION

This response requires advance planning. Many coastal structures could be elevated for protection from inundation Building codes could be devised for protection from surging waters and high winds Drainage could be modified, storm warning and preparedness plans could be strengthened. Where salt water damages agricultural lands, salt-tolerant crops may be introduced. Some agricultural lands may be converted to agricultural uses. Human activities that harm coastal resources may be banned. e.g filling weltlands, damming rivers, mining coral and beach sands and cutting mangroves. Undeveloped land can be set apart to accomocdate re-establishment of wetlands and mangroves. Exploitation of ground water could be controlled to prevent salinity intrusion

(c) PROTECTION

This response involves defensive measures against inundation, tidal flooding, shore erosion, salinity interaction and loss of natural resources. Those measures could be structures such as dikes, levees, flood walls, sea walls, and dune building, and pollution control.

(D) ECONOMIC IMPLICATIONS

While it is very difficult to estimate the economic implications correctly, it to possible to make some

broad statements about the various options. In densely populated and productive areas retreat may not be viable in general and in the case of small islands, could be impossible. Accommodation could be extremely costly but could be justifiable in particular situations. Protection would be economically viable, in particular cases but could be unafforable for poorer countries. One estimate quoted in the Inter-governmental Panel on Climate Change report gives the total additional costs to be more than 500 billion dollars with a major part to be incurred in developing countries.

(e) SOCIAL AND CULTURAL IMPLICATIONS

The life styles of people living on the coasts are distinct. The adaptive measures may, therefor impact heavily on the social and cultural mores of millions of people. Relocation of people whether planned or unplanned, could impose a traumatic burden on those relocated. The impacts on the people originally living in the relocation areas could be very high and cause great conflicts, even within the same country. Where such relocation crosses national boundaries, international conflicts could occur.

There is considerable optimism that among many that adaptation to climate change is feasible, since it is as old as man himself. At every location, human beings and other living things adapted successfully to varying

temperatures, precipitation, droughts, floods and storms. Because of economic and technological progress, the in built adaptability of humankind has improved. The world has many climatic zones and as long as new climate in the area has existing analouges anywhere in the world. People in that area can adapt and learn. Thus that is regarded as the best method through which a balance between the rising sea level and man can be maintained and the human species can see traces of survival for their future generation's comfortable and sound life.

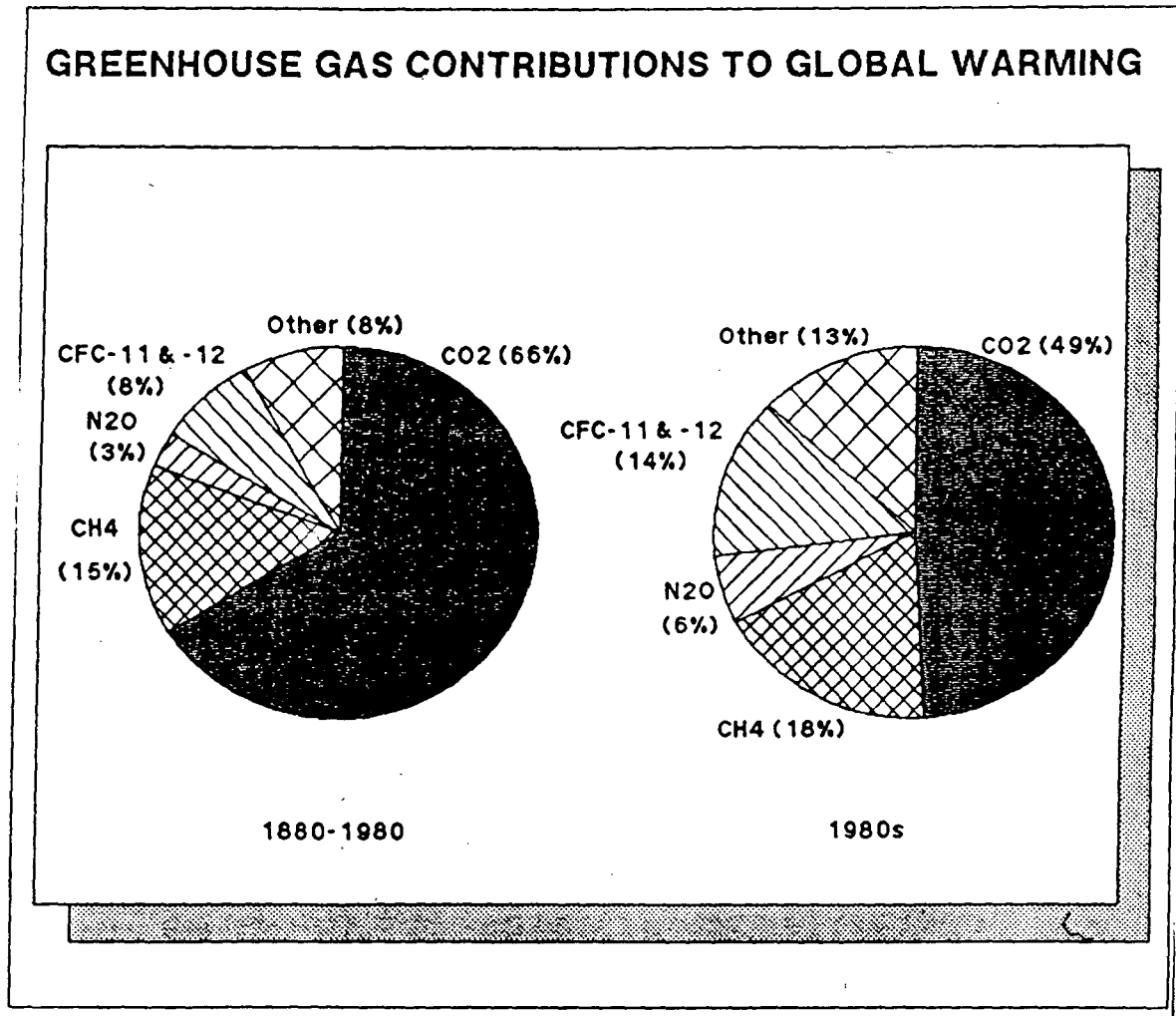
CHAPTER VI

INTERNATIONAL POLITICS AND LIKELY REGIME FOR COMBATING AND PREVENTION OF SEA LEVEL RISE

The sea level rise is an international problem, an issue which is of equal importance to all nations and human communities. In order to respond effectively to this problem the nations of the world must act in concert. Several international organisations have recognised the need for multilateral cooperation and have become involved with this issue. The United Nations Environment Programme (UNEP) is responsible for conducting research on and monitoring the changing Global Climate and its impact on the sea level rise and its further impacts on the human coastal communities and factors related to their existence and survival-in a biological as well as in an economic context.

An Intergovernmental Panel on Climate Change has been established under the auspices of UNEP and World Meteorological Organisation which held its first meeting in November, 1988 will also ensure an orderly international effort in responding to the threat of global climate and the rising sea level.

With all this work and awakening under way, impression of an illusion about the changing world response and the efficiency with which the global community is trying to, not just take preventive steps but also is making sure that there are definite reforms on the physical face of the earth so that no major changes can be brought about and the Earth remains the Home of Man in the true sense. But what

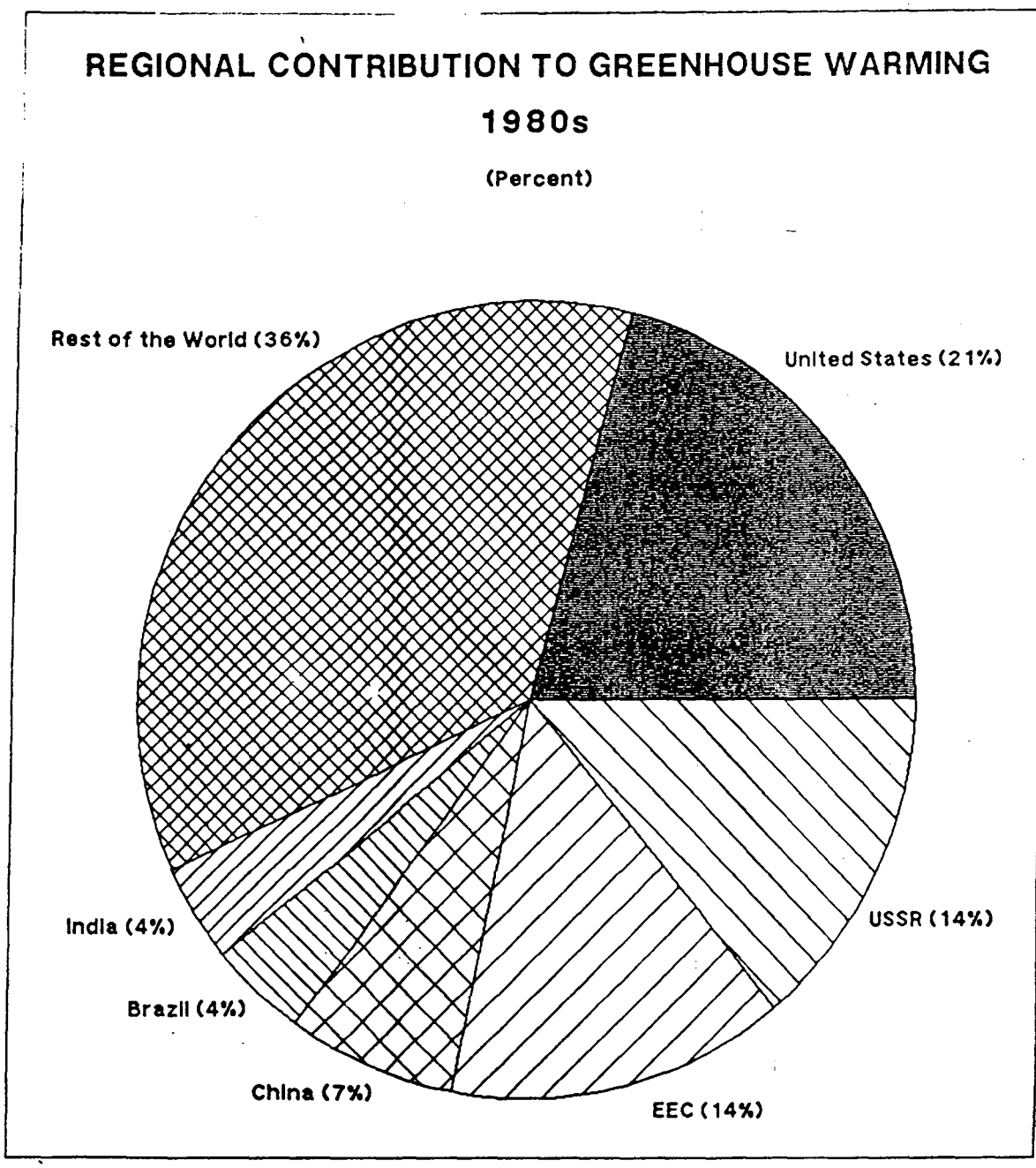


Based on estimates of the increase in concentration of each gas during the specified period. The "Other" category includes other halons, tropospheric ozone, and stratospheric water vapor. The contribution to warming of the "Other" category is highly uncertain. (Sources: 1880-1980: Ramanathan et al., 1985; 1980s: Hansen et al., 1988.)

can't be denied is that much of what is talked of is more of an illusion than solid facts. They are parts of an idealistic world rather than the world we live in and the nations and people we actually are.

One of the glaring examples of the start reality, which portrays the political disintegration of the environment and the future plans in respect to making it better and much more conducive for the future generations to use is the recently concluded Earth Summit in Rio de Janeiro, where the North South divide became even wider than before.

It has been estimated that Carbon di oxide (CO_2) the main culprit in the green house and the subsequent sea level rise is entering the atmosphere at the rate of 8.5 billion tonnes a year. Between 1980 and 1990, CO_2 was responsible for about half of the global warming. Other gases like the cholore fluro carbons CFCs (comprising 20% of the green house gases) methane (16%) and nitrous oxide (5%) are also contributing to the green house warming and the rise in the present sea level.Therefore the best way to reduce the impact of global warming would be to reduce the amount of carbon di oxide released in the atmosphere at present the USA emits a quarter of the CO_2 produced in the world followed by Russia (19%), countries of the European



Estimated regional contribution to greenhouse warming for the 1980s, based upon regional shares of current levels of human activities that contribute to greenhouse gas emissions. (Sources: U.S. EPA, 1988a; United Nations, 1987; U.S. BOM, 1985; IRRI, 1986; FAO, 1986a, 1987; Bolle et al., 1986; Rotty, 1987; Lerner et al., 1988; Seiler, 1984; WMO, 1985; Hansen et al., 1988; Houghton et al., 1987; Matthews and Fung, 1987.)

Community (15), China (10%) India (3%), Brazil (1%).[1] The South holds the North responsible for this act of pollution. The North, while admitting its mistake however argues that the CO_2 emission is just another factor in the global pollution scenario and that deforestation, over exploitation of resources, a galloping rate of population (factors which are caused largely by the South) are equally responsible for the global environment degradation.

It is incredible but true that in the last twenty years, human activity has cleared as of the Earth's forest cover as was previously cleared in all of the planet's history! The rate of deforestation is at present estimated to be around 11.4 million hectares per year and this rate is accelerating in the tropics. Some 3.4 billion cubic meters of wood are taken from the Earth's forests each year, with the forests disappearing at such an alarming rate, the use of fossil fuels like coal, petroleum, natural gas, etc. stands to increase dramatically-a combination that would further accelerate global warming and bring about a drastic increase in the sea level.[2] Along with the loss of forests, the extinction of wild life species is also disturbing the ecological equilibrium of the planet. Yet, despite the scenario there is a clear divergence of attitudes between the North and the South on the strategy to meet the

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1. K.N. Prakash, "Our Planet: Battling for survival," in Civil Services Chronicle Vol. III No.3, P-9.

2. Ibid

challenge. While the developed countries are calling for an international agreement on forestry that would impose a blanket ban on cutting the remaining tropical forests, developing countries are under enormous economic pressure to clear their forests and provide jobs and employment. These countries which comprise nations like India, Thailand, Brazil etc., argue that they want their natural resources-as the North has done-to provide basic amenities like food, education, health care etc., to the people of their respective countries. Forests are also a valuable source of foreign exchange and in most of the developing countries nearly all the timber produced is exported to earn the much needed foreign exchange. Developing countries also question why they should bear the economic burden for solving a problem largely created by pollution by the North which is caused by the burning of fossil fuels and excessive industrialization, along with a heavy emission of the greenhouse gases brought about by vehicles, nuclear waste, dumping of garbage, and other such means. They also insist that preserving the remaining forests would also preserve many types of plants and animal species which are part of the eco-system. But the South with its own domestic and regional problems of economy, polity and society is not willing to concede to these demands of the developed North.

The issue of the transfer of environment-friendly technology to be made available to the developing countries by the developed nations, at price they can afford,

technology to enable them to industrialize in a less environmentally destructive manner than has been done until now in the developed countries. In short this means funding highly sophisticated equipment and technology to the developing countries. The transfer of technology gets bogged down on the crucial issue of the Intellectual Property Rights (IPR)[3]. This is because most of the environment friendly technology devised in the industrial nations are developed and owned by huge private companies. Governments are not therefore able to dictate the transfer of patented technologies. While the South calls for a cheap and subsidised transfer, the companies which own the patents and the intellectual property rights view it merely as another commercial transaction which must be paid for, by the developing countries. This issue was also one of those issues which the U.S. tried to water down.

Another issue of grave concern is that of the increased and increasing rate of the emission of the green house gases especially by the developed countries about which the South has a lot of reservations. The United Nations Conference on Environment and Development showed a positive response to some extent towards the strategies for the decrease in these emissions. Although the US had some reservations, in the beginning it later on agreed to sign on the agreement, that might if carried out decrease the

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3. Ibid

emissions that contribute to the global warming phenomenon. The European Community and Japan who have more bending attitudes and who the world community feels are more responsible responsive to the call for saving the planet have promised to limit carbon di oxide emissions, which are contributing to global warming at the 1990 level by the year 2000[4]. The U.S. has not agreed to make any this kind of a promise which again paved a way for another road of political discontenment amongst the North.

Amongst one of the key bones of contentions in recent times and which sparked off various arguments mainly between the North and the South especially during the Earth Summit was that of the funding of the cleaning up of the degraded environment. According to the Secretary General of the United Nations Conference on Environment and Development Mr. Maurice Strong, has said that it is the developed countries who have degraded the environment and so now it becomes their responsibility to finance the cleaning up of the environment, and that it was not something in which the Developing countries should participate. The cleaning up process is a work which is required to be done by all the countries and all the countries should be ready to shoulder this responsibility. But this is one avenue where there is seen absolutely no scope for any kind of a compromise but where it is required the most. The G-77 group

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4. The Times of India, "Score card of the historic meet", June 15, 1992, p-5.

of developing countries in the Earth Summit proposed a deadline of 2000 AD for the North to pay 0.7% of its gross domestic product as overseas development assistance. But as it has already been seen that this kind of a concrete stand to specify its position has always led the other side to oppose to it vehemently, and the same was seen in the Rio Summit when the US refused to consider any such deadline. The US at present pays 0.23% of its GDP[5] Another example of the disrupted bonhomie unity was seen amongst the G-77 developing countries, as they could never project their views effectively due to lack of a clear headed leader among them. For example they gave up their stand of insistence on a Green Fund (GEF), which is to be one of the financial mechanisms for funding the greening of the Earth. It also preferred a weak and ineffective climate change convention because it depends heavily on coal and would have to curtail its use in the face of an energy regime.

Apart from the funding of the cleaning up of the environment another issue which has brought about a difference in opinion the global politics of environment, is that of the issue of Bio-diversity. An example of a country's self-centered approach without any thought for the globe in general was the refusal by the US to sign the treaty on Bio-diversity. Bio-diversity simple means as has been discussed in the previous chapter, the immense variety

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5. The Times of India,"Hitch over funding", June 8, 1992, pp-1 and 5.

Environment-Friendly substitutes

Items	Chemical to be phased out	Substitutes
Refrigerators	CFC-11/12	HCFC-134 A/152 A
Fire extinguishers	H-1211/1301	None
Air Conditioners	CFC-11/12	HCFC-22
Aerosols (Medical)	CFC-12	None
Aerosols (Non-Medical)	CFC-12	DME, LPG
Precision cleaning (Used in electronic industry)	CFC-113	HCFC-225
Water coolers	CFC-12	HCFC-22

CFC- Chloroflurocarbon; HCFC-hydrochloroflurocarbon; H-Halon; DME- dimethylene; LPG-Liquified petroleum gas

in forms of life on Earth. Scientists consider this mind-boggling variety to be a precious natural resource which must not be lost. Therefore the preservation and conservation of this bio-diversity had become one of the key issues at the Earth Summit. A pure usage of political loopholes has given the U.S. scope for justifying its actions of not signing the treaty to make extra efforts in protecting the endangered species of plants and animals. The US feels that the issue of Intellectual Property Rights (IPR) has not been protected under the Bio-diversity convention.[6] The convention as it stands now is more favorable to the developing countries. No amount of appeals from all over the world, last minute persuasions, and political isolation of the US at the Earth Summit could deter the US from its stand thereby creating even more of a rift between it and the developing nations of the world.[7]

The fact thus remains that even though such a picture of the terrifying future of the Earth has been portrayed by the scientists, it has still to bring the world to its senses and to get it to understand that no matter who will finance the cleaning, no matter who is responsible and it is we who live here and we who are going to go on living. So instead of putting more stress on the issue itself because global warming and rising sea level do not exactly

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6. Prakash, n.1

7. Times of India, n.4

know the meaning of geo-political boundaries, and our emphasizing on the political aspect of the situation will only deteriorate the situation and then there will be no more avenues left for any summit.

REGIME FOR THE COMBATING AND PREVENTION OF SEA LEVEL RISE

Sea level has risen 0.1 to 0.15 meters in the last century. The magnitude of this rise is consistent with the changes that would result from increases of carbon-di-oxide and other greenhouse gases in the atmosphere, as predicted by atmospheric and ocean models. The presently projected global warming may cause a substantial rise in the sea level. Current evidence indicates that a 0.3 meter rise could occur in the next 50 years, 0.5 to 2.0 meter rise by 2100, and a 5 meter rise in the next 200 to 500 years.[8]

Such a rise will inundate wetlands and low lands; accelerate coastal erosion; increase the risk of flood disasters; create problems with respect to drainage and irrigation system; and increase salt water intrusions into the ground water and bays, rivers and farmland. These effects could damage port facilities and coastal structures;' destroy quality farmland; disrupt fisheries and bird habitats; diminish storm buffer protection; and result in the loss of recreational beaches.

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8. Cees, B., Vrengdenhil and Herman G. Wind., Framework of analysis and recommendations', in Herman G. Wind (ed.) Impact of sea level rise on society-Report of a project-planning session/delft 27-29 August, 1986, p-17. (1987).

Because the increase in the rate of sea level rise will be gradual, it may be difficult to reach a consensus about the need for taking actions. Communities can respond to sea level rise by[9]

a) Defending the shore,
b) Raising the land surface either naturally or artificially,
c) Moving present activities and developments landward, or
d) Adapting to the increased flooding and innudation.

Many areas can be protected with dikes, sea walls, beach fill, landfill and other engineering solutions. However, economic and environmental impacts will often make such a protection unacceptable. Consequently, deferent strategies for protecting land will have to be developed. There is no limit to how high the dikes can be built. High dikes however can create a false sense of security. The larger the rise in the sea level, the greater the disaster that would result if a dike was to be breached.

A comprehensive view over a board of variety of aspects of society such as ecology, sociology, technology, engineering and economics will be required, Measuresto prevent or reduce the undesired effects of sea level rise should not be treated in isolation. Society requires multi functional solutions to its present day multi aspect

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9. Ibid

problems. Given the large difference in regional conditions analysis should be site specific.

A rising sea level is not unprecedented. Many areas of the world have experienced substantial local rises. This constiutes a valuable body of experience that could be useful when responding to future sea level rise.

A full perspective requires knowledge of the various systems and their interrelationships. Sea level rise and the implementation of response strategies will have serious effects at individual, regional and a national levels. Impacts on real income include the loss of production from land and seas as well as the effects of employment changes needed for reconstruction. Migration of the people and enterprises will disrupt the existing economic structure. The necessary redirection of national economic efforts may well meet overall capacity constraints particularly in the less developed countries. Where retreat from threatened areas is unavoidable, the migration of people may cause serious social losses. War and civil disruptions may increase the vulnerability of the infrastructure protecting the population against a higher sea level. Beach resorts provide important revenues to coastal areas throughout the world. However even a 0.3 meter rise projected for the next 40 years could erode the beaches 25 to 50 meters,[10] which in many cases would be the entire

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10. Ibid p-18

beach. The planning of the costal resorts should consider whether it would be cost effective to set buildings back further or to undertake substantial beach nourishment.

Governments and the world scientific community should develop a coordinated international research programme on the impact and policy implications of sea level rise. This would entail:[11]

a) the accuracy of estimates of future rises in sea level should be improved;

b) the ecological, economic and social costs benefits of (additional) costal defence systems, planned resettlement, and other strategies should be investigated;

c) methods and models for integrating the diverse inter-disciplinary information about the impact and policy implications of sea level rise should be developed to support policy formulation;

d) the experience of areas that have undergone local rises in sea level in the past should be investigated.

e) a coordinated international program of monitoring of sea level rise, related processes and their impact should be initiated.

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11. Ibid p-19

f) it is important to increase the awareness of the implications of sea level, rise for present and future development and planning activities. It will be necessary to bring together scientists, engineering and policy makers in international workshops, incorporate sea level rise and other effects of the global climate change into the curricula of schools and colleges and brief ministers of national governments on the potential impact of sea level rise.

Thus if these steps are taken it can be assumed that our society will be in a much better position to combat the present and future sea level rise.

Although in the present times scientists as well as policy makers have tried to understand the gravity of the situation as far as the question of sea level rise in concerned and the world community has started taking steps to reduce the carbon di oxide and other green house gases emissions so as to reduce the scenario of global warming which is actually understood to be responsible for the swelling up of the ocean bodies and have created such a flutter in the international arena about the future of the globe and the man.

The best way to reduce the ever growing problem of the changing world scene in the form of the rise of the sea level at places in a moderate way but at place in such am a manner that those places only will be wiped off from the

face of the earth, would be to reduce the global warming. Some of the examples of the crisis on the land areas are the low lying areas of the countries which have a large shoreline and which are mainly in the midst of the cyclonic area of the tropical regions of the world falling mainly in the Indian Ocean and the Pacific Ocean.

To reduce the constant threat of the rising sea level efforts will have to be made to reduce the emission of the green house gases which are actually held responsible for the increasing temperature of the Earth. This can be brought about by adhering to the strategies and plans made by the world community in general. Usage of the environment friendly technology in the industries and thereby involving themselves with a sustainable development should be every nation's motive and every nation should take extra care and make an extra effort to be true to the world community and not give into small temptations of short time gains for their respective countries. They should understand that efforts of today will be the cause of making their very own nations a better place to live and would also leave space for those nations who do not have the provision of having a high shoreline and who are in a dire emergency of being submerged in the giant ocean body.

To make an extra effort there are agencies which are trying to prepare the earth for the rising sea level but also trying to reduce the chances of the overwhelming sea

level rise which has been projected. Some of these agencies are governmental, non-governmental, inter-governmental, associated to the United Nations an also private agencies. The United Nations Environment Programme (UNEP), is one agency which has done a lot, beginning with the researches of various kinds to assess the rise in the sea level its causes and impacts-ecological and human as well as means of combating and preventing and rising sea level. Apart from the UNEP, other UN agencies like the UNDP also has made a lot of effort in the work on the prevention of the rising sea level, human responses to it and the development in the wake of the prevailing threats to the earth, in such a great magnitude.

The UN and its agencies, are not just the only ones who have made efforts in this direction. The world meteorological Society and the World Watch Institute are the agencies which have tried to assess the amount of the rising sea levels. Their projects have predicted what is the actual kind of the rise an what are the measure that can be taken to prevent it. Agencies like the United States Environmental Protection Agency (EPA), the Green Peace are the others who have provided such valuable information as well as their researches have given the true picture of what exactly the world needs today as far as the global climate change and the rising sea level. They also stress the need for a strict adherence to the agreements made by the nations at various

junctures about the emission of the green house gases and curbing the ever increasing pollution, as in the developed world.

There have been held a number of conference and Summits in this context (they already have been discussed in the previous chapter) the latest of who was the United Nations Conference on Environment and Development where a committee has been set up which will monitor the usage of the funds by the different countries in the cleaning up of the atmosphere and will see that the nations stick to the promises they made at Rio de Janeiro.

Thus, although the future looks bleak one cannot give up the hope that the rising sea level is something which man could only bring about but does not hold any chances when the issue of combating and preventing it is concerned. Efforts are being made, as they should be, so that one day in the future, the then generations of mankind would not be suffering the brunt of our negligence and selfish attitude.

CHAPTER VII

CONCLUSION :

PROSPECTS FOR SOUTH ASIA

Sea level rise is a problem, whose impact will be seen in nearly all the regions, especially coastal regions all over the world. But South Asian Region or the SAS to said to be the most vulnerable one. A vulnerability which is caused by factors like low lying coastal areas. Rapid deforestation, overgrowing rate of population, developing and poor economics and an uneducated population. These factors create all the more space for degradation of the coastal areas. Apart from the rise of sea level, other impacts of the global climate change, has left the South Asian Region in a very weakened position. The global warming which paves way for Acid deposition, deforestation, forest fires, reduction of agriculture, and many other such kinds of hazards. Global climate change and the rising sea level could also be responsible for the spread of diseases, an increase in their intensity, flooding of coastal areas, droughts, famine etc., a challenges that the South Asian Economics would not be in a position to meet. Concern about coastal swamps and marshlands comes from their special ecological value and the fact that they are already under stress from human development and pollution. And as these constitute an integral part of the South and South East Asian regions, especially in Bangladesh, Thailand, Indonesia, Sri Lanka, etc. where much of the land is bordered by the sea and who are in dire need of required steps to prevent the rising sea level, which if risen as

predicted could severely hit their social and economic situation.

Special programes thus have been started in the South Asian Region. These programmes would not just help combat the rise in the sea level, but have also taken steps for prevention of the rise.

Now it is widely accepted that the sea level is going to rise. Therefore, island nations and the third world under developed countries, which are situated in mountain belt and are likely to be most affected, should also examine the biological measures they can undertake to mitigate the adverse impact of sea level rise. Some of them are included here:

1. RECLAMATION OF LAND THROUGH SILT TRAPS

Hoogly Matta is one of the biggest estuarine systems in the globe. Weather Watch Research Institute, Washington has estimated that more that 12 billion tonnes of silt is discharged annually by this estuarine system over centuries. This silt has been deposited in the shape of Bengal Fan. Some of the coastal areas near the Diamond Harbor have also become shallower. Calcutta port also has problems relating to formation of sand and bars and sedimentation. Dredging of Calcutta Harbor is a recurring expenditure which is undertaken to maintain navigability of the system. Keeping in view the large amount of silt which

is available annually, it is proposed to undertake the following programmes

i) Brick Making and Estimation of Sustainable Yield from Selected Areas

Traditionally, the local people have constructed 'Bherics' along the estuaries in which brick making is undertaken as an artisanal measure. This is a major source of material used for bricks. It is suggested to study these bricks and develop experiments to determine methodologies to increase the hardness of bricks so that they could be used in coastal areas for low cost housing. The constant removal of the silt would also require scientific studies to indicate the quantity of silt which can be deposited annually in the artificially created silt traps.

ii) Reclamation of Land Through Silt Traps and Silt Barriers

After the monsoon season, large quantities of silt are deposited in the supertidal region. However, on a regular basis this silt is used by the local people for domestic purposes. Experiments conducted also indicate that if silt is collected in the selected areas, it results in raising of the land. Successive artificial barriers placed in an inclined plain help to arrest the silt but the water is slowly drained away. In this manner large low lying areas of depths less than half a meter can be reclaimed. It is therefore, proposed to design experiments to unertake

studies on the rate of situation. The total silt deposited and the time which will be required for reclamation of 1 hac. area with an average depth of half meter at the high tide level.

iii) Plantation and Beach Conservation

Supertidal regions are affected by storm surges and cyclones and are generally devoid of any major negetation. Extensive experiments have been conducted in Goa and Maharashtra along the West Coast of India where it has been found that few trees can be grown in the sand itself. There are casuariana and few other shady trees. The scheme can also be operated under social forestry programme. It is also proposed to study the extent to which this social forestry project would help in making greater availability of fuel and reducing the adverse effect of winds during storm surges and cyclones and the role. They will play in protection of the small residential houses which would be located behind the social forestry belt.

iv) Reclamation Through Fishery Estates

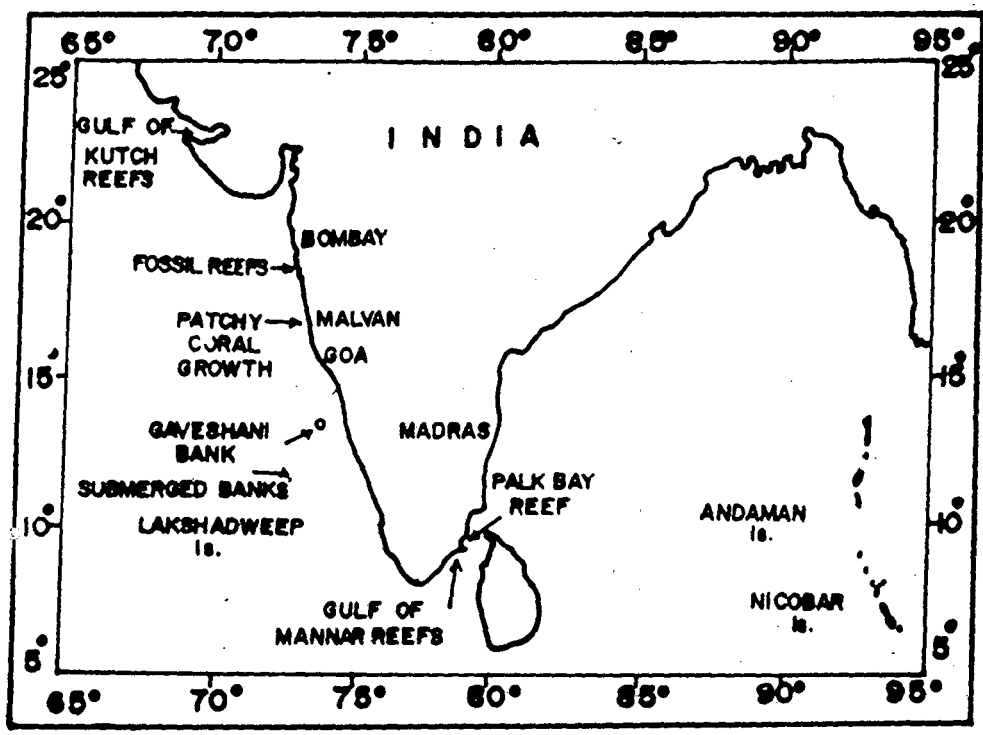
Traditionally, dykes and sea walls are built to check erosion. In this process, it is suggested that the low lying mud flats in swampy areas which lie in the vicinity of the estuarine region and coastal lakes can be reclaimed by construction of farms in semi protected areas which extends upto half a meter depth. These areas are normally rich in

prawn and fish larvae and with proper scientific inputs they can be used for aquaculture purposes the plantation of trees and coconuts are also useful for construction of bandhs and protection of the entire ecosystems. In this way, the coastal belt which is otherwise subject to storm surges and cyclones and is constantly eroded, can be reclaimed to a large extent. The experiments conducted in the coastal districts of Andhra Pradesh have shown encouraging results. It is therefore, proposed to select protected areas and backwaters for converting them into the fishery estates and using them for short term prawn and fish culture. Care should be taken to avoid major civil works. The process helps in raising the level of the land, land alignment and reshaping with the locally available materials. Through this process even the areas which could be subjected to half a meter flooding can be checked to provide adequate conservation measures against erosion.

v) Conservation of Coastal Lakes and Lagoons

Due to the continuous process of silting , the costal lakes become narrower and the sea water entry becomes restricted. The examples are Chilka lake in Orissa and Pulikut lake in Tamil Nadu. It is suggested to study the ecology and coastal oceanography of these areas to ensure that the silting does not take place so that with the sea level rise the immudation and damage in the interior areas is avoided. The shallower areas adjoining the outer edge of

Distribution of Coral reefs and Coralline banks in the Indian seas.



Distribution of coral reefs and coralline banks in the Indian seas

these lakes can also be converted into fishery estates and large farming systems.

vi) Aquaculture and economics of Locally Available Cultivable Fishes

It is well known that the aquaculture of prawn is very productive. The intention of undertaking fish aquaculture in south asia is to develop a new system by which the local community will be encouraged to reclaim the low lying areas,m raise their bandhs more than one meter and undertake plantation on these areas. In this way large areas of the coast line which get imundated can be prepared for combating the projected sea level rise.

vii) Coral Reefs in the Island Ecosystem

A small state conference was conducted in Maldives from 14-18 November, 1989 in which the question of the history of coral reefs and rate of the fast growing corals were discussed. It is therefore, suggested to plan artificial colonies of branching corals and study their growth rates. If the projected sea level rise by 2015 is less than half a meter, then it is quite helpful that by proper planning and implementation, artificial coral reefs can be grown in the vicinity of islands to combat the adverse effects of sea level rise.

viii) Mangrove Ecosystems

Due to the projected sea level rise, changes are

being caused in the mangrove swamps of sunderbans. In some areas, mangroves have also died out. In other areas, mangrove swamps have become more saline and the composition of species of both fauna and flora is changing. It is hence, proposed to study the physio-chemical conditions, productivity of benthos, phyto and zooplankton, availability of juvenile prawns and fish. In addition, it is also proposed to study the role of different kinds of ecosystems, for the kind of species they will support for breeding and reproduction, as nursery grounds and as habit for growing adult fish in south asia where it is required the most.

ix) Mangroves and Bio-Mass Production

Colonisation of mangrove trees is a very well known phenomenon. Thus a study of the zonation and bio-mass production of different mangrove species should be done, so that they may be used for plantation in the marshy land and backwaters. The studies will also help in estimating the regenerating capacity of the mangroves and other fliage under different environment conditions.

Sewage discharges lead to high degree of turbidity including heavy and trace metals in the aquatic environment. Turbidity depresses phytoplankton production and the benthic environment is altered by sedimentation. Addition of organic and inorganic nutrients due to this turbidity leads to sudden expansion of some biological communities. If the

sewage discharge through the pipeline is on the shore, the growth of sea weeds and intertidal animal species adapted to high nutrient levels may be encouraged. Such enhancement of limited group of species is an important effect of sewage input which disturbs the energy transfer through food webs, which ultimately lead to reduction in species diversity. However, treated sewage from properly designed and well positioned outfalls is unlikely to have significant detrimental effect over a long range.

Remote Sensing and Sea Level Rise

Sea level rise (SLR) is a slow phenomenon, and its impact is gradual. It needs long term and precise observations to understand and predict the likely changes that may occur along the coasts of the continents and islands. These impacts of SLR are global in nature but they undergo annual, regional and local variations. They are influenced by the coastal morphology and rainfall, particularly in the countries situated in the monsoon belt on Asia.

Monsoon and Floods

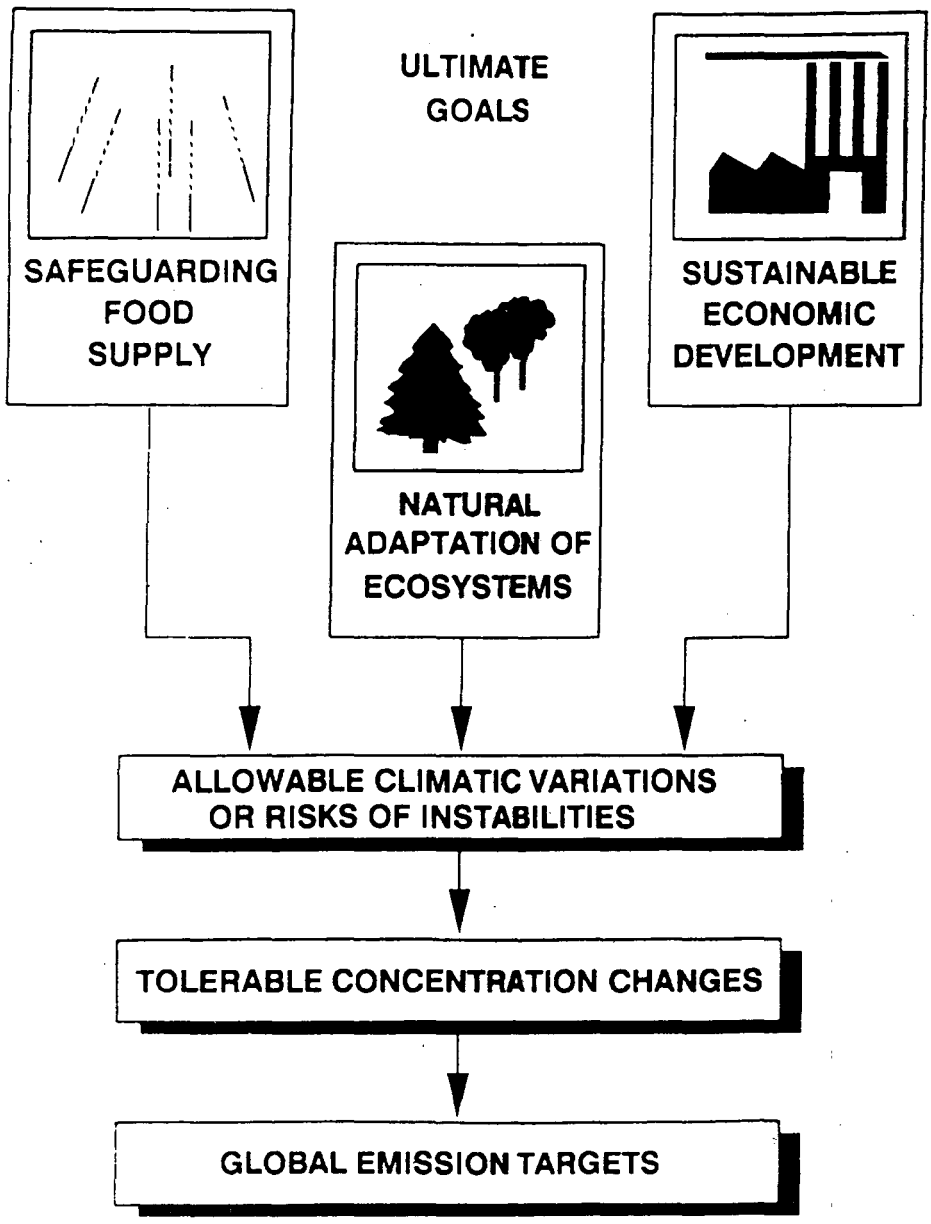
In the delta and estuaries of rivers like Mekong in Thailand, Brahmaputra in Bangladesh. Ganges and Godavari in India, Indus in Pakistan, flooding is almost an annual feature and loss of human life and damage to property in coastal areas occur frequently on the other hand, the coast

line in the tropical countries is a preferred area, as these regions are more productive and have a moderate climate and encourages fast development of large metropolitan cities as evidenced now in this zone. The coast line is being reclaimed an modified continuously. The coast of development and density of population is very high, therefore, if these areas get submerged due to climate change the loss will be very extensive.

Coastal Morphology

Due to coastal process, hydrography and currents the continental margins, estuaries and island undergo seasonal and long term fluctuations. The occurrence and disappearance of sand bars is caused due to silt movement. It influences closing and opening of the mouths of the estuarie and the coastal lakes and brings about changes in the hydrology and biological character of the area. Therefore, it is necessary to study the morphology of the coastal margins, estuaries, coastal lakes, back waters and lagoons and understand seasonal and annual variations.

The discharge of sewage and organic wastes in estuaries undergo quantitative changes. In many parts, the estuaries get connected to low lying coastal plains, mud flats, and marshes and pollute them, thus large areas become unfit for development. In these areas, production of organic debris and detritus is a continuous process. The disposal and deposition of detritus and silt depends on coastal



Long term environmental and development goals as a basis for short term policy targets.

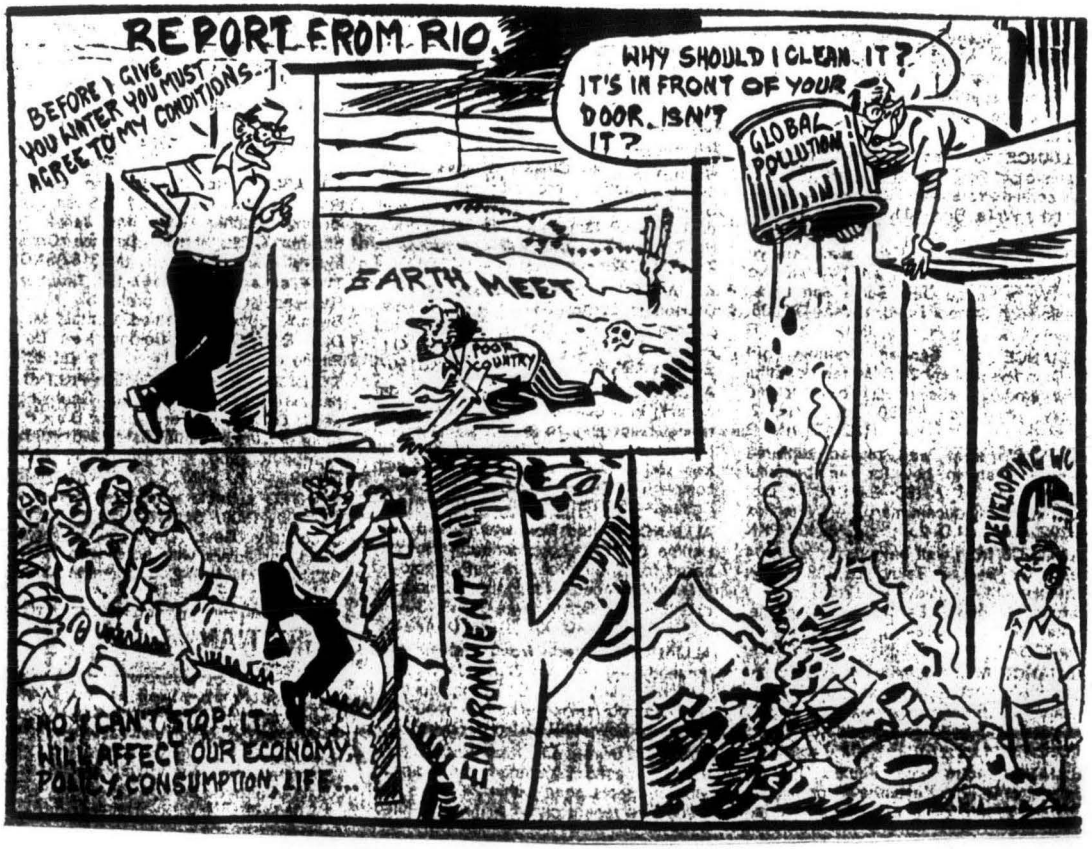
currents. Such areas are abundant near Bangkok, Calcutta, Bombay and in Shatal Arab in Iraq and are vulnerable to S.L.R.

Flooding changes the pattern of silt deposition, hydrography, rate of flow and mixing of estuarine waters. Consequently, changes in biology, productivity, diversity of fauna and flora, reproduction and population composition are brought about. It is necessary to develop a comprehensive, long term monitoring system using remote sensing, and satellite imagery supported by aerial photography, photo interpretation and verification by the ground trucks to study these areas. The ground truth requires continuous data updating, and data comparison, preparation of charts to catalogue annual changes. The study of long term changes will help in combating with the increased sea level and its drastic effect on the human beings in South Asia.

The developing countries of South Asia need a special treatment when talking of their prospects in the wake of the rising sea level and the climate change. Their economies need to be developed and only then can they dream of standing on par with the developed world of the North. As for a sustainable development-this is an issue, which naturally must take priority with any nation and so the South Asian nations are no exception. But trying to force their growth to meet the conveniences of the North is quite

an unreasonable requirement of the developed world. **South Asia cannot be denied its right to grow nor to choose their own pathways to growth. Nor should that right be constrained by new conditions of trade or financial aid imposed in the name of environment, because who would know the meaning of the impact of the rise in sea level, better than South Asia.**

A fact that can't be denied is that the South Asian Region does need financial support from the developed world, not just to develop,**but to develop in the cleanest possible way. The South Asian Countries must be enabled to leap frog the environmentally destructive paths pursued in the West since the Industrial revolution. To do this, they will need financial support, vastly improved professional and institutional capacities and the cleanest and latest technologies.** Hiding behind the facade, of improving and developing in an environmentally clean way, the developed nations have somehow tried to curb South Asia's more gingerly taken steps in that direction, as was evident during the recently held Earth Summit at Rio de Janeiro, where, the Indian Minister for environment Mr. Kalpnath Rai expressed his reservations against the treaty on climate change. In India's view, the 'safe' and clean' technology implied the exclusion of nuclear technology by which the US would like to bring in controls on national policies through the backdoor as it were. This amounts to using environment to enforce the nuclear non-proliferation treaty. Thus this


REPORT FROM RIO
BEFORE I GIVE YOU WATER YOU MUST AGREE TO MY CONDITIONS
WHY SHOULD I CLEAN IT? IT'S IN FRONT OF YOUR DOOR, ISN'T IT?
GLOBAL POLLUTION
EARTH MEET
POOR COUNTRY
NO, I CAN'T STOP IT. IT WILL AFFECT OUR ECONOMY, POLICY, CONSUMPTION, LIFE...
ENVIRONMENT
DEVELOPING WORLD

is not environment that is being talked of but something else altogether. This kind of an international political manipulation is what makes South Asia a part of the world that is disregarded of consideration of problem, which concerns it the most.

What the North fails to understand, that if the South Asian Region had funds, to develop their economies in a sustainable fashion, why would it still risk its whole existence in development. The problem of funding, which again was a major issue at the recently concluded Earth Summit in Rio is not just the North giving the South, monetary and technical help, but also securing its own future on this globe.There is a tendency to regard the costs of protecting the environment as an additional cost we can ill afford. But, much of what we often term 'cost' should really be regarded as investment which will produce a good return in economic as well as environmental terms. So the best way to move on to a sustainable growth would be through the help of the developed North.

Environment is an issue for which even individual on this earth is responsible for. So to allow policy makers to decide and rule the environment keeping in mind there own selfish interests is not part of a healthy scenario. Because their actions are motivated by a lot of things, and whether their decisions are implemented in toto is a thing which has to be waited for. As Mr. Maurice Strong in an interview said

Decision makers should not be allowed to hide behind science, in the name of seeking scientific certainty before acting. In science certainity is an impossibility and decision makers are used to making policy decisions under conditions of considerable uncertainty-that is what they are good at

Even if they are good at making decisions during conditions of uncertainty. I feel that global climate change, especially in South Asia does not have an ounce of uncertainty. The climate is changing and the sea level is rising, so there should be no faltering in the steps taken towards creating an environment of those clean pre-industrial times, because the environment to composed of a seamless web of relationships between living organisms and the air, water and the land that surround them accordingly rather than continue toadrers environmental issues in a isolation from each other-we must expand our efforts to understand and protect the functional integrity of the environment and our place in it.

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Just as philosophies, religions and ideals know no boundaries, so the protection of our planet itself involves rich and poor, North and South, East and West. All of us have to play our part if we are to succeed. And succeed we must for the sake of this and future generations.

One of the great English poets George Herbert, in his poem 'Man 'Wrote:

Man is all symmetry
Full of proportions, one link to another, and all to all the world besides;
Each part may call the farthest, brother; for head with foot hath private amity,
and both with moons and tides

We are in symmetry with nature. To keep that precious balance, we need to work for our environment. Because **We have not inherited this earth from our fore fathers. We have borrowed it, from our children.**

BIBLIOGRAPHY

BIBLIOGRAPHY

PRIMARY SOURCES

1. Chandler, W.U., **The Changing Role of the Market in National Economics** (Washington, D.C.: World Watch Institute, 1986).

2. Council on Environmental Quality, **Global Energy Futures and the CO_2 Problem** (Washington, D.C.: The Council on Environmental Quality, 1981)

3. Daniel A. Lashof and Tirpak, Dennis, A., eds., **Policy Options for Stabilizing Global Climate - Draft Report to Congress** (Washington, D.C.: United States Environmental Protection Agency, 1989).

4. Edmonds, J.A. and Reilly, J.M., **The IEA/ORAU Long-Term Global Energy CO_2 Model** (Tenessee : Carbon Dioxide Information Centre, Oak Ridge National Laboratory, 1984).

5. Edmonds, J.A., Reilly, J.M., et. al. **Uncertainty in Future Global Energy Use and Fossil Fuel CO_2 Emissions 1975-2075** (Washington, D.C. : U.S. Dept. of Energy, 1986)

6. Emery, K.O., and Uchupi, E., **Western North Atlantic Ocean Memoir 17**. (Tulsa : American Association of Petroleum Geologists, 1972)

7. Everts, C.H., **Potential Impact of Sea Level Use on the Beach at Ocean City, Maryland** (Washington, D.C., U.S. Environmental Protection Agency, 1985)

8. FAO (Food and Agriculture Organisation), **Agriculture : Toward 2000** (Rome : FAO, 1981) 9. Food and Agriculture Organisation of the United Nations, **Production Yearbook,** Vol.39 (Rome : FAO, 1986)

10. Goldenberg, J., Johansson, T. Betal., **Energy for a Sustainable World** (Washington, D.C. : World Resource Institute, 1987) p.119.

11. Lacis, A., Hansen, J.E., Le, P., Mitchell, T., and Lebedeff, S., **"Greenhouse effect of trace gases, 1970-1980"**, Geophysical Research Letters, n. 81(10), 1981, pp.1035-1038.

12. Lashof, D., **The Dynamic Greenhouse : Feedback Processes That May Influence Future Concentrations of Atmospheric Trace Gases** (Washington, D.C. : U.S. Environmental Protection Agency, 1988)

13. MacCracken, M.C., and Luther, F.M., **Projecting the Climate Effects of Increasing Carbon Dioxide** (Washington, D.C. : Department of Energy, 1985)

14. National Academy of Sciences, **Carbon Dioxide and Climate : A Scientific Assessment** (Washington, D.C. : National Academy Press, 1979)

15. National Academy of Sciences, **Changing Climate** (Washington, D.C. : National Academy Press, 1983).

16. National Academy of Sciences, **Current Issues in Atmospheric Change** (Washington, D.C. : National Academy Press, 1987).

17. Natioal Research Council, **Changing Climate** (Washington, D.C., : National Academy Press, 1983).

18. Office of Technology Assessment, U.S. Congress, **Technologies to Sustain Tropical Forest Resources** OTA-F-214. (Washington, D.C., : Government Printing Office, 1984).

19. Schnell, R.C., ed. Geophysical Honitoring for Climatic Change (Boolder : National Oceanographic and Atmospheric Administration Environmental Research Laboratories, U.S. Dept. of Commerce, 1987).

20. Schuh, G.E., **Agricultural Policies for Climate Changes Induced by Greenhose Gases** (Washington, D.C., : U.S. EPA, 1988)

21. Seidel, S., and Keyes, D., **Can we Delay a Greenhouse Warming?** (Washington, D.C. : Office of Policy and Resources Management, U.S. Environmental Protection Agency, 1983).

22. Sharma, H.S., ed. **Perspectives in Geomorphology,** Vol.I. (India, 1981).

23. Smith, Hance, D., and Vallega Adalberto, eds., **The Management of Semi-Enclosed Seas : The Emerging Global Pattern and The Ligurian Case** (Genova : International Geographical Union, 1990).

24. UNEP, **Possible Effects Of Man's Activities on the Ozone Layer and Climate**, (Nairobi : UNEP, 1986).

25. U.S. Agency for International Development, **Energy and the Environment : An Appraisal of Energy Assistance Strategies for Minimizing Environmental Impacts in Developing Countries** (Washington, D.C. : AID, 1988)

26. U.S. Army Corps of Engineers, **Handbook of Coastal Processes and Erosion** (Fort Belvoir : Coastal Engineering Research Center, 1983)

27. U.S. Environmental Protection Agency **Meeting Summary of Workshop on Agriculture and Climate Change** (Washington, D.C. : J.T. & A., Inc., 1988)

28. World Meteorological Organisation, **Atmospheric Ozone 1985 : Assessment of Our Understanding of Processes Controlling its Present Distribution and Change** (Geneva: World Meteorological Organisation, 1985).

29. World Resources Institute, World Bank and United Nations Development Programme, **Tropical Forests : A Call for Action** (Washington : WRI, 1985)

SECONDARY SOURCES

1. Abrahamson, Dean Edwin, ed., **The Challenge Of Global Warming** (Washington, D.C. : Island Press, 1989)

2. Aggarwal, Anil and Narain, Sunita, **Global Warming in an Unequal World : A Case of Environmental Colonialism** (New Delhi : Centre for Science and Environment, 1990)

3. Ahmed, E., **Coastal Geomorphology of India** (New Delhi : Orient Longman, 1972).

4. Bach, W., Pankranth, J., and Kellog, W.W., eds., **Man's Impact on Climate** (Amsterdam : Elsevier Scientific Publishing House, 1983)

5. Barth, M.G., and Titus, J.G., **Greenhouse Effect and Sea Level Rise** (New York : Van Nostrand Reinhold, 1984)

6. Berger, W.H., and Crowell, J.C., **Climate on Earth History** (Washington, D.C. : National Academy Press, 1982).

7. Bhumralkar, Chandra Kant, M., eds., **Meteorological Aspects of Acid Rain** (New Delhi, 1984)

8. Bird, E.C.F., **Coastline Changes** (Chichester : Wiley Interscience, 1985)

9. Bird, E.C.F., et.al. eds., **Man in the Mangroves** (Tokyo: United Nations University, 1987)

10. Bird, E.C.F. and Schwartz, eds., **The World's Coastline** (1985)

11. Bleviss, D., **The New Oil Crisis And Fuel Economy Technologies : Preparing the Light Transportation Industry for the 1990's** (New York : Quorum Press, 1988).

12. Bolin, B., et. al. eds., **The Greenhouse Effect, Climate Change and Ecosystems** (Chichester : John Wiley and Sons, 1986).

13. Brunee Jutta, **Acid Rain and Ozone Layer Depletion : International Law and Regulation** (New York : Transnational Publishers, 1988)

14. Budyko, M.I., **Climate and Life** (New York, 1974)

15. Chandra Soysa, Chia Lin Sien and Collier, W.L., **Man, Land and Sea.** (Bangkok : Agricultural Development Council, 1982)

16. Corell, R.W., and Anderson, P.A., eds., **Global Environmental Change** - NATO ASI Serries Vol.1. (Berlin: Springer - Verlg, 1991)

17. Flavin, C., and Durning, A., **In State Of The World 1988: A Worldwatch Institute Report On Progress Toward a Sustainable Society** (New York : W.W. Norton and Co., 1988)

18. Flenley, J.R., **The Equatorial Rain Forest** (London : Butterwortas, 1979)

19. Fung, I., **Agricultural Emission Coefficients Estimates** (Washington, D.C. : U.S. EPS, 1988)

20. Goldenberg, J., Johansson, T.B. et.al., **Energy for a Sustainable World** (New Delhi : Wiley Eastern Limited, 1988)

21. Goudie, A., **Environmental Change** (Oxford : Uarendon Press, 1986)

22. Hanssen, J. and Takanashi T. eds. **Climate Processes and Climate Sensitivity** (Washington : American Geophysical Union, 1984).

23. Hawett, E.A. **Energy, Economics and Foreign Policy in the Soviet Union** (Washington, D.C. : The Brookings Institution, 1984)

24. Hoffman, J.S., Keys, D., and Titus, J.G., **Projecting Future Sea Level Rise** (Washington, D.C. : Government Printing Office, 1983)

25. Jager, J., and Ferguson, H.L., **"Climate Change : Science, Impacts and Policy"** (Cambridge : Cambridge University Press, 1991).

26. Kuo, C., ed., **Potential Impact of Sea Level Rise on Coastal Drainage Systems** (Washington, D.C. : U.S. Environmental Protection Agency).

27. Kellog, W.W., and Schware, R., **Climate Change and Society** : Consequences of Increasing Atmospheric Carbon Dioxide (Boulder : Westview Press, 1981)

28. Lamb, H.H., **Climatic History and the Future** (Princeton: Princeton University Press, 1977)

29. Lamb, H., **Climate, History and the Modern World** (London: Methuen, 1982)

30. Lamb, H.H., Climate : **Past, Present and Future,** Vol.2 (London : Methuen Co. Ltd., 1977).

31. Meier, M.F., et.al., **Glaciers, Ice Sheets and Sea Level** (Washington, D.C. :National Academy Press, 1985)

32. Hoffman, J.S., Keyes, D., Titus, J.G., **Projecting Future Sea Level Rise** (Washington, D.C. : EPA., 1983)

33. Hull, C.H.J., and Titus, J.G., eds., **Greenhouse effect, sea level rise, and Salinity in the Delaware Estuary** (Washington, D.C. : U.S. Environmental Protection Agency, 1986)

34. Husselbee, W.L., **Automotive Emission Control** (Virginia, Reston Publishing Co., 1987)

35. Nordhaus, W.D., and Yohe, G., **Changing Climate** (Washington, D.C. : National Academy Press, 1983)

36. Parry, M.L., **Some Implications of Climate Change For Human Development-Sustainable Development of the Biosphere** (Cambridge : Cambridge University Press)

37. Rajamanickam, Victor, G., ed., **Sea Level Variation And Its Impact On Coastal Environment** (Thanjavur : Tamil University Offset Press, 1990)

38. Repetto, R., and Gillis, M., eds., **Public Policy And The Misuse Of Forest Resources** (Cambridge : Cambridge University Press)

39. Revelle Roger and Waggoner Paul, **Changing Climate** (Washington, D.C. : National Academy Of Sciences, 1983)

40. Springer, Allen, L., **Protecting the Global Environment** in a **World of Soverign States** (Westport, Conn. 1989)

41. Titus, J.G., **Effects of Changes in Stratospheric Ozone and Global Climate, Vol. 4** (Washington, D.C. : D.S. Environmental Protection Agency., 1986)

42. Titus, J.G., and Barth, M.C., eds., **Greenhouse effect and Sea Level rise : A Challenge for this Generation** (New York : Van Nostrand Reinhold, 1984)

43. Ward, Barbara and Dubos, Rene, **Only One Earth, The Care and Maintenance of a Small Planet** (London : Penguin Books in association with Andre Deutsch, 1972)

44. Wind, Herman, G., ed., **Impact Of Sea Level Rise on Society** (Rotterdam : A.A. Balkema, 1987).

ARTICLES

1. Aggarwal, Anil, "The North-South Perspective : Alienation or Inter Dependence", **Ambio** vol.2, April, 1990

2. Bacastow, R.B., Keeling, C.D., "Seasonal Amplitude Increase in Atmospheric CO_2 Concentration at Mauna Loa", **Journal of Geophysical Research** No.90, 1985, pp. 10529-10540

3. Barnelt, T.P., "The examination of global sea level Changes : A problem of Uniqueness", **Journal of Geophysics Research,** n.87, 1984, pp.7980-7988.

4. Barnett, T.P., "Recent Change in Sea Level and Their possible Causes", **Climate Change**, vol.5, 1983, pp.15-38

5. Bingemer, T.M., Crotzen, P.J., "The Production of Methaue from Sahid Wastes", **Jouranal of Geophysical Research**, no.92, 1987, pp.2181-2187

6. Bird, E.C.F., "The effects of a rising sea level on the coasts of Thailand", **ASEAN Journal on Science and Technology for Development.,** Vol.6, 1989, pp.1-13

7. Blake, D.R. and Rowland F.S., "Continuing Worldwide Increase in Tropospheric Methaue 1987-88", **Science**, No.239, 1988,, pp.1129-1131.

8. Bowden, W.B. and Bormann., F.H., "Transport and Loss of Nitrous Oxide in Soil Water After Forest Clear-Cutting", **Science** No.233, 1986, pp.867-869

9. Broecker, W., "Unpleasant Surprises in the Green House?", **Nature**, No.328, 1987, pp.123-126

10. Bruun, P., "Sea Level rise as a cause of shore erosion", **Journal of Waterways and Harbours Divisions** n.1., 1962, pp.116-130

11. Butzer, K.W., "Adaptation to global environmental change", **Prof.Geogr**, n.32(3), 1980, pp.269-278

12. Cess, R.D., and Goldenberg, S.D., "The Effect of Ocean Heat Capcity Upon Global Warming Due to Increasing Atmospheric Carbon dioxide. **Journal of Geophysical Research**, n.86, 1981, pp.498-502.

13. Clark, J.A. and Lingel, C.S., "Future Sea-level changes due to West Antarctic ice sheet fluctuations", **Nature**, n.269, 1977, pp.206-209

14. Crutzen, P.J., et.al., "Bio-mass Buring As a Source of Atmospheric Gases CO_2, H_2, N_2O, NO, CH_3Cl and COS", **Nature**, No.282, 1979, pp.253-256

15. D. Arrigo, et.al., "Boreal Forests and Atmosphere - Biosphhere Exchange of Carbon Dioxide", **Nature**, No.329, 1987, pp.321-323

16. Detwiler, R.P. and Hall, C.A., "Tropical Forests and the Global Carbon Cycle", **Science**, No.239, 1988, p.4247.

17. Diahor - Klokar, V.I., and Yorganov, L.N., "A Spectroscopic Study of the Global Spacetime Distribution of Atmospheric CO_2", **Tellus**, No.33, 1981, pp.262-273.

18. Dickinson, R.E., and Cicerone, R.J., "Future Global Warning from Atmospheric Trace Gases", **Nature** No.319, 1983, pp.109-115

19. Edmonds, J.A. and Reilly J.M., "A Long Term Global Energy - Economic Model of Carbon Dioxide Release from Fossil Fuel Use", **Energy Economics** No.5, 1983a. pp.74-88.

20. Edmonds, J.A., and Reilly, J.M., "A Long-Term Global Warming from Atmospheric Energy - Economic Model of Carbon Dioxide Release from Fossil Fuel Use", **Energy Economics,** No.5, 1983, pp.74-88.

21. Edmonds, J.A. and Reilly, J.M., "Global Energy and CO_2 to the Year 2050", **The Energy Journal,** No.4, 1983, pp.21-47

22. Fairbridge, R.W., and Krebs, Jr., W.S., "Sea Level and Southern Oscillation", **Geophysical Journal**, n.6, 1962, pp.532-545

23. Goldemberg, J, Johansson, T.B., et.al. "An End-Use Oriented Global Energy Strategy", **The Annual Review of Energy**, No.10, 1985, pp.613-618.

24. Glebov, I.A. and Kovalenko. "Strategies for conservation of Fuel and Energy Resources in the Leningrad Region", **Energy**, n.12, 1987, pp.949-952

25. Gornitz, V.S., Zebedeff, S., and Hanssen, J., Global Sea Level Trend in the past Century., **Science**, n.215, 1982, pp.1611-1614.

26. Gupta, S.K., "Chronology of the raised beaches and inland coral reefs of the Saurashtra Coast", **Journal of Geology**, Vol.80, 1972, pp.357-361.

27. Hansen, J., et.al., "Climate Impact of Increasing Atmospheric Carbon Dioxide", **Science**, n.213, 1981, pp.957-966.

28. Hansen, J.E., Johnson, D., et.al., "Climate Impact of Increasing Atmospheric Carbon Dioxide", **Science**, No.213, 1981, pp.957-966.

29. Hao, W.W., et.al., "Sources of Atmospheric Nitrous Oxide from Combustion", **Journal of Geophysical Research** No.92, 1987, pp.3098-3104.

30. Katupotha, J., "Evidence of high sea level during the mid-Holocene on the South West Coast of Sri Lanka", **Boreas**, Vol.17, 1988, pp.209-213

31. Khalil, M.A.K., and Rasussen, R.A., "Carbon Monoxide in the Earth's Atmosphere : Indications of a Global Increase", **Nature**, No.332, 1988, pp.242-245

32. Khalil, M.A.K., and Rasussen, R.A., "Causes of Increasing Atmospheric Methane : Depletion of Hydroxyl Radicals and the Rise of Emissions", **Atmospheric Environment**, No.19, 1985, pp.397-407.

33. Lacais, A., Hansen, P., et.al., "Greenhouse Effect of Trace Gases - 1970 - 1980", **Geophysical Ressearch Letters** No.8, 1981, pp.1035-1038.

34. Meier, M.F., "Contribution of Small Glaciers to Global Sea Level", **Science**, n.226 (4681), pp.1418-1421

35. Mercer, J.H., "Antarctic ice and Sangamon Sea Level", **Geological Society of American Bulletin, No.79, 1968, p.471.**

36. Milliman, D., and Meade, R.H., "World-wide delivery of river sediment in the Oceans", Journal of Geology, **n.9(1), 1983, pp.1-21.**

36. Peters, R.L., and Darling, J.D., "The Greenhouse effect and nature reserves, Bio. Sci., **n.35(11), 1989, pp. 707-717**

37. Ramanathan, V., Cicerone, R.J., "Trace Gas Trends and Their Potential Role in Climate Change", Journal of

Geophysical Research, No.90, 1985, pp.5557-5566.

38. Raynavd, D., and Barnold, J.M., "An Antarctic Ice Core Reveals Atmospheric CO_2 Variations Over the Past Few Centuries", Nature, No.315, 1985, pp.309-311.

39. Roemmich, D., and Wunsch, "Apparent Changes in the Climatic State of the deep North Atlantic Ocean", Nature, n.307, 1984, pp.47-450.

40. Rotty, R.M., "A look at 1983 CO_2 Emissions from Fossil Fuels", Tellus, No.39B, 1987, pp.203-208

41. Schneider, S.H., and Chen, R.S., "Carbon dioxide flooding: Physical factors and Climatic impact", Annual Review of Energy, n.5, 1980, pp.107-140.

42. Thomas, R.H., Sanderson, T.J.O., and Rose, K.E., "Effect of Climate Warming on the West Antarctic Ice Sheet", Nature, n.227, 1979, pp.355-358

43. Wilman, Ingela, "Expecting the Unexpected : Some Ancient Roots to Current Perceptions of Nature", Ambio, Vo.2, April, 1990.

NEWSPAPERS AND MAGAZINES CONSULTED

1. Employment News (New Delhi)
2. Hindu (New Delhi)
3. Hindustan Times (New Delhi)
4. Indian Express (New Delhi)
5. Pioneer (New Delhi)
6. The Statesman (New Delhi)
7. The Times of India (New Delhi)
8. Civil Service Chronicle (New Delhi)
9. Competition Master (New Delhi)
10. Competiton Success Review (New Delhi)
11. India Today (New Delhi)
12. Kurukshetra (New Delhi)
13. M'n'M Series (New Delhi)
14. Newsweek (New York)
15. Time (New York)
16. Yojna (New Delhi)