ISSN : 0974 - 7451 Volume 6 Issue 6

Trade Science Inc.

Environmental Science

An Indian Journal

Tutorial Review

ESAIJ, 6(6), 2011 [360-364]

# Challenges of producing food on a warming planet and adaptation

**Arsheen Tabassum, D.Sunita*, M.Shailaja Raj**

**Department of Microbiology, St.Francis College for Women-Begumpet, Hyderabad.500016 (INDIA)**

**E-mail : sunitagoud_gnk@yahoo.co.in**

*Received: 7th September, 2011 ; Accepted: 7th October, 2011*

## ABSTRACT

Global warming happens when greenhouse gases (carbon dioxide, nitrous oxide, and methane) trap heat and light from the sun in the earth's atmosphere and the temperature rises. On a very hot day, the car gets hotter when it is out in the parking lot because the heat and light from the sun can get into the car, by going through the windows, but it can't get back out. This is what the greenhouse effect does to the earth. The heat and light can get through the atmosphere, but it can't get out. As a result, the temperature rises. The greenhouse effect makes the earth unusually warmer, and many plants, animals, and people will die. Whether it be the crops we grow, the livestock we raise, or the wild plants and animals that we harvest, every organism that we rely on as a food source depends on a unique confluence of climatic conditions that determine whether it will merely survive, deteriorate, or flourish.



## KEYWORDS

Global warming;
Food;
Green house gases;
Adaptation;
Fertilizers;
Food chain.

## INTRODUCTION

For thousands of years, factors responsible for causing global warming has tended to change only slowly or infrequently. Encouraged by this predictability, people have been able to build civilizations around specific food sources. Over time, their sustained and focused attention has led to the great advances in the science and technology of food production that allow humanity to sustain a rapidly growing population. Now, however, that progress may be coming undone. The accumulation of greenhouse gasses threatens to simultaneously, and in unpredictable and potentially dramatic ways, alter nearly every variable with an input into the grand equation that is our food production system[1]. It is nearly impossible to predict, on a large scale, just how our agriculture, livestock, and fisheries will respond to the new climate conditions we have created for ourselves. However, by inspecting the following individual effects, a clearer picture may begin to emerge. So the Challenges we have in producing food on our warming planet are:

## EFFECTS OF ENHANCED $CO_2$ ON CROP GROWTH

Higher concentrations of atmospheric carbon dioxide allow plants to grow faster and larger. From a food production standpoint, this is generally good news. Yields should increase, less fertilizer may be needed, and faster growing crops can be developed. However, if the $CO_2$ concentration increases more the effects of carbon dioxide fertilization will not prove beneficial. For instance, the magnitude of the $CO_2$ fertilization effect is different for different types of plant species. Plants growing under heightened $CO_2$ conditions can exhibit abnormal characteristics with regard to the way they absorb and process nutrients. Also, $CO_2$ fertilization can sometimes cause plants to speed through the growth phase in which they generate their harvestable grains, fruits or vegetable matter. As a result, fields filled with more outright biomass may, at the same time, produce diminished and less nutritious harvests.

## ALTERATIONS TO HYDROLOGY

Agriculture of any kind is strongly influenced by the availability of water. Climate change will modify rainfall, evaporation, runoff, and soil moisture storage. The occurrence of moisture stress during flowering, pollination, and grain-filling is harmful to most of the crops. Increased evaporation from the soil and accelerated transpiration in the plants themselves will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought tolerance. Areas that currently derive water from melting glaciers and snowpack are likely to see some dramatic changes as well[2]. Himalayan glaciers, for instance, which now provide the majority of non monsoon water flow for some of Asia's most important agricultural regions, are in danger of shrinking or even disappearing completely as a result of global warming. Low water availability and abnormally timed flows disrupt more than agricultural irrigation. They can disrupt and devastate fisheries (such as salmon) that rely on freshwater rivers for spawning.

## RISING AVERAGE TEMPERATURE AND SHIFTING HABITAT RANGES

As global warming increases the baseline temperature at most locations on our planet, organisms or populations are free to move in order to remain in their ideal temperature range. Some food producers, especially those at higher latitudes and altitudes, may welcome the opportunity to grow, raise, and harvest plants and animals in areas formerly too cool for that activity. Those in temperate climate zones will be forced to adopt new practices better suited to a more tropical environement. Still others, especially those in the newly superheated tropics, will face an unprecedented climate zone, for which no food producing species have had time to evolve. On the whole, this phenomenon of range shifting can pose a real danger to fisheries, livestock, and agriculture. It may push populations into new areas for which they are otherwise poorly adapted. Global biodiversity will dwindle as some high altitude and polar climates simply cease to exist. Some species will shift more readily and quickly, while others may experience almost no range shift. Intra-species relationships that have developed through thousands of years of co-evolution will be affected.

## EXTREME WEATHER EVENTS

Extreme meteorological events, such as spells of high temperature, heavy storms, or droughts, disrupt crop production. Certain varieties of crops are grown near their limits of maximum temperature tolerance, such as rice in Southern Asia, heat spells can be particularly detrimental. Similarly, frequent droughts not only reduce water supplies but also increase the amount of water needed for plant transpiration. As heat energy accumulates in our atmosphere and oceans it may produce more frequent and powerful storms[3], which can damage crops, kill or stress livestock, and disrupt or destroy both natural resources and necessary infrastructure.

## PARASITES, DISEASES, FUNGI & OTHER PESTS

These organisms can harm, poison, eat, or otherwise reduce the yield of the species we use as food. All tend to thrive and spread more rapaciously in warmer and more humid climates. The check of climate change will require the use of even more fungicides and insecticides for crops and antibiotics in livestock production and aquaculture. Conditions are more favorable for the proliferation of insect pests in warmer climates. Altered wind patterns may change the spread of both wind-borne pests and of the bacteria and fungi that are the agents of crop disease. Crop-pest interactions may shift as the timing of development stages in both hosts and pests is altered. Livestock diseases may be similarly affected. This brings about greater use of chemical pesticides.

## SEA LEVEL RISE

Global warming is predicted to lead to thermal expansion of sea water, along with partial melting of land-based glaciers and sea-ice, resulting in a rise of sea level. According to present estimates of the Intergovernmental Panel on Climate Change (IPCC), such a rise could pose a threat to agriculture in lowlying coastal areas. Low-lying coastal areas already suffering from poor drainage, agriculture is likely to become increasingly difficult to sustain. Some island states are particularly at risk[4]. Global warming is causing ocean levels to rise and is therefore rendering agricultural areas such as fertile river deltas, and brackish estuaries, which often serve as critical nurseries for commercial fish species, increasingly susceptible to salt water intrusion and inundation.

## SOIL FERTILITY AND EROSION

Higher temperatures in soil will create warmer conditions and are likely to speed the natural decomposition of organic matter. They also affect fertility of soil, so additional application of fertilizer may be needed to counteract these processes. This can come at the cost of environmental risk and may impact water and air quality. The continual cycling of plant nutrients- carbon, nitrogen, phosphorus, potassium, and sulfur-in the soil-plant-atmosphere system is also likely to accelerate in warmer conditions, enhancing $CO_2$ and $N_2O$ greenhouse gas emissions. Nitrogen is made available to plants in a biologically usable form through the action of bacteria in the soil. In warmer climatic conditions and higher $CO_2$ concentration there is greater root development, if soil moisture is not limiting[5]. Contrastingly if drier soil conditions exist, suppression of both root growth and decomposition of organic matter occurs. Extreme precipitation events can cause increased soil erosion.

## OCEAN ACIDIFICATION

Atmospheric carbon dioxide has always naturally dissolved into our oceans. Now, however, the rate at which this is happening is increasing and, as a result, the ocean is becoming more acidic[6]. Under these conditions it is more difficult for sea creatures to develop and maintain their calcium based shells and exoskeletons. As a result, populations of certain species will experience stress and could eventually even collapse[7]. The oceans are affected by global warming in other ways, as well. One thing that is happening is warm water, caused from global warming is harming and killing algae in the ocean. The floating green algae is food to many consumers in the ocean. Fewer algae is a problem because there is less food for us and many animals in the sea.

## ADAPTATION

In the face of these challenges, people in the world must begin to make critical adaptations to our global food production system. Some key areas include:

## FORECASTING OF CLIMATE CHANGE

It is important to understand global climatic trends and forecasting of weather can be used in order to prepare for the coming changes. The accomplishment of this task will require policies and investments related to climate change and weather[8].

Multidisciplinary response programme should be instituted to understand about upcoming conditions. Financial experts and policy makers need to make sure that food producers have the ability to make changes accordingly.

## GENETIC ADAPTATION

Once future conditions can be forecasted, scientists can begin with breeding or genetically engineering process to improve the food characteristics sources and make them better suited to their environment. Through the use of advanced technology, we can now implant (even from completely different species) the genetic code associated with a desirable genotype directly into a food species[9]. Special attention must also be given to preserving a wide and diverse gene pool against the threats to biodiversity.

## A DIVERSIFIED, ADAPTABLE, AND GLOBAL FOOD ECONOMY

In almost every way, the expected distribution of positive and negative climate change effects has the appearance of being unfair. As we have seen, climate change, may produce positive as well as negative effects. However, these effects are not equally distributed. The preponderance of those beneficial effects will occur in higher latitudes, mostly in well-developed Northern Hemisphere countries. By contrast, equatorial regions, populated by less developed countries also are responsible for a small percentage of historic greenhouse gas emissions, are the most likely to bear the burden of the negative effects of climate change.

In any instance where food is made scarce or prohibitively expensive, or where there is some perceived injustice at play, problems like political instability, forced migrations, widespread health emergencies, collapsed markets, and war can quickly follow. To head off these types of scenarios, the international community must help to form responsive governments, an informed and interlinked scientific community. These improvements are required in any region that hopes to successfully cope with climate change.

## REDUCING OUR FOOD'S IMPACT ON CLIMATE CHANGE

Our food production system produces sizable emissions of three primary greenhouse gases: carbon dioxide, methane, and nitrous oxide. Specific activities related to growing, raising, or harvesting food that have particularly large impacts on global warming include enteric fermentation, manure, fertilizers, deforestation & soil disruption, and fuel consumption[10]. Fortunately, there are solutions to move forward and reduce our food's impact on climate change.

### Enteric fermentation

In the process of digesting plant matter, bacteria in the guts of ruminants produce and emit large amounts of methane gas. Some amount of mitigation may be achieved by modifying the diet fed to these livestock . The only realistic way to substantially mitigate these emissions is to cut our demand for meat.

### Manure

Livestock also produce manure which emits greenhouse gasses as it decomposes. If the waste is allowed to degrade in the open air, aerobic bacteria will dominate the digestion and produce nitrous oxide. If the animal waste is instead pooled or submerged in rice paddies, the oxygen available to bacteria is limited. Here anaerobic bacteria break down the material and produces methane. With the right infrastructure, the methane emitted from the anaerobic decomposition of manure can be captured and used as a fuel.

### Fuel consumption

Fuel consumption creates large amounts of emissions in the process of transporting requisite input materials and food products. One way to mitigate these emissions is to discourage the purchase of non-local, out of season, or heavily processed and packaged foods.

### Deforestation & soil disruption

Throughout the world, forests (which act as carbon sinks by absorbing atmospheric $CO_2$ in the process of producing biomass) are being cleared, and often burnt. In this process, much the carbon content of these habitats have been accumulated over hundreds of years[11]. It is important to note that in some areas, the soil itself above ground, contains a high level of sequestered greenhouse gasses that can be released into the environment if disrupted. The most important way to mitigate greenhouse emissions from deforestation is to simply stop the process.

### Fertilizers

Artificial fertilizers are used in massive quantities throughout our modern global agriculture system. Many of these chemicals are manufactured from natural gas in a process that produces nitrous oxide. These emissions can best be mitigated by using less chemical fertilizer overall. One way this is being achieved is through the use of better technology and agricultural science that allow for more precise application of these chemicals. Another approach is seen in organic farming, which eschews industrial fertilizers entirely[12]. This process, however, is not without its own problems, for some techniques of organic fertilization of rice can lead to high levels of nitrous oxide and methane emissions.

## CONCLUSION

Many people believed that the earth had a nearly endless capacity to absorb the burden of producing cheap food without limit. The reality of climate change and the specter of even larger environmental collapse are now proving that assumption false. The fact that policy makers throughout the world are now considering the implementation of various schemes to put a price on the emission of greenhouse gases is proof that we now know that it is untenable to simply coast into the future with same attitudes and technologies that worked in the past. However, overcoming both inertia and our sense of entitlement will not be easy. As we move forward, we should be reminded that we can still produce good, nutritious, satisfying food for the world's population while also mitigating greenhouse gas emissions. That goal is attainable. But we can not do so without making serious commitments to restructuring our economic systems, partaking in large scale collaborative efforts to develop and implement new food technologies, and adjusting our cultural assumptions about the role of food in daily life.

## ACKNOWLEDGEMENTS

The authors thank the Principal and the Management of St. Francis college for women, Begumpet, Hyderabad for providing the necessary facilities and support.

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