To Study the Role Played by Green House Gasses on Climatic Change and its Further Effect on Agriculture

Dr. Abhimanyu Kumarm[1] and Lalit Kumar Goyal[2]

[1] Invertis University Bareilly

Received: 14 December 2012 Accepted: 5 January 2013 Published: 15 January 2013

Abstract

Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth?s atmosphere. These greenhouse gases include carbon dioxide (CO2), methane (CH4) and nitrogen dioxide (N2O), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth?s atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change. Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern are likely to lead to severe water shortages and/or flooding. Melting of glaciers can cause flooding and soil erosion. Rising temperatures will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria and dengue fever. Temperature increases will potentially severely increase rates of extinction for many habitats and species (up to 30 per cent with a 2° C rise in temperature).

Index terms — Earth?s atmosphere, Ecosystems, Greenhouse gases, soil erosion.

1 I. Introduction

road scientific agreement now exists that continued accumulation of heat-trapping "greenhouse" gases in the atmosphere will eventually lead to changes in the global climate, and in the climates of regions around the world. The agreement is expressed in the 1996 report of the Intergovernmental Panel on Climate Change (IPCC), an international body of leading natural and social scientists sponsored by the United Nations Environment Programmed and the World Meteorological Organization. According to the panel's report, an increase in atmospheric concentrations of greenhouse gases equivalent to a doubling of carbon dioxide (CO2) will force a rise in global average surface temperature of 1.0 to 3.5 degrees Celsius by 2100. Average precipitation also will rise as much 10 to 15 percent because a warmer atmosphere holds more water.

The general circulation models (GCMs) that the IPCC used to analyze climate change are in reasonably good agreement that with a doubling of atmospheric CO2 the global average temperature will rise within the range of 1.0 to 3.5 degrees Celsius, as indicated above. The models also agree reasonably well that the northern latitudes will warm more than the tropics. With respect to all other regional changes, however, agreement among the models is poor. Because human activities and ecological systems are highly variable among regions, this lack of accord greatly complicates the task of estimating the impacts of the changes on activities of interest to humans.

Despite this limitation, much useful work has been done on estimating the potential impacts of different climate change scenarios. In this paper potential climate change impacts on agriculture are examined on both a global scale and with regard to the United States in particular. Even if the reader's interest lies only in the impact on the United States, the global scale still must be considered. U.S. agriculture is inextricably entwined with agriculture worldwide. What might happen nationally cannot be understood without taking account of impacts elsewhere in the world.

2 II.

3 Global Impacts

The IPCC report estimates climate change impacts on grain production at the global level and then zeros in on the estimated effect on the developed countries (DCs) of North America and Europe as well as on the less developed countries (LDCs) of Asia, Africa, and Latin America. 2 (Grain is often used as a proxy for all food because it accounts for over half of all food calories consumed in the world.) The sources of the IPCC estimates are the three different GCMs, reflecting four different scenarios for estimating climate change impact on grain production.

? First scenario -Disregards any adjustment that farmers might make to offset the impacts of climate change on grain production, and disregards the effects on production of an atmosphere richer in CO2. (CO2 is essential to plant growth, and much experimental work shows that higher concentrations of it in the atmosphere in fact stimulate such growth); B

? Second scenario -Incorporates the CO2 enriching effect on growth; ? Third scenario -Includes both the CO2 enriching effect and the effect of modest adjustments that farmers could make using currently known practices, for example, shifting to a different variety of the same crop and changing the planting date by less than one month in response to a change in the length of the growing season; ? Fourth scenario -Includes the CO2 effect on growth, the modest adjustments to farming just mentioned, as well as more ambitious adjustments, such as shifting to an entirely different crop, changing the planting date by more than one month, and using more irrigation.

4 Note :

The farming adjustments considered in the IPCC scenarios apparently did not include developing entirely new crop varieties designed to be more productive under changed climate conditions. However, research done on the impacts of climate change in the Midwestern United States indicates that such new technologies could potentially offset much of the negative effects of climate change on crop production. And, since the climate change contemplated is not expected to be fully realized until sometime in the second half of the next century, plenty of time is still available for researchers to develop the new technologies needed to make this most advanced type of adjustment (see further discussion of this adjustment in the account of impacts on U.S. agriculture, below).

The IPCC analyses of the four scenarios are summarized in Table 1. The range in each entry reflects differences in the results obtained with the various climate models. Notably, the CO2 fertilization effect substantially reduces yield losses and may even lead to net increases in grain output in developed countries as a whole. Smaller but significant offsets are obtained by allowing for adaptive behavior by farmers. Notwithstanding these adjustments and offsets, however, climate change is indicated by the IPCC report to reduce grain yields in developing nations, underscoring the greater vulnerability of these countries.

The sharp difference in impact that climate change is expected to have on grain production in developed as opposed to less developed countries has two main causes. The first one might be called the "physical" factor. As noted above, the GCMs estimate that the high latitudes will warm more than the tropics. Most of the DCs are in the northern latitudes, and their agriculture would benefit from the longer growing seasons that a warmer climate would bring. Most LDCs, on the other hand, include much terrain in the tropics where the negative effects of a warmer climate would not be offset by other favorable trends.

The second reason might be called the "ecostructural" factor. The IPCC notes that, compared with the LDCs, the DCs have much greater economic resources that can be devoted to helping farmers adjust to climate change. In addition, the institutional structures of the DCs appear to be more efficient than those in the LDCs in mobilizing the resources needed to pursue specific social objectives, whether they be adjustments to climate change or anything else.

If the GCMs are right in predicting generally beneficial climate change in the northern latitudes, then the physical factor accounting for the difference in impacts on the DCs and the LDCs would seem to be pretty much fixed. But the effect of the eco-structural factor may be more malleable. In east and south east Asia, and to a lesser extent in south Asia, agricultural performance over the last 10 to 15 years has been impressive. Farmers have adopted new, more productive technologies as they have become available and production, both per person and per hectare, has increased. This strong agricultural performance has been part of a generally impressive economic performance in the countries of those regions.

It is not clear why some Asian countries have been so much more successful than countries in Latin America, and especially in Africa. Their success does suggest, however, that the eco structural weaknesses so common now among the LDCs are not fixed for all time. The Asian experience offers some promise that, given time and incentive to improve their material standard, farmers in other LDCs can and will seize the opportunities presented. This prospect provides some reason to hope that by the time that climate change begins to impinge negatively on LDCs, they will have developed a capacity to adjust to it well beyond what they could accomplish under present conditions. If so, the differences between the DCs and LDCs in terms of the effects of climate change on grain production could be much less than the 1996 IPCC report suggests.

Recent studies done at the U.S. Department of Agriculture (USDA) and by Cynthia Rosenzweig and Martin Parry generally support the findings of the 1996 IPCC report about the global impacts of climate change on agriculture. A 1995 USDA study, for example, indicates that-overall-the impacts would be small, taking into account adjustments in agriculture and other sectors of the economy made possible by wide trading opportunities among countries. Specifically, the study showed that, given these trading opportunities, gross world economic product in the face of climate change would be 0.2 less-or 0.1 percent more-than it would be in the absence of climate change. Allowing for trading opportunities and farm-level adjustments, including the ability of farmers to move land into and out of production depending on the economic effects of climate change, the study found that world cereal production would increase 0.2 to 1.2 percent. These results did not include the positive production effects of CO2 enrichment.

5 Global Journal of Human Social Science

Volume XIII Issue IV Version I Rosenzweig and Parry also estimated changes in cereal prices resulting from climate induced changes in production. The direction of change is consistent with well-established knowledge about price-production relationships in agriculture: Prices are what economists call "inelastic," that is, a given percentage change in production is associated with a significantly greater "opposite direction" percentage change in price. That is, a given percentage decline in production because of climate change would result in a greater percentage increase in prices, and vice versa for production increases.

The 1995 USDA study mentioned above found that in the United States both crop and animal output would fall under the type of long-term climate change likely to occur in response to a doubling of atmospheric CO2 (hereafter written 2XCO2). The model used in this study took account of climate change impacts elsewhere in the world, and the consequent changes in U.S. trading opportunities in agricultural commodities. The crop production declines in the United States would be small, from 0.8 percent to 3.4 percent. Livestock production would fall between 0.5 percent and 1.3 percent.

6 IV.

7 Policy Issues and Caveats

In thinking about policy issues related to prospects for global agricultural development, especially in the LDCs (where, studies show, over 90 percent of the increase in global demands for food will occur over the next 30 or 40 years), the prospective impact of climate change is at most of secondary importance. Studies done to date show that the impact on the already struggling LDCs is likely to be negative, but not disastrous (according to the IPCC report production would be down only 6 to 8 percent after accounting for on-farm adjustments). Moreover, by the time climate change impacts become significant in the middle of the next century, LDCs should be in much better shape to deal with the impacts than they are now. This will be especially the case if the world trading system in agricultural commodities remains as robust as it presently is and if the global impacts of climate change on agriculture are small (or positive). I return to these caveats below.

In addition, the amount of time before climate change impacts occur is expected to be long relative to the time needed to develop technological and managerial responses. Many of the farm level responses incorporated into the impact models described above are already known to farmers and suppliers of farm inputs. They could be adopted in a year or two. To develop entirely new technologies and practices better adapted to the changed climate, the elapsed time from beginning of research to the availability of results to farmers would be some 10 to 20 years. Thus, if significant impacts on agriculture are not likely to be felt for another 30 or 40 years, there is time to develop technological responses, if investments in agricultural research do not lag. Only development of large surface irrigation projects involves a time span comparable to that expected before the impacts of climate change on agriculture are felt. And most irrigation systems developed over the last decade or so operate by pumping groundwater. These systems require much less time to develop than surface systems.

Quite apart from the relatively long-term issue of climate change impact, many LDCs-especially in Africa but also to some extent in Latin America and parts of Asia-face immediate problems that are severe. These problems inhibit achievement of sustainable agricultural systems-6 systems that can meet rising demands for food and other agricultural commodities at socially acceptable economic and environmental costs into the indefinite future. Natural resource degradation is serious in some parts of those countries, but recent studies indicate that, in general-and contrary to a widely held view-degradation of land and water resources is not a major threat to agricultural sustainability in the LDCs. The critical issue, rather, is whether in the immediate future and over the next several decades these countries can develop the capacity to increasingly expand the knowledge base needed to achieve sustainable agricultural systems.

The needed knowledge is embodied in people, technology, and institutions. Over the last thirty years food output per person has increased 15 to 20 percent in the LDCs as a whole (but not in Africa). Farmers are better educated and trained, new technologies-those embodied in the Green Revolution being the outstaynding examples-have been developed and widely adopted by farmers, and institutional performance has improved as people have become more aware of the importance of markets and secure property rights in providing farmers the incentives they need to adopt new technology. Now, however, evidence suggests that the systems that generated the powerful increases in the three kinds of knowledge are in jeopardy. In Africa, for example, where supplies of the three kinds of knowledge are in particularly short supply, investments in rural education, after advancing smartly in the 1960s and 1970s, declined sharply in the 1980s and have not yet shown much evidence of a turn-around. Spending on agricultural research in that region also has declined in recent years, precisely the period when it should have been increasing robustly if Africa is to achieve sustainnable agricultural systems. According to studies done at the International Food Policy Research Institute, agricultural research spending elsewhere in the developing world also is either declining in absolute amount, or the rates of increase in such spending are down sharply.

These threats to the knowledge base needed for continued progress in LDC agriculture is immediate and of major importance. If the threats can be overcome, LDC agriculture will prosper and, by the time the climate may change significantly, those countries will be in a reasonably strong position to deal with its consequences. If the threats are not overcome, the resulting economic, social, and political consequences over the next few decades will make the consequences of climate change pall in significance.

8 V. Implicit Assumptions

The assertion that, from a policy standpoint, the agricultural consequences of climate change on LDCs are relatively less important than other problems of agricultural development in those countries hinges on four so far implicit assumptions. One is that the GCMs used in climate change research give a reasonably accurate account of the changes that might occur, at least on global and continental scales. However, enormous uncertainty still surrounds most aspects of climate change, particularly its characteristics on sub continental and smaller regional scales. It is on these scales that, as the saying go, "the rubber hits the road," that is, where we need to know in some detail how the climate might change. We do not now know this.

A second implicit assumption is that the climate will change in what climate researchers call a "linear" fashion. That is, it will evolve without major ups and downs from what it is today to whatever it will be at equilibrium with 2XCO2 warming sometime in the second half of the next century. The assumed gradualness of the process underlies the thought that society will have time to adjust to whatever climate change may bring. The assumption of linear change, however, may prove unfounded. Some evidence from the ancient climate record suggests that, occasionally, for unknown reasons, the world's climate has changed in a rather short and chaotic fashion. If global warming produced such a response, the consequences for agriculture could be more severe. Even "linear" climate change could increase the frequency of extreme weather events, with more pronounced periods of drought and flooding. These possibilities are not picked up in the relatively benign scenarios of the IPCC and of the other researchers referred to above.

9 VI. Conclusion

The conclusion that the impact of climate change on global and LDC agriculture will prove less important than other issues also assumes that the impacts will be limited to those resulting from 2XCO2 warming. But the focus on 2XCO2 is simply an analytical convenience adopted by climate researchers. Nowhere is it written that the atmospheric accumulation of CO2 and other greenhouse gases must stop at an equivalent of 2XC02. Unless measures are taken to eventually bring the emissions of these gases to a level where they can be absorbed by the oceans and the terrestrial biosphere, they will continue to accumulate in the atmosphere and continue to warm the earth beyond what might occur with 2XCO2. In this case, all the studies of climate change consequence reviewed above likely would prove to be irrelevant.

Finally, the conclusion that the climate change impact on LDC agriculture is of relatively small importance assumes that LDCs will continue to make good economic progress, and that the world trading system in agricultural products will be no less robust than it is now. Both of these assumptions underlie the argument that, by the time climate change begins to pose a threat to their agriculture, LDCs will be in much better shape than now to deal with the threat. If either of the assumptions fails, then the conclusion probably would no longer be warranted. These caveats must be kept "up front" in thinking about climate change and its consequences for global and LDC agriculture. Given that, we nonetheless must go with what we think we presently know about these consequences. What we think we know supports

10 Global Journal of Human Social Science

Volume XIII Issue IV Version I [1] [2]

Figure 1: B

1

Scenario	World	Developed Countriesz	Developing Countries (Asia, Africa, Latin America)
No offsetting effects considered	-11 to -20	-4 to -24	-14 to -16
Including CO_2 fertilization effect	-1 to -8	-4 to +11	-9 to -11
Including CO_2 fertilization and Modest farmer adaptation	0 to -5	+2 to +11	-9 to -13
Including CO_2 fertilization and more ambitious farmer adaptation	-2 to +1	+4 to +14	-6 to -7

Figure 2: Table 1 :

[Cross On ()] 'Climate Change and Mid-Latitudes Agriculture: Perspectives on Consequences and Policy Responses'. Pierre Cross On . *Climate Change* 1989. 15 (1) p. .

[Inter governmental Panel on Climate Change (IPCC). 1996. Climate Change Contribution of Working Group II ()] 'Inter governmental Panel on Climate Change (IPCC). 1996. Climate Change'. *Contribution of Working Group II*, 1995. Cambridge University Press.

[Rosenzweig and Parry ()] 'Potential Impact of Climate Change on World Food Supply'. Cynthia Rosenzweig , Martin Parry . *Nature* 1994. 367 p. .

[Mendelssohn ()] 'The Impact of Climate Change on Agriculture: A Ricardian Analysis'. Robert Mendelssohn . *American Economic Review* 1994. 84 (4) p. .

[Rosenberg ()] *Towards an Integrated Assessment of Climate Change: The MINK Study*, Norman J Rosenberg . 1993. Boston: Kluwer Academic Publishers. 173 p. pp.