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GLOBAL CHANGE AND ITS IMPACT ON AGRICULTURE

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Climate is a primary determinant of agricultural productivity. In turn, food and fiber production is essential for sustaining and enhancing human welfare. Hence, agriculture has been a major concern in the discussions on climate change. In fact, the United Nations Framework Convention on Climate Change (UNFCCC) cites maintenance of our societal ability for food production in the face of climate change as one of the key motivations it's existence and for it's efforts in stabilizing greenhouse gas emissions (GHGE).

Food supply vulnerability to climate change is an issue in two different ways. First, future food supply may be directly threatened by climate change. Second, food supply capacity may be altered by efforts to reduce GHGE as society tries to mitigate future implications of climate change. This chapter reviews both sides of the issue summarizing economic considerations, concerns and research findings, building on the recent literature. In doing this the paper is broken into sections in with section 2 highlighting the longer run agricultural climate change issue. Section 3 treats the shorter run role of agriculture in mitigating GHGE. Section 4 presents concluding comments.

Agriculture and climate change:

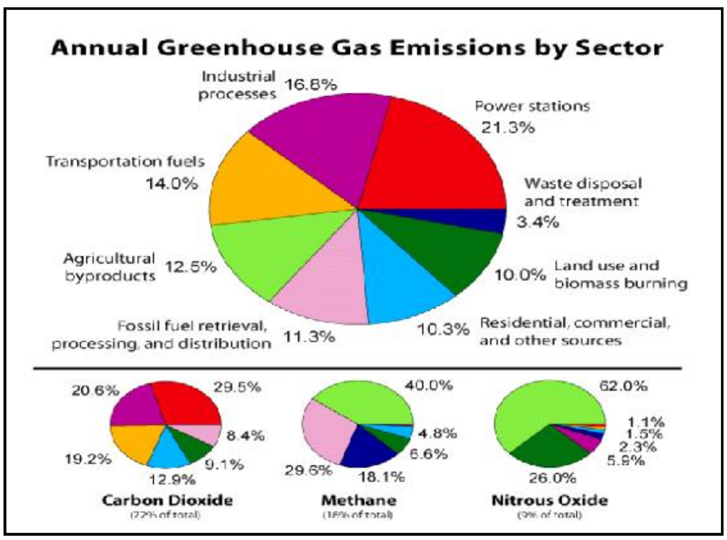
Agronomic and economic impacts from climate change depend primarily on two factors:

– the rate and magnitude of change in climate attributes and the agricultural effects of these changes, and

– the ability of agricultural production to adapt to changing environmental conditions.

Climate change effects on agricultural productivity: Temperature, precipitation, atmospheric carbon dioxide content, the incidence of extreme events and sea level rise are the main climate change related drivers which impact agricultural production. The main agricultural productivity implications of these drivers are described briefly the main categories of agricultural productivity implications are:

Crops and forage productivity and production cost: where temperature, precipitation, atmospheric carbon dioxide content and extreme events are likely to alter plant growth and harvestable or grazable yield through a mixture of climatic and CO_2 fertilization effects as well as impacts on plant water demand (through temperature affects on respiration and evapo-transpiration as well as CO_2 affects on water use efficiency). Extreme events also play a role. For example where droughts and floods become more severe or frequent, agricultural losses would increase.



Soil suitability for agricultural production: which is affected in terms of available soil moisture for plant growth, moisture storage capacity and fertility. In particular, soil moisture loss is determined by temperature and maintenance of a constant water supply given any temperature increases need to be offset by precipitation increases and/or expansions in applied irrigation water. Furthermore, microbial decomposition is stimulated by warmer temperatures so the availability of soil nutrients and organic matter which helps hold the soil moisture may be negatively affected by warmer temperatures.

Livestock productivity and production cost: which are affected both directly and indirectly. Direct effects involve consequences for the balance between heat dissipation and heat production. In turn according to Hahn (1995,2000) a change in this balance can alter: a) animal mortality, b) feed conversion rates, c) rates of gain, d) milk production, and e) conception rates. Appetite may also be affected). Finally, carrying capacity in a region is altered by changes in the availability of feed and fodder.

Irrigation water supply will be influenced by changes in the volume of water supplied by precipitation as well as by temperature alterations effects on evaporation. Also changes in temperature regimes can alter the timing of snow melt based runoff and thus both the seasonality of available water supply and the needed size of impoundments holding water for summer supplies. Groundwater recharge rates and aquifer exploitation may also be altered. Nonagricultural water demand by municipalities and possibly some industries is also likely to be increased by increases in temperature. Extreme events also play a role where, for example, some studies indicate that the hydrologic cycle will be intensified such that droughts and floods will become more severe in low- to mid-latitude regions again altering water availability seasonally and the need for impoundments.

Other Effects: In addition to the direct effects of climate change on agriculture, there are important indirect effects that can affect production. For example, sea level rise can inundate or require mitigation efforts along low-lying coastal regions. Indirect effects may also arise from alterations in the growth rates and distribution of weeds, pests and pathogens, rates of soil erosion and degradation, and alterations in ozone levels or UV-B radiation.

Adaptation: The consequences of climate change-induced agricultural productivity impacts will be, in great part, determined by human adaptations. Societies have adapted agriculture to a wide variety of climates around the world and the predicted rise in temperatures is less than the variability exhibited between regional climates. Thus adaptations to climate changes of the size forecast are already in existence in other parts of the world. Farm level cropping adaptations can be made in planting and harvest dates, crop rotations, crop mix, crop varieties, irrigation, fertilization, and tillage practices. Livestock producers can adapt to climate change by the provision of shading, sprinklers, improved air flow, lessened crowding, altered diets, and more care in handling animals. Herds or the locus of livestock production may also be moved to more hospitable locations. In the longer term, new crop varieties and livestock breeds may be developed that perform better under the anticipated future climate regime. Given these options, the IPCC (1996) report concluded that intensively managed livestock systems are potentially more adaptable to climate change than crop systems, particularly because they are better able to adapt to extreme events. Overall, adaptation can lessen the yield losses that might result from climate change, or improve yields where climate change is beneficial.

General findings on climate change impact: Several key findings have emerged across the large number of studies measuring the physiological effects of climate change on crops and to a lesser extent livestock.

– The effects of changes in temperature, precipitation and carbon dioxide concentrations on crop productivity have been studied extensively using crop simulation models. The combined effects of climate change have been found to have implications for dryland and irrigated crop yields as well as irrigation water use.

– The effect on production is expected to vary by crop, and location as well as the magnitude of warming, the direction and magnitude of precipitation change.

– Different crops exhibit different sensitivity. It is thus important that the full range of cropping possibilities is considered when assessing climate change. Treatment of only selected crops can bias the results. For example, early US studies only examined corn, soybeans and wheat, in contrast to later studies which included many more heat tolerant crops. The economic implications were moderated as a result. For an example of such an effect, see the experiment on cotton in McCarl (1999) which showed that explicit inclusion of the differential response by this more heat tolerant crop caused a reversal in sign of the total welfare impact showing a beneficial effect rather than detrimental effect of climate change.

– The CO_2 fertilization effect is an important factor. Inclusion of the effect in yield studies significantly raises the estimates of climate effected yields of many crops.

– Yield effects vary latitudinally across the world. Yields generally improve in the higher latitudes. On the other hand there are estimates that there will be net reductions in crop yields in warmer, low latitude areas and semi-arid areas.

– Yield changes can be reduced or enhanced by adaptations made by producers. Farmers may adapt by changing planting dates, substituting cultivars or crops, changing irrigation practices, and changing land allocations to crop production, pasture, and other uses.

– Livestock effects can be significant. The EPRI sponsored (R.M. Adams *et al.*, 1999) and recent US national assessment (Reilly *et al* , 2000a,b) used livestock productivity alterations ranging from -1.5 to -5% changes in rate of gain and milk production coupled with proportional adjustments in feed and grazing requirements and reductions in input usage costs at a rate of 40% of the reduction in productivity. Adjustments were also made in pasture requirements and range productivity in accordance with the change in pasture yield.

– Irrigation water availability is an issue. Data from the US National assessment water study were used in the parallel agricultural assessment under the assumption

Contd....... P. 63