

## **Biotic Effects of Climate Change**

W. Selvamurthy, Bhuvnesh Kumar and Rajeev Varshney

Defence Research and Development Organization

DRDO Bhawan, Rajaji Marg,

New Delhi-110 105

### ***Abstract***

Climate change and its consequences are being increasingly viewed as the foremost problem of the 21<sup>st</sup> century. The challenges of climate change at global, regional and national level are interconnected and have obvious implications on biological systems in plant, animal and the human being. These are closely linked with national security as well. Climate change, which was a conjecture a decade ago is now a reality as seen from severe heat waves, disappearing and shrinking glaciers, rising sea level and increased frequency and intensity of extreme weather events. Such happenings will drastically affect biosphere, impacting a large populace and harm badly our agriculture and animal husbandry. Tropical diseases, especially the vector borne, which will increase their range as the climate warms, can have devastating impact on human lives. Changing pattern of rainfall will lead to local shortage of food and safe drinking water. Large-scale human migration in response to rising sea level and other climate-induced stresses will impoverish many people with insecurity. It is the need of the hour to educate ourselves about

---

*Correspondence:* Dr W Selvamurthy , Distinguished Scientist & Chief Controller (R&D), 201, DRDO Bhawan, Rajaji Marg, New Delhi-110 105. Phone : 011-23016976, 011-23014259 ; Email: [Selvamurthy2003@yahoo.co.in](mailto:Selvamurthy2003@yahoo.co.in)

Revised version of the talk delivered at the Scientific Symposium on 'Health Effects of Climate Change' at the 48<sup>th</sup> Annual Conference of NAMS, Jammu, 2008.

implications of climate change, formulate the national strategy to conserve the eco-environment and also to mitigate the impact of climate change on biological systems.

**Key words:** climate change, global warming, disease outbreaks, water scarcity, agricultural eco-system.

## **Introduction**

Biological system, known for its complexity, consists of many sub-systems deeply interlinked to each other and are directly or indirectly affected by climatic vagaries. Evidence of climate change has been seriously addressed by the Intergovernmental panel of scientists who have concluded that the concentration of green house gases has increased markedly in recent past as a result of increased human activities leading to global warming. They have also concluded that the global increase in carbon dioxide concentration is primarily due to excessive use of fossil fuel and industrialization, while those of methane and nitrous oxide are due to changes in agricultural practices. Higher temperatures on the earth, as a result of global warming, cause sea water to expand with heat and glaciers to melt, raising the sea level year after year. A 2-3°C increase in earth's average temperature (14 -15°C) is expected to

raise the sea level by about one meter by the year 2050. A higher sea level intensifies erosion on natural beaches, with particularly serious impact on sandy beaches. As per the projections of IIT Chennai, sea level due to climate change could rise by as much as five meters by the turn of this century. In terms of the effects of climate change, the future is becoming increasingly clear. The expected greenhouse gas emissions scenario projected by the Intergovernmental Panel on Climate Change (1) portends a world in which people and nations will be threatened by massive food and water shortages, devastating natural disasters, and deadly disease outbreaks.

## **Greenhouse effect and global warming**

The earth receives energy from the sun in the form of solar radiation, most of which is in visible and infrared wavelengths. Much of solar radiation, about two third (shorter wavelength of

visible radiation) is absorbed by the earth surface and the rest (longer wavelength of infrared radiation) is reflected back towards space which is trapped by green house gases- carbon dioxide, water vapor, methane, nitrous oxide and a troposphere ozone thus creating the green house effect, warming the planet and causing global warming, which in turn affects the entire eco-system and terminates into climate change.

The green house effect is actually very important, because without it, our earth would become too cold to live on. But now more and more green house gases are being produced and entering to our atmosphere. Human activities have been increasing the concentration of greenhouse gases in the atmosphere (mostly carbon dioxide from combustion of coal, oil, and gas; plus a few other trace gases). Pre-industrial levels of carbon dioxide (prior to the start of the Industrial Revolution) were about 280 parts per million by volume (ppmv), and current levels are greater than 380 ppmv and increasing at a rate of 1.9 ppm/ yr since 2000. The global concentration of CO<sub>2</sub> in our atmosphere today far exceeds the natural range over the last 650,000 years of 180 to 300

ppmv. According to the IPCC Special Report on Emission Scenarios (SRES), by the end of the 21<sup>st</sup> century, we could expect to see carbon dioxide concentrations of anywhere from 490 to 1260 ppm (75-350% above the pre-industrial concentration).

### **Melting of glaciers and rising sea level**

The Arctic and Antarctic regions feel the heat effect first and therefore can be the earth's climate early warning system but this does not end here. Melting of glaciers and rising of sea level are the common sights everywhere. The impact of all these changes is expected to be greater in India, South East Asia, the Middle East and Africa.

Glaciers in the Himalayan region feed important rivers like Ganga, Indus and the Brahmaputra that provide water for millions of people as well as for irrigation and industry. The accelerated melting of these glaciers is being experienced as a result of the earth's warming, which will have profound effect on future water availability. The Gangotri glacier, one of the largest in Himalayas, has been retreating rapidly in recent decades. Data analyzed by Space Application

Centre, Ahmedabad for 466 glaciers in the Himalayas revealed that their surface area has shrunk by about 21% since 1962.

A one meter rise in sea level by the year 2050 as predicted by Bangladesh Centre for Advanced Studies, leading think tank in Bangladesh, will submerge about one third of its population, uprooting 25 to 30 million people. Large scale migration to Indian territory will pose not only the serious economic pressure in the areas they migrate to but also the security challenges due to conflicts for meeting basic needs like food, clothing and shelter (2). Under such scenario, there is every likelihood that terrorist may lay hands to further deteriorate the panic situation. This would exacerbate many existing tensions and heighten instability in the region.

India too will face severity due to rise in sea level as a quarter of India's population lives within 50 Km of the coast line. The major costal cities – Kolkata, Chennai and Mumbai would bear the brunt expecting to affect more than 43 lakh Indians who will migrate to cities like Delhi, Bangalore, Hyderabad, Pune, Ahmedabad and other places which are already burdened by their growing population.

Besides, much of the coastal region has fertile agricultural land. Low-level areas such as those in Orissa and West Bengal could be vulnerable to inundation (3).

### **Impact on water resources**

Increasing water scarcity due to climate change will contribute to instability throughout the world. As discussed, in many parts of Africa, for instance, populations will migrate in search of new water supplies, moving within and across borders, creating the conditions for social or political upheaval along the way. Water scarcity also shapes the geopolitical order when states engage in direct competition with neighbors over shrinking water supplies. Although this threat may evoke apocalyptic images of armies amassing in deserts to go to war over water, yet the likelihood of such open conflict in this scenario in near future is low (4).

Global warming accelerates the normal cycle of rainfall and evaporation, destroying balance of water supply and demand and even possibly expanding worldwide gap in water availability. For example, there would be areas that were frequently flooded on one hand, and areas

constantly suffering drought and water shortage on the other. In areas which already have a water shortage problem, the situation will worsen; many other areas will face similar problems. In certain places like coastal areas of Bangladesh, there may be severe problems of alkalinity, high iron, fluoride and arsenic content.

Water resources are already under strain in our country. We have about sixteen percent of global population but only four percent of global water resources. Across India the hydrological cycle is predicted to become more intense, both with higher annual average rainfall as well as longer period of drought.

### **Impact on agriculture and animal husbandry**

Global warming will seriously affect agriculture as well, which constitutes the single largest component of India's economy, nearly 27 % of the GDP. A temperature increase of 2 °C is predicted to result in a 10-16% reduction in rice yields, while a 4°C rise may lead to 21-30% reduction (5). Other agricultural crops will also be adversely affected by higher temperatures, increased weeds and harmful insects. It is also possible that global warming will lead to global food

shortages. It is estimated by Information on Environment Policy and Technology, Osaka that the production of winter wheat will decrease by 55% in India and 15% in China by the year 2100.

The warming is occurring with shifting pattern of rainfall and incidence of extreme weather events. The rate of global climate change and warming expected over the next century is more than that has occurred during the past 10000 years. The changes in global environment will have profound effects and consequences for natural and agricultural eco-system and the changes could alter the location of the major crop production region on the earth (6). Also the vigorous changes in climate may lead to emergence of new pathogenic strains for which we do not have counter measures. For example blue tongue virus threatening Europe livestock, H5N1 bird flu still ravaging chicken farms across Asia. Similarly, fungal infection of wheat due to UG -99 strain may threaten most of the world's wheat crop (7).

Global warming will cause animals and plants to shift their habitats to northern and mountainous areas. It is anticipated, however, that some will become extinct if they cannot migrate

due to topographical obstacles. It is predicted, for example, that alpine flora growing near mountain summits will become extinct, and that many beech forests will disappear and be replaced by oak forests, which are widely distributed in warm regions. As a result, not only wild animals that live in or feed on these trees, but also fruit cultivation and forestry will be seriously affected.

Protected zones of flora and fauna demarcated by today's environmental conditions will become inappropriate following climatic changes, and can even accelerate extinction. Changes in temperature and rainfall associated with global warming could result in about 80% of the existing forests in India undergoing a change in the type of vegetation. Such changes are bound to have a very significant impact on the forest and wild life they supported. As the Indian forests are already highly fragmented, many species of plants and animals might not be able to cope with climate change and could, therefore, face extinction.

### **Impact on human health**

Climatic change affects human health in many different ways, most of which are adverse; it is anticipated that climatic change will lead to the loss of

many lives. Direct causes of death will include intensified heat waves, UV B radiation and diseases. Indirect causes will include expanded geographical sphere of activity of organisms carrying contagious diseases, and their extended period of activity, resulting in an increase in contagious diseases, including malaria, dengue fever and yellow fever (8). Higher atmospheric temperatures and more frequent flooding are expected to result in higher rates of salmonella poisoning and cholera (9).

Climate change will have a range of decisively negative effects on global health during the next three decades, particularly in the developing world. The manner in which countries respond or fail to respond to these health challenges will have a significant impact on the geopolitical landscape. Water-borne and vector-borne diseases, such as malaria and dengue fever, will be most prevalent in countries that experience significant additional rainfall due to climate change. Conversely, many airborne diseases will thrive in those areas that become more arid due to drought and higher temperatures, such as in parts of Brazil. Shortages of food or fresh drinking

water will also render human populations more susceptible to illness and less capable of rapidly recovering. Moreover, the risk of a pandemic is heightened when deteriorating conditions prompt human migration (10).

According to American Lung association, the climate change can alter air quality in many ways. Changes in temperature, winds and cloudiness can all be important. Some of these changes will also alter the impact of stratospheric ozone depletion. As an example, an increase in atmospheric CO<sub>2</sub> concentration would accelerate photosynthesis, which might enhance the emissions of biological volatile organic compounds from forests and other natural ecological systems. Other sources of tropospheric air pollutants may be affected by global warming. It is known that local and large-scale biomass fires used for land-clearing, are rich sources of nitrogen oxides, carbon monoxide, methane, and other non-methane hydrocarbons, that can lead to enhanced tropospheric ozone production. Climate changes resulting from global warming may increase the risk of large scale forest and brush fires. The resulting particulates in the

atmosphere can scatter sunlight, thus improving the efficiency of UV-B absorption of the boundary layer ozone and contributing to global warming. As an illustration of the impact of tropospheric aerosols upon atmospheric chemistry, the aerosol can reduce the intensity of radiation, leading to a reduction in ozone production. Such a reduction offsets the impact of stratospheric ozone depletion.

### **Societal impact**

Submergence of agricultural land, dwellings and other income generating assets of those residing in costal areas due to rising sea level will trigger large population migration. Loss of cultivated land due to floods and draughts will lead to food insecurity, starvations and poverty, whereas decline in drinking water availability as predicted from 1820 m<sup>3</sup>/ yr/ capita in 2001 to 1140 m<sup>3</sup>/ yr in 2050 in South Asian region may lead into clashes among haves and have nots .Such panic situation will ultimately result in economic instability affecting normal pace of growth.

The increase in the incidence of disease will inevitably generate disputes between nations over the movement of people. Immigrants or

even simply visitors from a country in which there has been a significant disease outbreak may not be welcomed and could be subject to quarantine. If the policies that underlie such practices are perceived as discriminatory or motivated by factors other than legitimate health concerns, they will severely damage political relations. This outcome might be averted if countries establish common immigration policies in advance that are specifically designed to cope with international health crises. Unfortunately, this kind of coordination will most likely occur after the fact, as it did in Europe following several cholera pandemics during the nineteenth century (11).

Restrictions on the movement of goods could also be a source of economic and political turmoil. Pandemic-affected countries could lose significant revenue from a decline in exports due to limits or bans placed on products that originate or transit through them. The restrictions placed on India during a plague outbreak that lasted for seven weeks in 1994 costed it approximately \$2 billion in trade revenue (12). Countries that depend on tourism could be economically devastated by even relatively small outbreaks. The fear of

SARS sharply curtailed international travel to Thailand in 2003, whereas the 2006 military coup had little impact on tourism. Furthermore, as with the controls placed on the movement of people across borders, restrictions on the movement of goods can be politicized in a way that generates significant international friction.

There is also a small chance that the balance of power between neighboring states could suddenly and decisively shift if one country's military or political elites were seriously affected by a disease while the other country's were not. The high HIV infection rate in several African militaries provides a recent example of how a disease can come to have a disproportionate impact on a sector of the population that is critical to a country's national security (13)

### **Ethical issues**

Climate change raises a number of ethical issues. How should we all of us living today evaluate the well being of future generations, given that they are likely to have more material goods than we do. Many people, some living, others yet to be born, will die from the effects of climate change (14). Many people may die even before they bear children,



so climate change may prevent the existence of children who otherwise would have born (15). By emitting greenhouse gases merely for our comforts, are we not doing injustice to the future generations? For example, a population collapse may cause the premature deaths of billions of people. So one must try to estimate how bad, ethically speaking, it is for a person to die early. The issue remains one of the hardest and most debated problems in practical philosophy. But until a satisfactory solution is found, it will be impossible to properly judge the badness of climate change.

### **Proposed national strategy to mitigate climate changes**

This includes minimizing Green House Effect (Healthy city concept), which can be achieved by afforestation and reforestation practices, clean energy mechanism that includes harvesting and application of solar, wind, bio-fuel, nuclear energy. There is also an urgent need to improve public transport system as it depends on oil for about 98% for its fuel. Minimizing the emission of CFC is another strategy to mitigate climate change.

Development of prophylactic and therapeutic measures for vector, water

and food borne diseases; food security by developing drought & heat resistance varieties through conventional breeding and transgenic plant technology; development of economically viable and user friendly technologies for water purification in rural areas; community education to create environmental awareness and development of adaptive measures for adjustment form important part of national strategy.

### **DRDO's initiatives**

DRDO, besides carrying out R&D on strategic systems and platforms has a group of laboratories, actively engaged in optimizing human performance in challenging environment, indigenous life support systems, radiation protection, military nutrition, bio-fuel technologies, potability of water, insect & vector control, greening of high altitude, environment safety and snow and avalanche study. These labs have developed many technologies and products which can be used in quick detection of pathogens, providing health cover, containment of vectors, water purification, development of transgenic plants for draught and salt tolerant, greening of cold desert, environment protection and safety and

snow and avalanche forecasting. Some of the technological interventions include.

### Conclusion

Global warming impacts our economy, safety, environment and national security. India is surrounded by countries, which are poor and prone for weather disasters. Migration of large population may be a challenge to country's security. Therefore, there is an urgent need to evolve an *Umbrella mechanism* to integrate relevant

Scientific Knowledge Base to deal with Global Warming Issues. Through S&T capacity building, we have to nurture new technologies to generate user-friendly products. To achieve this, we have to build human and institutional capacities, identify national knowledge institutions and develop a self sustaining knowledge network, develop and adopt new S&T methods for causes and results and also develop knowledge grids for each domain area and form working groups to mitigate the effects of climate change on biological systems.

### References

1. Intergovernmental Panel on Climate Change (2007). Summary of 4<sup>th</sup> Assessment Report on Climate change. Cambridge University Press. [www.ipcc.ch](http://www.ipcc.ch).
2. Joehnk, T.F (2007). Security and climate change. In: The world in 2007. [www.tyndall.ac.uk](http://www.tyndall.ac.uk)
3. Sengupta, S. (2007). Sea's rise in India buries island and a war of life. New York Times, April 11. [www.nytimes.com/2007/04/11/world/asia/11india](http://www.nytimes.com/2007/04/11/world/asia/11india).
4. Otcher, A. (2001). Saber rattling among thirsty nations. UNESCO courier, Oct 2001. [www.unesco.org/courier/2001\\_10/uk/doss01.htm](http://www.unesco.org/courier/2001_10/uk/doss01.htm).
5. Malhotra, R.K. (2008). Key Note Address. In: Bio-fuel Seminar Proceedings. Institute of Applied System and Rural Development, New Delhi, p 8-14.
6. Pant, T. (2007). Climate changes and crop productivity. *DRDO Science Spectrum* 7: 291-296.
7. Jeremy Webb (2008). Editorial note. The spectra returns "If you thought hunger had been banished, think again". *New Scientist* March Issue: 5.

8. Bhattacharya, S., Sharma, C., Dhiman, R. C. and Mitra, A. P. (2006). Climate change and malaria in India. *Current Sci.* **90**: 369-375
9. World Health Organization (WHO) Climate change and human health, report, 2001
10. Anyamba, A. (2006). Developing global climate anomalies suggest potential disease risk for 2006-07. *International J. Health Geographics* **5**: 60. [www.ij.healthgeographics.com](http://www.ij.healthgeographics.com).
11. Maglen, K. (2003). Politics of quarantine in the 19<sup>th</sup> century. *J Am Med Assoc* **290**: 2873. [www.jama.ama.assn.org](http://www.jama.ama.assn.org)
12. Cecchine, G. and Moore, M. (2006). Infectious diseases and national security: Strategic information needs. *RAND*, p19-21. [www.rand.org/pubs/technical\\_reports](http://www.rand.org/pubs/technical_reports).
13. Lovgren, S. (2001). African army hastening HIV/AIDS spread. *J Culture and African Woman Studies*. [www.jendajournal.com](http://www.jendajournal.com).
14. John Broom (2008). The ethics of climate change. *Scientific American* June issue: 69-73.
15. Nessos G (2008). Ethical issues with global warming. In: Strategies for the 21<sup>st</sup> century and beyond. *Sustainable Enterprise* 1 Jul 2008. [www.Sustainability.com/blog/2008/07/ethical\\_issues.html](http://www.Sustainability.com/blog/2008/07/ethical_issues.html).

