Climate Change and Agriculture: Global and Regional Effects Using an Economic Model of International Trade

by

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Abstract

Empirical estimates of the economic welfare implications of the impact of climate change on global agricultural production are made. Agricultural yield changes resulting from climate scenarios associated with a doubling of atmospheric trace gases are used as an input into a global model of agricultural supply and demand. The agricultural production, price and economic welfare implications for 32 separate geographic regions are computed for 9 scenarios. The 9 scenarios reported are based on 3 different general circulation models (GCMs), estimated with and without the direct effects of carbon dioxide on plant growth, and with different levels of adaptation. The major conclusions are that economic welfare losses tend to be more severe in developing countries, major agricultural exporters can gain significantly if world agricultural prices rise, and the carbon dioxide fertilization effect substantially offsets losses dut to climate change alone. In one scenario, the combination of carbon dioxide fertilization and adaptation led to net global welfare increases. Policy implications of the potential changes and uncertainty in the magnitude, direction , and timing of change are discussed.

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Early attempts to evaluate the economic impact of climate change on agriculture included studies by Martin Parry *et al.*, Richard Adams *et al.*, Louise Arthur, and Sian Mooney and Arthur (Steve Sonka provides a complete review). Significant advances in understanding and evaluating the economic effects of climate change have occurred since these early studies. In this paper, we present new economic model simulation results based on the significant effort of Cynthia Rosenzweig, et. al. to develop a broader understanding of how yield effects vary across the world. The broader purpose of the paper is to consider what these findings imply for agricultural policy. Two features of the results standout: 1) economic impacts of climate change must be considered in the context of global effects recognizing the role of international trade and 2) despite the considerable advance in understanding, the implications of climate change for world agriculture and even more so for individual countries or regions is highly uncertain in both magnitude and direction of effect. Considerations of national or international responses that might improve adaptive response to climate or compensate potential losers must be considered in light of these two features.

A limitation of early efforts at evaluating the economic impact of climate change was that they focused on domestic agricultural impacts and did not consider the effects of climate change on world production and markets. Sally Kane et. al., James Tobey et. al., and Reilly and Hohmann have shown that

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for open economies the effect of climate change on agriculture in any individual country cannot be considered in isolation from the rest of the world. A small country argument can justify an analysis limited to that country if environmental change occurs wholly within the country. Where effects occur simultaneously throughout the world, however, the only way to justify considering a sub-global region is to assume the economy of the region is closed, an extremely poor assumption for most countries. The recent work of Rosenzweig, et. al. seriously investigates this issue by developing a far more detailed set of crop response studies with broad geographic coverage. This paper utilizes the same yield data that has been graciously provided by Rosenzweig, et. al. Their considerable effort is our point of departure for a set of economic model simulations.

To set out the case for the importance of trade and to demonstrate the remaining uncertainty, we begin by discussing the limits of current climate predictions (Section I) and the challenges inherent in translating climate predictions into agricultural and economic impacts (Section II). We then report on an economic simulation study of the potential global and regional effects of climate change which includes a discussion of the yield estimates used which are those developed by Rosenzweig, et. al. (Section III), a description of the model used to simulate economic effects (Section IV), and a presentation of key results (Section V). We then turn to the issue of agricultural and food policy in the context of what is currently known about long-run climate change (Section VI). Finally, we offer a brief summary of the main points of the paper (Section VII).

I. Climate Predictions

Specific impact estimates require specific climate predictions. With the considerable uncertainty in climate impacts, there remains debate about the usefulness and credibility of impact studies. It is, in our view, critical to translate climate impacts into impacts of more direct relevance to society such as agricultural production effects so that policy design can be strengthened. However, taken as predictions, the value of impact studies can be no better than the climate scenarios. In this section, we briefly review areas of agreement and disagreement on potential climate change.

The Intergovernmental Panel on Climate Change summarized the current scientific consensus on climate change. We repeat here only those conclusions that are most relevant for agricultural production.

Quoting from the IPCC: Based on current model results, we predict:

- under the IPCC Business-as-Usual (Scenario A) emissions of greenhouse gases, a rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2° C to 0.5°C); this is greater than that seen over the last 10,000 years. This will result in a likely increase in global mean temperature of about 1°C above the present value by 2025 and 3°C before the end of the next century. This rise will not be steady because of other factors.

- that land surfaces warm more rapidly than the ocean, and high northern latitudes warm more than the global mean in winter.

- regional climate changes different from the global mean, although our confidence in the prediction of the detail of regional changes is low. For example, temperature increases in Southern Europe and central North America are predicted to be higher than the global mean, accompanied on average by reduced summer precipitation and soil moisture. There are less consistent predictions for the tropics and Southern Hemisphere (J. T. Houghton, *et al.*, 1990, p. xi).

Regarding soil moisture, the IPCC considered a global average increase in precipitation of 3 to 15 percent and an increase in soil moisture in high latitudes as fairly likely. With less confidence they predicted decreased soil moisture over northern mid-latitude continents in summer. Decreased soil moisture (except in the high latitudes) is possible even with global increased precipitation both because of the pattern of rainfall (the precipitation increase is more pronounced in the high latitudes) and because evaporation increases with temperature (J. T. Houghton, *et al.*, 1990, p. 135).

The 1992 Supplement to the Intergovernmental Panel on Climate Change (J. T. Houghton, *et al.*, 1992) presented a broadly similar picture. With regards to the regional effects of climate change it stated that "although confidence in regional changes simulated by GCMs remains low, progress in the simulation of regional climate is being made with both statistical and one-way nested model techniques." (J. T. Houghton, *et al.*, 1992, p.112). The supplement warned about interpreting GCM results as predictions, noting that GCM runs do not include the negative radiative effects of sulfate aerosols and indirect effects of trace gases such as the depletion of stratospheric ozone.

Simulation of several transient scenario runs and analysis of possible changes in climate variability represent some of the new directions for GCM modeling with relevance to climate impact analysis. The transient runs confirm the general patterns of change presented in the 1990 IPCC in the opinion of the 1992 Supplement (J. T. Houghton, *et al.*, 1992, p. 101). Only four transient runs of GCMs ranging from 60 year to 100 year integrations have been completed. The transient runs demonstrate that climate change is unlikely to be smooth over time but no obvious pattern emerges. Slow initial warming is observed in several scenarios but may be an artifact of the experimental design (J. T. Houghton, *et al.*, 1992, p. 102). Transient runs, however, emphasize the uncertainties still inherent in climate predictions. Climate models are not coupled effectively with ocean models and without correction transient runs are subject to drift even if left unperturbed. With only four transient runs, it is presumptuous to speak of consensus regarding the pattern of change over time for the world or for particular regions.

In studying climate impacts, one area of particular concern is climate variability. Regarding agriculture, daily and seasonal variation in temperature has potential effects on crops. Some crops perform better with cool nights and warm days. At the same time, early fall and late spring season frosts that can damage crops are more likely to occur with large diurnal variation. Seasonal cold may be important in limiting pest ranges. Extreme variability from year to year, for example, drought one year and flood the next, could be extremely disruptive to agriculture even though mean temperature and precipitation averaged over 30 years remains unchanged. However, the IPCC 1992 Supplement report concludes that "model experiments with doubled CO_2 give no clear indication of systematic change in the variability of temperature on daily to interannual time-scales, while the changes in variability for other climate features appears to be regionally (and possibly model) dependent." (J. T. Houghton, *et al.*, 1992, p.118). The few results generally show conflicting changes in variability for temperature at nearly each scale from daily to seasonal to annual. The exception is that a slight reduction in the globally averaged diurnal temperature variability has held up in two examinations. The result, however, is not uniform, as local factors are sufficient to increase diurnal variability in some areas (J. T. Houghton, *et al.*, 1992, p. 119).

Regarding extreme events, the potential for increased tropical storm activity has been a concern but the 1992 Supplement cites GCM results as inconclusive; whether tropical disturbances increase or decrease depends on how cloud cover is treated. GCM evidence on cyclones and hurricanes is inferred from the results on tropical disturbances because GCMs cannot simulate cyclones or hurricanes in detail. A second extreme event change indicated in some GCM runs is an increase in convective precipitation. The implication of increased convective precipitation is for more intense local rain at the expense of gentler but more persistent rainfall events (J. T. Houghton, *et al.*, 1992, p. 119).

The reported results generally come from evaluation of only a few GCMs. Whether the results will stand up across other GCMs in transient runs when ocean/atmosphere links are improved, or with improved cloud modeling (or under different prescribed cloud formation) is uncertain. These few analyses of variability and of the transient pattern of climate change are at best suggestive particularly given the limitations of climate models. Caution suggests that the variability results can be taken as neither confirmation of changes in variability nor confirmation that variability will not change.

II. The Micro-Analytic Foundations for Production Impacts of Climate Change

Assuming climate models could accurately predict climate change, what weaknesses exist in methods currently used to translate climate into economic impacts? Most work to date has involved the estimation of yield effects by agronomists. The yield effects are then used as an input into economic models. Separating the problem as such can lead to over- or under-estimating impacts, particularly as impact analysis moves to consider adaptation. The broader problem is that of evaluating the response of the entire production system, not just the farm level producer. In this section, we A) discuss the general components of the agricultural production system, B) focus on the issue of separating the production problem into an agronomic and economic component, C) discuss adaptation, and D) consider some problems of aggregation.

A. The general components of an agricultural production system.

In considering the micro-analytic foundation for production impacts of climate change, it is useful to distinguish 1) technical relationships between outputs and inputs, 2) behavioral assumptions of the farm decision makers, and 3) a description of the supply of inputs to production. Together, these components describe, in principle, the production system and how it will change if a commodity price or the climate changes. The technical relationship between outputs and inputs, or production function, can be written as:

$$(1) \qquad X = F\left(v, k, k_p, c, l\right)$$

where X is output such as tons of rice; v is a vector of variable inputs (frequently fertilizers, pesticides, labor, irrigation water, etc. are considered variable inputs); k is a vector of capital inputs such as machinery, draft animals, and irrigation equipment; k_p are public investments or other investments external to the individual production decisions such as roads, water reservoirs, grain elevators, research and development etc.; c is a vector of climate inputs which can, in principle, include very detailed and extensive descriptions of weather such as day-by-day or hour-by-hour temperature, precipitation, wind, daylight, CO_2 concentrations, etc.; and l is land which might be differentiated with regard to fertility, tilth, slope, water holding capacity, and location. The function, F, describes how output changes as any one or all levels of the inputs change.

The availability (or supply) of inputs is critical in determining the extent and costs of adjustment. The extreme assumptions in economic terms are that inputs are either variable or fixed. Variable inputs are available at a price that may change from year-to-year but is unaffected by the level of production. Fertilizer may be a good example of a variable input in developed countries. But in developing countries over a shorter period (such as a year), the supply of fertilizer may be limited. Thus, there may be a cost of adjusting the level of fertilizer use (beyond a quoted price of the fertilizer) in developing countries that farmers in developed countries would not bear. As a result, some researchers have modeled fertilizer as capital good. Land is frequently seen as the characteristic fixed factor. But clearly, land has been and continues to be converted to agricultural purposes. The "supply' of land to agriculture is thus critical to estimating food supply under changed climate--if land can be converted fairly easily then food supplies will be forthcoming. But the supply of land to agriculture is also critical in evaluating the potential pressure on natural ecosystems and other uses of land--easy conversion of land to agriculture may mean draining of wetlands, forest clearing, and farming of highly erosive land. Land thus can be adjusted and is a key linkage to other potential climate effects (e.g. natural ecosystems and forestry.). Climate is the better example of a fixed input: it varies but the farmer does not control the climate.

These broad categories of different inputs are identified in equation 1. Equation 1 also provides a distinction between private capital and public capital. The individual farm producer does not have control over public investments but benefits from them. Public investments are probably the most difficult to incorporate effectively in a model. If an area becomes increasingly productive, new roads, crop development stations, and similar public investments may well be developed but evaluating the cost and the speed with which such public investments are made is extremely difficult. Similarly, if agricultural production declines in an area and existing public infrastructure is abandoned or underutilized, the lost value of the investment is a specific cost of climate change. Ideally economists would like to estimate these input supply relationships that lead to long-run supply response but data limitations have limited the extent to which statistical estimation can fully identify supply relationships. (For a discussion, see, for example, Binswanger.)

The assumed behavior of farmers is also critical in determining the costs of adjustment.[1] Two aspects of behavioral constraints, both involving information, are important: 1) how do farmers gain information about crops, techniques and production practices that they currently do not use and 2) how do farmers develop information about climate. In the first case, the fact that a variety of rice exists in southern India that may grow relatively well in a warmer climate may be relevant to farmers in northern India if the climate of northern India becomes warmer. But northern Indian farmers can only take advantage of the variety if they know of it and any specific management considerations involved in growing it. How (and how fast) farmers can learn about the variety and gain experience growing it will determine how costly and quickly farmers can adjust.

The problem of developing information about climate relates to the fact that agricultural production involves sequential production decisions over the course of the growing season (e.g., see Antle) in anticipation of expected harvest price and weather conditions. While these decisions are made every

[1]The basic behavioral assumption being made here is optimization but recognizing that the skill, information, and knowledge available to the farmer produces a constrained (possibly severely constrained) optimum that may be far from an experimental farm "optimum." We also allow in the abstract for the optimization of utility rather than profits, recognizing that social values and cultural preferences may be factored into decisions about what to produce and how to produce it.

year and thus would appear to be quite flexible in response to climate change, the key problem of adjustment is how farmers update their information about the coming season's weather. In the context of optimization, the farmer is constrained by the information he has available when the crop is planted and when he makes other key production decisions. If the farmer is unable to detect climate change (possible because climate is highly variable) he will not take adaptive measures. On the other hand, reacting to normal climatic variation as if it were permanent climate change could lead to losses as well--a farmer may decide to give up growing maize in a drought year only to find that the following year provided normal precipitation. Much recent work in economics has focused on the role of expectations in various aspects of economic decision making but this has not been integrated into the types of models used for agricultural policy assessment or climate impact analysis.[2]

Existing work barely addresses input supply or the process of learning of economic agents. This lack essentially prevents meaningful measurement of adjustment costs, even if transient climate scenarios were available, because the process of adjustment is not described in the models.

B. Separability of economic and agronomic components of the production function.

The separate analysis of crops response model and economic models assumes that equation 1 can be separated into two parts. The agronomic contribution is plant productivity (which is a provisional yield). Economic models generate price changes and resulting production responses which either

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[2]Existing work is fairly rudimentary in incorporating these various considerations. At the extreme are that of Binswanger, et. al who attempt to estimate production relationships like those implied by equation 1, assuming profit maximization and that of Mendelsohn, et. al. who attempt a completely reduced form estimation of how land values are affected by climate. Binswanger et. al., not motivated directly by the issue of climate change, specify many fixed factors that help explain production over time and across countries including a crude measure of climatic potential. They do not estimate the factors that determine many of the public investments in fixed factors such as roads, education, and agricultural research and development and these may be climate/price determined and hence may be expected to change when climate changes. Thus, the danger in this approach is to underestimate adjustment potential. On the other hand, Mendelsohn et. al. consider the other extreme; they estimate a fully reduced form model where only primary resource considerations are included. In principle, this approach, estimates the full adjustment to climate but essentially assumes that both public and private investments have an indefinite period to adjust to the new climatic conditions. Suggestive empirical evidence on the differential effects of weather and climate is that of Hansen. In a cross-section estimation effort using data for the United States corn belt he found that at the sample mean that an unusually warm season depressed yields but a warmer climate enhanced yields. The quantitative and qualitative results varied across the sample as might be expected--already warm areas did not benefit from more warming.

implicitly or explicitly affect yields and crop area. Three basic issues arise in this integration of agronomic and economic results: (1) What limitations are involved by assuming separability of plant productivity and economic decisions? (2) How can adaptation be addressed within this framework? and (3) How are the extremely different levels of aggregation addressed?

Separating equation 1 to distinguish plant productivity and technical relationship considered in economic models can be described as:

$$(2) \qquad X = F_1\left(v, k, k_p, l_a; \bar{\theta}\right) \text{ where } \theta = f\left(c, l_s; \bar{v}, \bar{k}, \bar{k}_p, \bar{l}_a\right)$$

In equation 2, θ is plant productivity, the land vector has been further separated into an area measure (subscript a) and soil characteristics (subscript s). The function *f* represents a crop response model. In making estimates of these relationships economists must assume something about plant productivity and agronomists must assume something about the level of other inputs. These assumed values are denoted by the bars above the variables. In developing economic models and agronomic models, economists and agronomists make implicit assumption about the levels of these fixed variables and these implicit assumptions are unlikely to be consistent across the disciplines or even across different models within a discipline.

Equation 2 is still quite general in that individual inputs can be altered independently in response to the aggregate change in plant productivity. However, the fertilizer response to a change in plant productivity, for example, is the same whether the change in plant productivity is due to a change in January temperature or July precipitation and regardless of the soil type. More typically the simplification used when introducing agronomic evidence into existing economic models is:

$$(3) \qquad X = \theta F_1\left(v, k, k_p, l_a\right)$$

That is, plant productivity is a simple proportional shift in the level of output and the same shift occurs regardless of the level of inputs. Economic models sometimes further recognize a separation between yield per unit of land area and land area, A

$$(4) \qquad X = A \cdot \theta f_1\left(v, k, k_p\right)$$

The area, A, devoted to any specific crop may itself be a function of the productivity of land in one crop relative to other uses (other crops or nonagricultural uses).

C. Adaptation and adjustment.

How do adaptation and adjustment fit into the simplified economic model like the one considered above? Economic models generally include significant adaptation; production and consumption change to bring about an equilibrium price where the quantity supplied is equal to the quantity demanded. This tends to involve substantial changes in area devoted to different crops and more limited change in yield. Evidence suggests that production of individual crops is quite responsive to changes in the relative profitability of the crop but the overall responsiveness of agricultural supply to changes in prices has been more difficult to measure (See Binswanger, et. al.). Crop response models themselves have the automatic adjustment mechanisms of the plant as part of the models; precipitation changes generate a change in crop yield.

Crop response models are typically based on experimental conditions where agronomists highly manage the experiment such that conditions are near ideal. Thus, crop response models generally overestimate the average yields that farmers actually achieve because maintenance of ideal crop growth conditions is not economically justified in commercial settings. Economic models assume an "average" value based on the sample from which parameters are estimated. For most of agricultural economic models used for policy simulation, estimates of price responses are gleaned from surveys of various econometric literature. In this case, base productivity levels are parameters that cause the model to reproduce the base year.

As the discussion above indicates, both agronomic and economic models include adaptation. The left out adaptations in these efforts are those adaptations omitted because of the specific separability assumptions. Two examples illustrate the important considerations in estimating adaptation and effects.

Commonly production is modeled as a simple supply response to price and a change in plant productivity is taken to be a shift in supply at a given price (see, for example, the description of the SWOPSIM model in Section IV). This assumption means that if yields fall 20 percent and it previously cost $200 to produce a ton of corn, after climate change the same $200 would only produce .8 tons. To produce a full ton would now cost $240. The normalization that would be ideal would be for agronomic studies is to consider what type of adjustments in the production process could be made without spending more than $200 to get the largest yield possible. Changes in the timing of planting or other cropping production activities most easily meets this "no cost" adjustment test. If the adaptations involve increases in inputs, however, the adaptive response may overestimate the yield gain as it should be specified in an economic model. Increased irrigation may reduce yield losses but would also add costs. The correct estimate would involve consideration of whether the farmer should irrigate while offsetting the increased expense by using less of other inputs, for example, less land.

The CO_2 fertilization effect provides another example. Agronomists general recognize that full realization of the CO_2 fertilization effect would not occur if other nutrients were limiting. Most analyses treat the CO_2 fertilization as an exogenous and independent increase in yield. If other nutrients are required, in reality the farmer may face somewhat increased costs of the fertilizer that must be applied to take advantage of the yield. In practice, the bias may be small. Fertilizer expenses, while a substantial component of variable costs, tend to be a small component of the total cost as indicated by crop revenues. For example, in the United States fertilizer, lime and pesticides expenses were $12.8 billion in 1990 when crop revenues were $80.3 billion (USDA, 1991). Assuming fertilizer expenses are roughly 1/2 of the $12.8 billion, then fertilizer costs were on the order of 8 percent of crop revenue. A typical estimated effect of doubling CO_2 is to increase production by 20 percent. This increase would thus increase revenues by 20 percent with prices unchanged. But if this required a 20 percent increase in fertilizer, then the costs would increase as well. However, because fertilizer costs are a small share of total costs the increase would only be, in our example, 1.6 percent. I.e. it is the fertilizer cost share times the increase in fertilizer use (.08 times 20 percent). This would mean that the corrected supply shift would be 19.68 percent rather than 20 percent. At least these crude calculations suggest that the bias in this case is quite small.[3]

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[3] This also illustrates the potentially significant economic incentive to increase fertilizer application to take advantage of the carbon dioxide fertilization effect; if no carbon dioxide effect is forthcoming without additional fertilizer, then this rough analysis suggests that by increasing costs by only 1.6 percent one can obtain an increase in revenues of 20 percent.

D. Aggregation.

Separability and adaptation problems are further aggravated by the disconnection between levels of aggregation in economic and agronomic models. A technical description ("technology") in crop response models is specific to a particular crop variety or cultivar and to the locality of the crop canopy and root zone. Even the most disaggregated economic models aggregate across varieties of a single crop (e.g. early and late maturing maize varieties or winter and spring wheat) and typically aggregate across several crops (e.g. a coarse grain aggregate typically includes corn, sorghum and millets). Furthermore, global economic models generally must deal with geographic areas at the level of the nation or larger. The more detailed may include agronomic zones, but since similar zonal economic data are generally not available parameterization of these models requires some arbitrary assumptions. The detail of the agronomic models requires difficult assumptions about how the relatively few sites and few crops considered represent the average conditions for broad regions and for other crops.

The intent of this section has been to discuss the general microanalytic foundation for production and economic adjustment in the context of the general types of approaches currently used. Given the limitations discussed in II.A through II.D, the possible degree and even the direction of bias is difficult to assess. The many shortcomings in the analysis are unsettling, but the results would be more suspect if it was clearly the case that the approach generated a specific bias. For a another discussion see Mendelsohn and Reilly, 1993. In the following sections, specific estimates are developed. The previous discussion provides a foundation for recognizing some of the limits inherent in the following analysis.

III. Yield Effects of Climate Change

For purposes of simulating the economic effects of climate change on world agriculture in succeeding sections, the yield effects estimated by Rosenzweig, et. al. were used as inputs into the SWOPSIM agricultural trade model. The specific yield changes by country/region are detailed in Appendix A.[4] Rosenzweig *et al.* used equilibrium, doubled trace gas climates as predicted by the

[4] For more detail on the yield study and crop response models see Rosenzweig, et. al.

Goddard Institute of Space Studies (GISS), Geophysical Fluid Dynamics Laboratory (GFDL) and the United Kingdom Meteorological Office (UKMO) GCMs. The climate scenarios differ among these models in terms of the seasonality, regionality, and overall magnitude of temperature and precipitation change. The changes between the 2 times CO_2 equilibrium and the control climate in global mean surface temperature and global precipitation for the models were: GISS, +4.2° C and +11%; GFDL, +4.0° C and +8%; UKMO, +5.2° C and +15%. These global averages provide only the broadest description of how these scenarios differ.

The Rosenzweig et. al. study estimated yield changes for each GCM scenario using crop response models run for 112 sites in 18 countries. Their methodology was the following: By using a climate record of 1950 to 1980 as a base, they evaluated yields each year as estimated by the crop response model for the base climate. Next, they added the GCM-derived temperature and precipitation changes to the base climate record and reevaluated yields for each of the 30 years with the changed climate. Yield change estimates were then the difference between the 30-year average yield for the base climate and the changed climate. Crop response models for wheat, maize, rice, and soybeans were used. The sites were assumed to be representative of broader areas and weighted by current production to generate a weighted yield change for countries. These new crop studies were combined with existing estimates for other countries and regions. Together these estimates provided neither complete country nor complete crop coverage. Yield changes for estimated crops and countries were judgementally extended to other crops and other countries on the basis of their similarity to crops and regions that were estimated.[5] Carbon dioxide fertilization effects were incorporated into the crops response models via effects on photosynthesis rates. The effect was based on the assumption that CO_2 concentrations were 555 parts per million compared to 330 ppm for the base production period of 1950-1980 allowing that the remaining 105 ppm necessary for trace gas doubling was contributed by other trace gases.

Yield estimates were developed for the 3 climate scenarios with and without carbon dioxide

[5] While such extension is somewhat arbitrary, failure to do so in an economic model would lead to production shifting dramatically toward those countries and crops for which estimates were not made (assuming climate effects were generally to reduce yields). Thus, extension of the effects to other regions and crops is a reasonable "neutral" assumption in the absence of evidence to the contrary.

fertilization with no adaptation, and with 2 levels of adaptation. The level 1 adaptations consisted of production changes that generally would not lead to increased cost--these were shifts in the planting date of less than one month, increasing the rate of water applied on crops that were already irrigated, and choosing different cultivars of existing crops. Level 2 adaptations involved shifts of planting dates by more than one month, increased fertilizer application, installation of irrigation systems, development of new varieties, and a change from winter to spring wheat.

For purposes of our simulations, we did not use level 2 adaptations because at least some of these responses appeared to be costly responses and, as discussed in Section II, were inconsistent with a horizontal supply shift. In fact, the level 2 adaptations were mixed; large shifts in planting dates seem minor adjustments when one considers that the shift would occur over the course of 100 years (a one-month shift is only about 8 hours per year). Similarly, the change from winter to spring wheat does not appear to be a difficult or costly change given that farmers shift among crops from season to season without particular difficulty. Also, as discussed previously, increased fertilizer application may have a fairly minor effect on cost. As modeled, however, the CO_2 fertilization effect does not appear to have been significantly limited by lack of fertilizer. The costly adaptation among those in level 2, however, is irrigation. Irrigation response may be limited by water supply. While Rosenzweig, et. al. considered irrigation only if water supplies were available, the relevant considerations would be the extent of water supply in 50 to 100 years under the changed climate conditions. One might expect that most existing unused water resources to have been developed over the next 50-100 years even in the absence of climate change as population and food demand increases.

IV. SWOPSIM Model Structure

We used the SWOPSIM (Static World Policy Simulation) model of world food markets to simulate economic effects of climate change. SWOPSIM describes world agricultural markets with supply and demand equations specified by matrices of own and cross price elasticities.[6] The model contains 20

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[6] The discussion presented here borrows heavily from Vernon Roningen , *et al.* which contains a full discussion of and complete documentation of the SWOPSIM modeling framework.

agricultural commodities, including eight crop, four meat/livestock, four dairy product, two protein meal, and two oil product categories. The base year for the model was 1989; it was constructed to separately treat 33 countries/regions (See Appendix A). The country coverage is globally comprehensive. Crop coverage includes all grains, oilseeds, sugar crops, and tobacco. Fruits, vegetables, and root and tuber crops are not included.

The basic model structure is as follows: for each country/region i and commodity j in the model, constant elasticity demand and supply functions are specified. For country i and commodity j quantity demanded (QD) and supplied (QS) are given as:

$$(5) \qquad QD_{ij} = d_{ij}\left(1+sd_{ij}\right)*\prod_{k=1}^{n} CP_{ik}^{\alpha_k} \quad \text{and} \quad QS_{ij} = s_{ij}\left(1+ss_{ij}\right)*\prod_{k=1}^{n} PP_{ik}^{\beta_k}$$

where CP_{ik} and PP_{ik} are domestic prices facing consumers and producers of commodity k =1, ...,n. j. For k=j, the α_k and β_k are the own, uncompensated demand and supply price elasticities and for $k \neq j$ they are cross-price elasticities. The d_{ij} and s_{ij} are base quantities and the sd_{ij} and ss_{ij} are demand and supply shift parameters. A climate impact scenario involves specifying ss_{ij} for all countries (i) and all commodities (j) affected by climate change. In the simulations reported here, climate is assumed only to directly affect crop production. Secondary products such as livestock, oils, and protein meals are affected primarily because crops such as coarse grains and oil seeds are used in producing these secondary products and secondarily by changes in demand brought on by price changes. Percentage yield changes developed from crop response models are used as a measure of ss_{ij}. Domestic consumer and producer prices reflect world prices, government interventions in production, PSW_{ij} (domestic producer, export, and import subsidies) and government interventions in consumption, CSW_{ij}. Because of these interventions prices in any one country may differ from the world price and the consumer price for a country may differ from the producer price. The basic price linkage equations are:

$$(6) \qquad PP_{ij} = pp_{ij} + w_{ij}WP_{ij}^{\gamma_{ij}} + PSW_{ij} + TP_{ij} + NW_{ij} \text{ and}$$

$$(7) \qquad CP_{ij} = cp_{ij} + PP_{ij} + CSW_{ij} + PSW_{ij}$$

The w_{ij} are either 0 (nontraded commodities) or 1 (traded commodities) and NW_{ij} are domestic prices (solved within the model). The NW_{ij} are zero when w_{ij}= 1. The pp_{ij} and cp_{ij} are constants determined by the base data and the TP_{ij} are trade (export and import) interventions. The γ_{ij} are price transmission elasticities and reflect additional government interventions that limit the transmission of world price changes to domestic prices.

Market equilibrium is characterized by a set of prices where excess world demand (world supply minus world demand) equals zero for all commodities. A numerical solution is obtained in the model through iteration. Once a solution is obtained, producer and consumer surplus changes are measured as the integral of the supply and demand functions from the initial price to the new equilibrium price. Government intervention generates revenues (or tax expenditures). Changes in government revenue or tax expenditures are a third source of change in welfare. Part of this change results from the price transmission elasticity which implicitly generates government revenue or tax expenditure. Changes in government revenues or tax expenditures are borne by taxpayers who are also consumers and/or producers. Thus, the ultimate distributional effects of climate change depend on how the government revenue/expenditure change is distributed among taxpayers. We report economic effects in terms of changes in economic welfare that include changes in consumer surplus, producer surplus, and government payments.[7]

Some particular caveats apply to this model structure. SWOPSIM is a static, partial-equilibrium model and does not capture agricultural interactions with other economic sectors nor does it explicitly capture the costs of adjustments. M. Kokoski and V. Smith show that the climate change welfare effects of fairly large, single-sector impacts, can be adequately measured in a partial-equilibrium setting.[8] SWOPSIM treats resource and other inputs implicitly through specification of supply parameters.

Rosenzweig et. al. simulated economic and production shifts using the Basic Linked System (BLS) model developed at the International Institute for Applied Systems Analysis (IIASA). The principal advantage of the SWOPSIM model over the BLS model is that production and price changes are summarized as changes in welfare. Welfare measures are more directly useful for comparing the benefits

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[7] For a complete discussion of welfare measurement in SWOPSIM see Vernon Roningen , *et al*. The model uses Marshallian measures of economic surplus. For a discussion see Tobey *et al.*

[8] This conclusion may hold less well in developing countries where a significant share of the economy may be climate sensitive.

of avoided climate change with the costs of emissions reductions and for considering, for example, what level of monetary transfers might be required to compensate countries suffering particularly large losses.

IV. Basic Results Based on GCM Simulations

Detailed results by the 33 countries/regions in the SWOPSIM model for welfare, prices, and production are given in Appendix B. Here we summarize the principal results:

1) For the three GCMs net global annual welfare changes without adaptation and without (with) the carbon dioxide effect in billions of 1989 US dollars were: GISS; -$115.5 (-$.1), GFDL; -$148.6, (-$17.0), UKMO; -$248.1 (-$61.2). That is, under the GISS climate the positive effects of CO_2 fertilization offset all but $.1 billion of the losses due to climate change alone. In these cases, losses are substantial. These global losses are from .5 to 1.5 of global GNP in 1989.

2) For the three GCMs the net annual global welfare changes with the CO_2 fertilization effect and without (with) adaptation were: GISS; -$.1 (+$7.0); GFDL; -$17.0 (-$6.1); UKMO; -$61.2 (-$37.6). That is, the adaptations considered were worth on the order of $7 to $25 billion. Carbon dioxide fertilization was worth on the order of $115 to $190 billion.

3) Even under the GISS climate with CO_2 fertilization and adaptation where the net annual welfare effect for the world is positive, all three developing country income class groups suffered welfare losses (table 1). Individual developing countries experienced economic impacts different than indicated by these aggregate results. For example, China, included among the less than $500 per capita countries, experienced net economic gains in the 3 scenarios reported in Table 1.

4) The commodity price changes are closely linked to welfare changes (table 2). In the cases with CO_2 fertilization and adaptation, prices generally fall for wheat, soybeans, cotton, and tobacco under the GISS and GFDL climates but rise for rice, sugar, and maize. Under the UKMO scenario, prices rise for most commodities. Without CO2 fertilization and adaptation the price rises as much as 620 percent (rice, UKMO). Crops generally grown in warmer regions (e.g. rice, sugar cane) show the largest increase.

Table 1: Welfare Effects by Country Group
(millions of 1989 US Dollars)

	With CO_2 and Adaptation			With CO_2, No Adaptation			No CO_2, No Adaptation		
Region\GCM	GISS	GFDL	UKMO	GISS	GFDL	UKMO	GISS	GFDL	UKMO
Developing;									
<$500/capita	-210	-2573	-14588	-2070	-5322	-19827	-56692	-66110	-121083
$500-$2000/capita	-429	-2927	-10669	-1797	-5135	-15010	-26171	-27839	-48095
>$2000/capita	-603	-534	-1021	-818	-878	-328	-6661	-4351	-3870
East. Europe/USSR	2423	-125	-4875	1885	-2048	-10959	-12494	-28854	-57471
OECD	5822	25	-6470	2674	-3644	-15101	-13453	-21485	-17606
Total	7003	-6135	-37623	-126	-17028	-61225	-115471	-148640	-248124

Table 2: Percentage Price Change from Base Resulting from Climate Change

	With CO_2 and Adaptation			With CO_2, No Adaptation			No CO_2, No Adaptation		
Commodity\GCM	GISS	GFDL	UKMO	GISS	GFDL	UKMO	GISS	GFDL	UKMO
Beef	-.39	.98	2.68	.74	2.19	4.82	5.30	7.17	10.30
Pork	-1.76	2.79	9.27	1.38	6.62	16.33	19.31	25.98	37.98
Lamb	-.51	-.02	-.33	-.14	.14	.41	-1.21	-.17	.96
Poultry Meat	-1.52	2.95	9.22	1.84	6.88	16.43	19.14	25.74	37.72
Poultry Eggs	-1.60	2.33	7.86	1.00	5.58	13.96	16.46	22.56	33.50
Milk - whole	.00	.00	.00	.00	.00	.00	.00	.00	.00
Butter	-.05	-.97	-2.72	-.56	-1.94	-3.79	-5.77	-6.53	-7.97
Cheese	-.15	.10	.36	.04	.28	.75	.67	1.08	1.70
Milk Powder	-.17	.72	2.06	.40	1.55	3.28	4.25	5.35	7.18
Wheat	-21.84	2.18	49.70	-17.83	20.41	88.20	130.48	207.18	351.58
Maize	1.30	19.59	44.21	24.35	43.80	91.66	98.55	137.94	219.41
Sorghum	-6.72	12.79	42.35	1.02	27.19	74.10	95.55	141.77	235.64
Rice	24.15	22.84	78.09	34.01	41.17	109.12	359.66	371.59	618.18
Soybeans	-20.26	-7.15	28.31	-17.14	-3.66	63.42	73.74	102.60	248.94
Soybean Meal	-5.51	3.49	19.14	.45	10.22	37.22	42.15	57.40	98.26
Soybean Oil	-18.57	-10.50	12.92	-19.04	-11.21	27.76	38.14	50.48	109.93
Groundnuts	-22.76	-11.96	23.48	-21.38	-8.90	36.19	111.93	156.65	289.13
Groundnut Cake	-7.27	1.05	17.44	-2.71	6.80	30.15	48.66	66.35	105.38
Groundnut Oil	-12.43	-6.97	9.51	-12.22	-6.19	14.31	39.78	51.78	83.49
Cotton	-22.22	-14.23	26.61	-21.32	-12.09	42.47	131.75	164.76	393.41
Sugar	14.48	20.10	78.15	16.30	25.99	87.29	179.24	196.52	359.49
Tobacco	-42.02	-32.89	-5.39	-26.43	-13.90	28.11	222.32	298.29	550.78

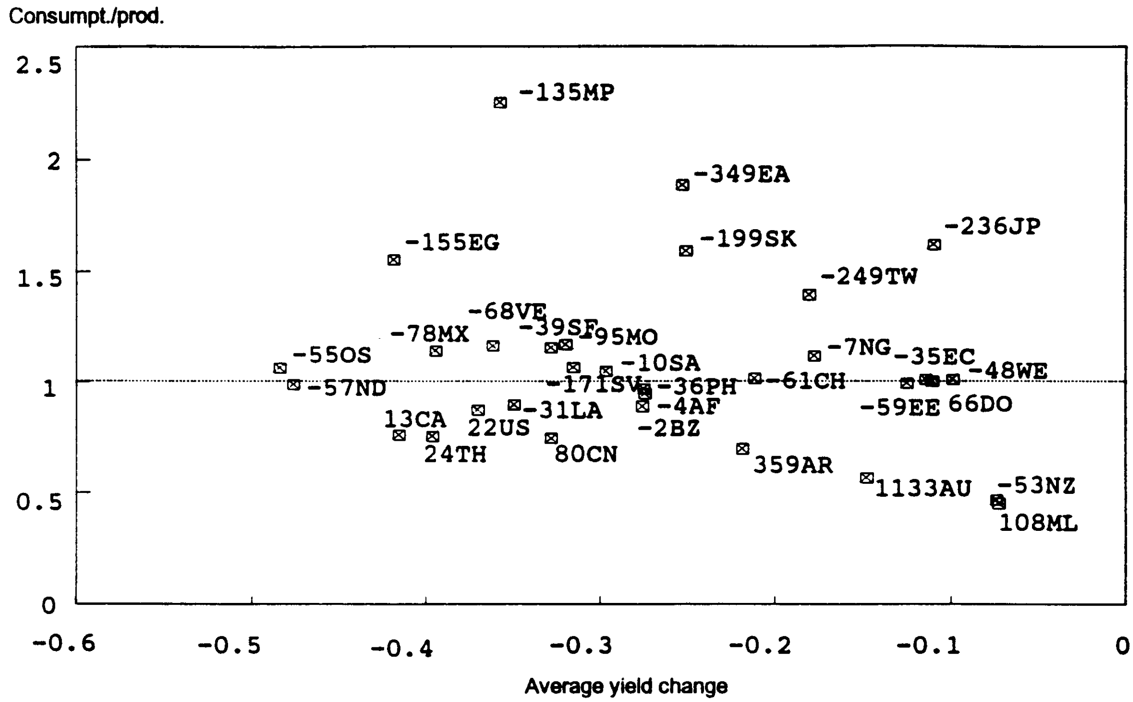
The above general results are similar to the Rosenzweig, et. al. study conclusions and flow fairly directly from the yield estimates. The more unique contribution of the SWOPSIM results are to provide the net welfare effects for individual countries and by producer and consumer groups within countries. As we have argued elsewhere (Tobey, et. al.), the net welfare effect on a country depends jointly on the country's status as a net exporter or importer and whether the yield change was negative or positive.

The specific relationship suggested by Tobey et. al. was that exporting countries could gain if world prices rose. In fact they observed that in some cases producers in exporting countries could gain even if they suffered yield losses and these gains were substantial enough to more than make up for the country's consumer losses from higher prices. The opposite was observed if global climate change generally enhanced production worldwide and world prices fell. In such a circumstance, agricultural exporting countries could suffer welfare losses even if agricultural yields were improved in the country. The basic economic reasoning for this result is that agricultural demand is generally observed to be inelastic. Thus, production restrictions will generally increase revenues to producers. When climate change is deleterious, it acts as a production restriction. In a closed economy (as is the world as a whole), the net effect of such reductions will be negative because consumer losses will outweigh producer benefits. But, where some countries are large exporters while others are large importers, individual country effects can be positive.

Figures 1- 7 plot the average yield change for a country against the ratio of consumption to production for several of the cases investigated. (See table 3 for a definition of country codes plotted with per capita welfare.) As such, these figures display the SWOPSIM results in a way that tests the relationship suggested by Tobey et. al. The yield change is the exogenously determined supply shift that served as an input to SWOPSIM. The average yield change for a country is the value-weighted average of all crops. The consumption/production ratio provides a normalized measure of import/export status. When the ratio is above 1.0 the country is a net importer. When the ratio is below 1.0 the country is a net exporter. The ratio was developed from the base data; i.e. prior to climate change impacts. The plotted numbers are per capita welfare losses for the country.

The figures also provide a reasonably compact presentation of key inputs and results. Note that for the cases without the CO_2 fertilization effect and without adaptation, all of the direct production impacts are negative under the UKMO (fig. 1) case and all but one are negative for the GISS case (fig. 2). The value-weighted yield changes for countries range from -5 to -50 percent in the UKMO case and from +5 to -40 percent in the GISS case. Thus, it is not surprising that the net global effect of these cases gives fairly severe economic welfare losses. Once CO_2 fertilization is considered, the yield losses are far smaller and some countries experience yield gains; for the UKMO case (fig. 3) the yield changes range

Figure 1: Per capita Welfare Change: UKMO, No CO_2 Fertilization, No Adaptation (1989 $ per capita)



Note: Country/region codes are plotted with per capita welfare change--see table 3 for code definitions. The average yield change for a country is the value-weighted average of all crops. The consumption/production ratio is the total value of consumption divided by the total value of production based on 1989 base data. Above 1.0 = net importer; below 1.0 = net exporter.

from about +15 percent to near -30 percent and for the GISS case (fig. 4) the yield changes range from about +25 percent to -25 percent.

The plots basically confirm the relationship suggested by Tobey, et. al.[9] The UKMO case with

[9] The one notable outlier in all cases in the lower left corner is New Zealand. New Zealand yield changes are generally the most favorable but the country generally experiences net welfare losses. The principal reason is that New Zealand agricultural exports are dominated by lamb, the price of which does not rise substantially. Hence producer gains are somewhat limited but consumer losses are substantial because of rising world prices for other commodities. This result may depend on the omission of grazing effects. No direct climate effects on livestock production are included in the SWOPSIM simulations. The livestock sectors are affected by the prices of crops that are used as livestock feed. Pasture and grazing are not treated explicitly in the model, however, nor were the productivity effects on grazing lands evaluated in the Rosenzweig study. Grazing is particularly important for lamb production. If New Zealand grazing land benefited from climate change as did crop production in several of the cases, then a direct positive supply shift on lamb production (reflecting improved pastures) should have been included as well. This would have tended to increase producer surplus in New Zealand. The omission of grazing is likely to affect other livestock categories as well but it is less apparent for other countries. For example, dairy is another livestock production activity where grazing/forage is an important input. Note in Appendix B

no fertilization and no adaptation (fig. 1) provides some of the strongest support for the relationship because world crop prices rise strongly and consistently across crops. Price increases range from about 200 percent for maize to over 600 percent for rice (see table 2). Hence, exporting countries generally gain substantially despite experiencing yield losses.

The GISS case with both CO_2 fertilization and adaptation (fig. 7) demonstrates how these effects are reversed when the net effect of climate change on world agriculture is positive. In this case, commodity prices generally fall on the order of 20-25 percent (table 2). The exceptions were rice with a price increase of nearly 25 percent and maize with a price increase of about 2 percent. Net importing countries with yield increases (the top left quadrant) benefit from lower commodity prices and better yields. These gains are only partly offset by producer losses due to lower prices. Negative welfare effects are generally experienced by exporting countries even though some experience positive yield effects; i.e. the lower two quadrants. At the same time, some importing countries show net benefits despite yield losses because consumers benefit from lower prices and this effect dominates producer losses; i.e. the top right quadrant. As might be expected, the GISS case with fertilization but without adaptation (fig. 4) shows the weakest pattern because the net effect on world welfare is near zero and crop prices increase for some crops but decrease for other crops. In the GFDL case with CO_2 fertilization and adaptation (fig. 6), welfare gains are largely restricted to those exporting countries with yield gains because price increases are fairly modest and generally not enough to offset yield losses. The other plots are generally similar to the UKMO, no carbon fertilization, no adaptation plot but somewhat less striking because the price effects were not as large.

The per capita welfare changes are also of interest. For the cases where the CO_2 fertilization effect and adaptation are included, the per capita welfare changes are fairly small. For these three scenarios, welfare losses never exceed \$50 (1989 dollars) per capita. Welfare gains are as much as \$134

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that prices change little or not at all for dairy products because grains are a minor input. In general, the omission of forage and other crops (such as fruits, vegetables, tubers, etc.) may understate changes due to climate change. It is difficult to assess the direction of bias of such omissions. If the productivity of these crops are affected in the same direction as included crops then the effect would be to underestimate the magnitude of the effect (whether positive or negative).

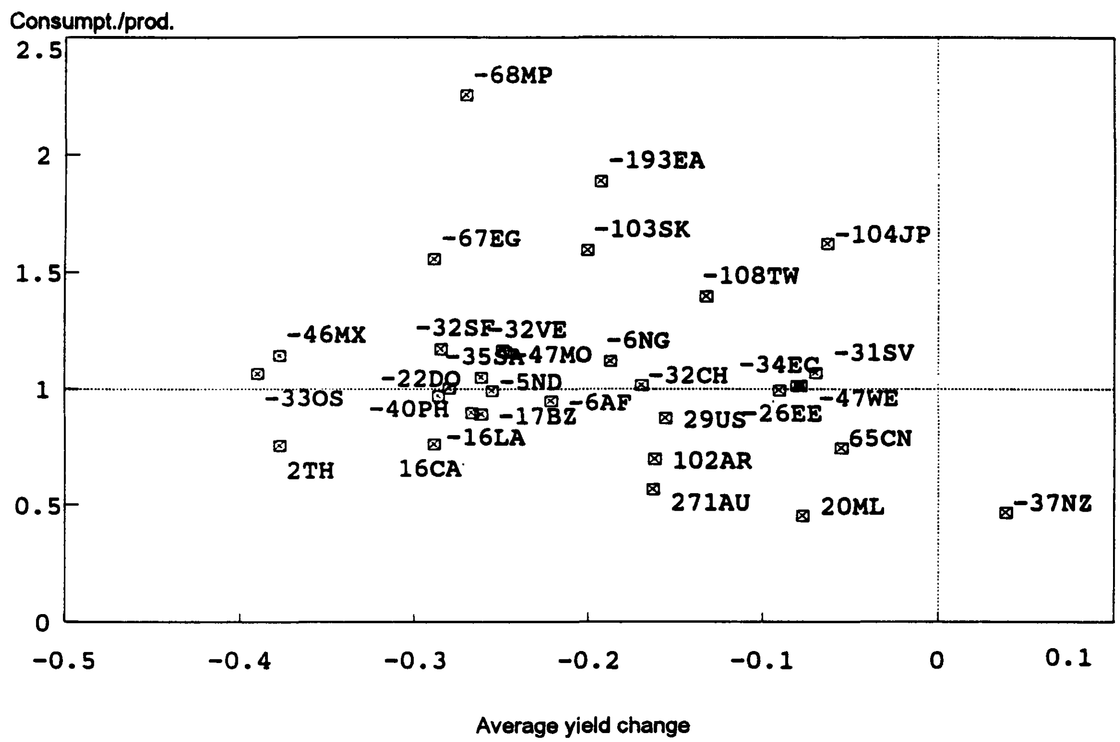
per capita. In all the scenarios, the largest per capita welfare changes are experienced by exporting countries and (except for the GISS with CO_2 fertilization and adaptation) the largest changes are welfare gains. This is not a particularly surprising result; a countries exposure to the risk of agricultural climate change depends on how important agriculture is in the economy. There is wide variation in agricultural production per capita but relatively less variation among countries in consumption (of basic commodities) per capita.[10] Thus, the greater than average exposure to climate change risk (on a per capita basis) occurs for those countries that are very large producers. The risk for this group, however, is generally the risk of significant increases in income if climate change generally causes a deterioration of global agricultural conditions. Big losses for exporting countries occur when climate change leads to generally lower world commodity prices. Thus, the largest and most concentrated financial losses from climate change would likely occur to agricultural exporters if climate change is generally beneficial. Observers of commodity markets generally should not be surprised by such a finding. The most severe economic distress tends to occur for basic commodity exporters when prices are depressed.

In the most severe cases, those without adaptation or CO_2 fertilization, the per capita losses for commodity importers are quite high for some countries. In the UKMO case, losses in a number of countries are on the order of $100 to $350 dollars per capita. These countries/regions include Japan, East Asia (Hong Kong, Macao, North Korea), South Korea, Taiwan, the Middle East Oil Producers, and Egypt. For developed countries such losses may not provide substantial problems. However, if these effects were experienced in the poorer developing countries where incomes per capita incomes are on the order of $500 to $1500, serious malnutrition and starvation might result. These large losses occur primarily for large importing countries (a consumption/production ratio of greater than 1.5) when world prices rise substantially. In this same scenario, Australia benefits by over $1100 per capita. These scenarios indicate the potential for significant change in comparative advantage and redistribution of wealth among countries not unlike that which occurred when petroleum price rose in the 1970's. These cases, however, probably should be considered extreme bounds on potential world price increases because

[10] Household consumption expenditures may vary more between developed and developing but this is due to processing expenses which are probably largely independent of climate change effects.

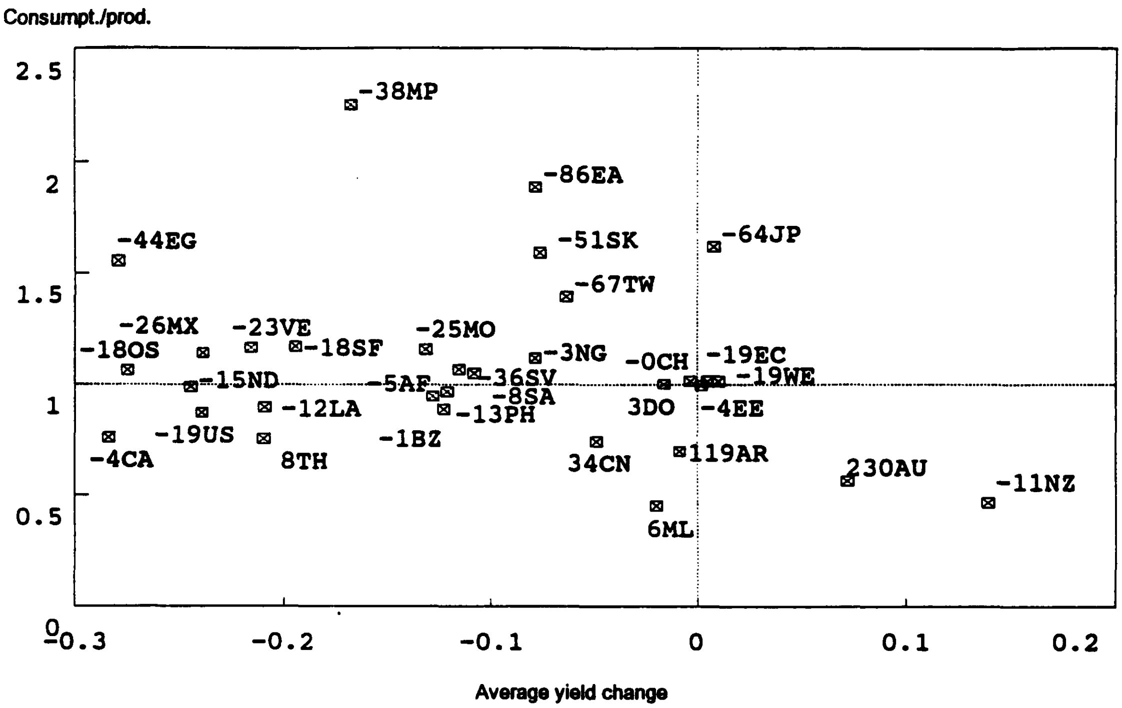
at least some CO_2 fertilization effect and some adaptation is likely. Moreover, by the time these climate changes occur per capita income may have improved in developing countries such that they can better afford these magnitudes of commodity price increases. While rising incomes would not limit the magnitude of the wealth transfer, it limits the extent that income losses result in starvation because wealthier consumers can choose food at the expense of other goods whereas subsistence consumers have few such choices.

Figure 2: Per capita Welfare Change: GISS, No CO_2 Fertilization, No Adaptation (1989 $ per capita)



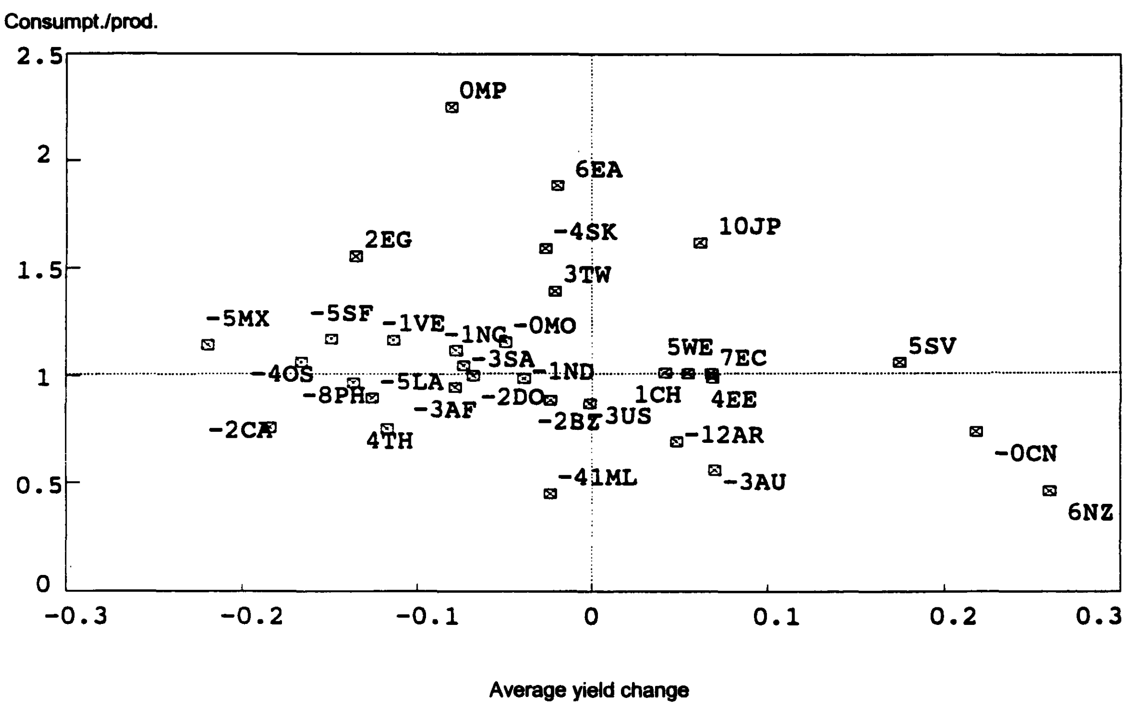
Note: see note, figure 1.

Figure 3: Per capita Welfare Change: UKMO, CO_2 Fertilization, No Adaptation (1989 $ per capita)



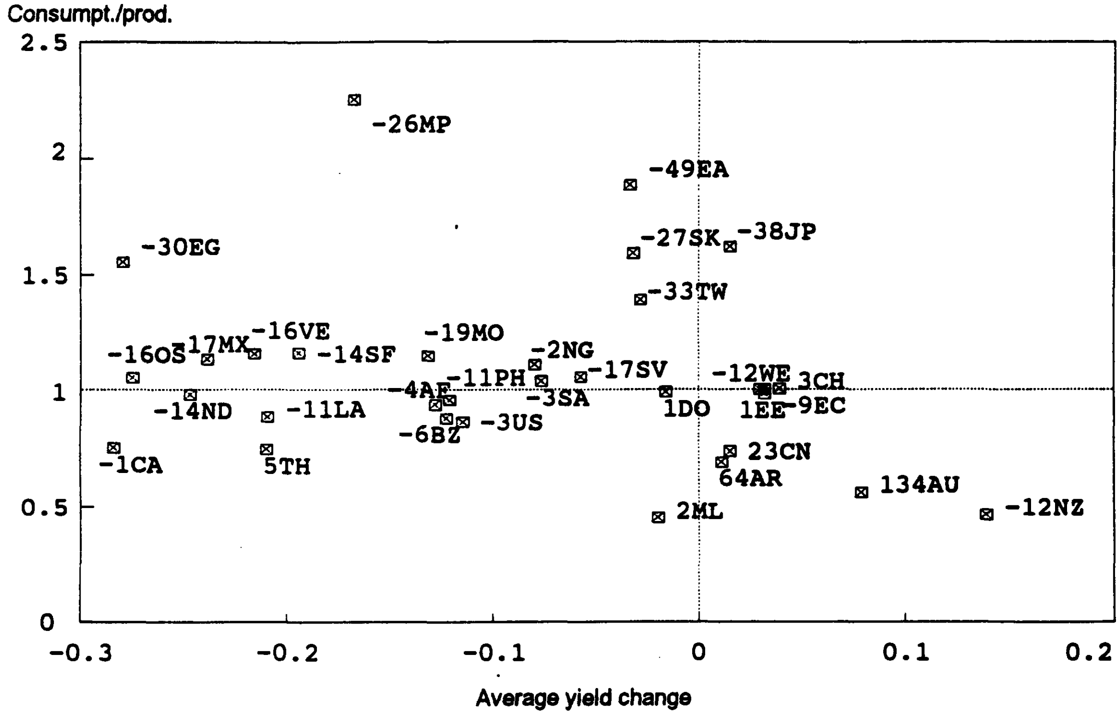
Note: see note, figure 1.

Figure 4: Per capita Welfare Change: GISS, CO_2 Fertilization, No Adaptation (1989 $ per capita)



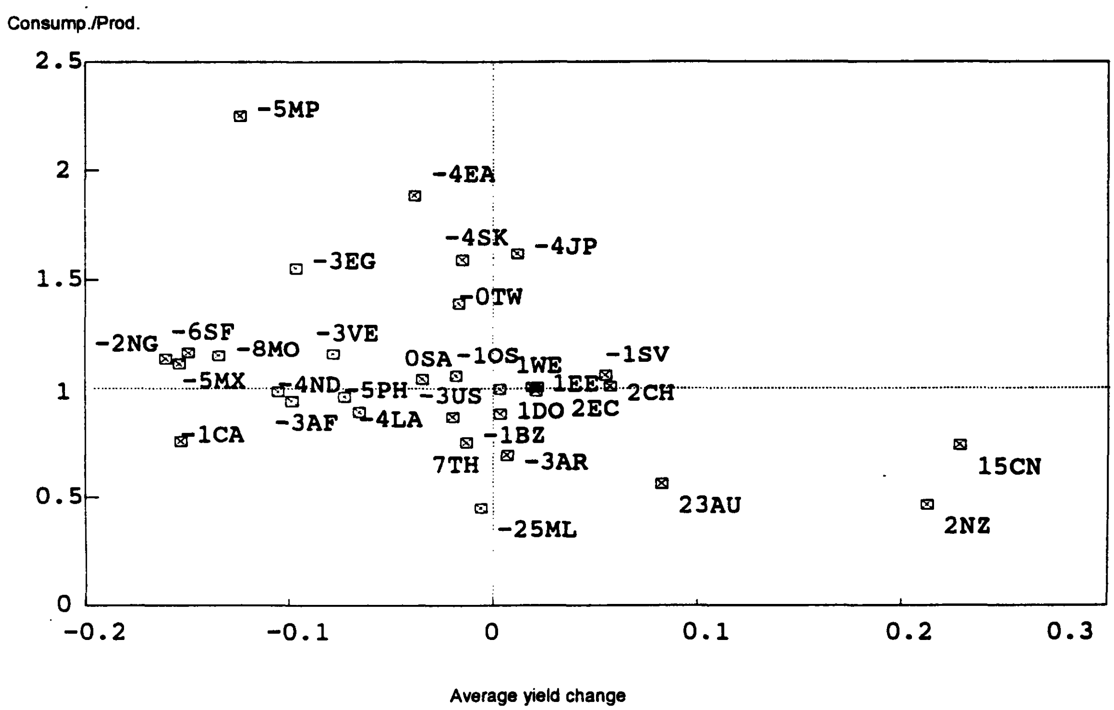
Note: see note, figure 1.

Figure 5: Per capita Welfare Change: UKMO, CO_2 Fertilization, Adaptation (1989 $ per capita)



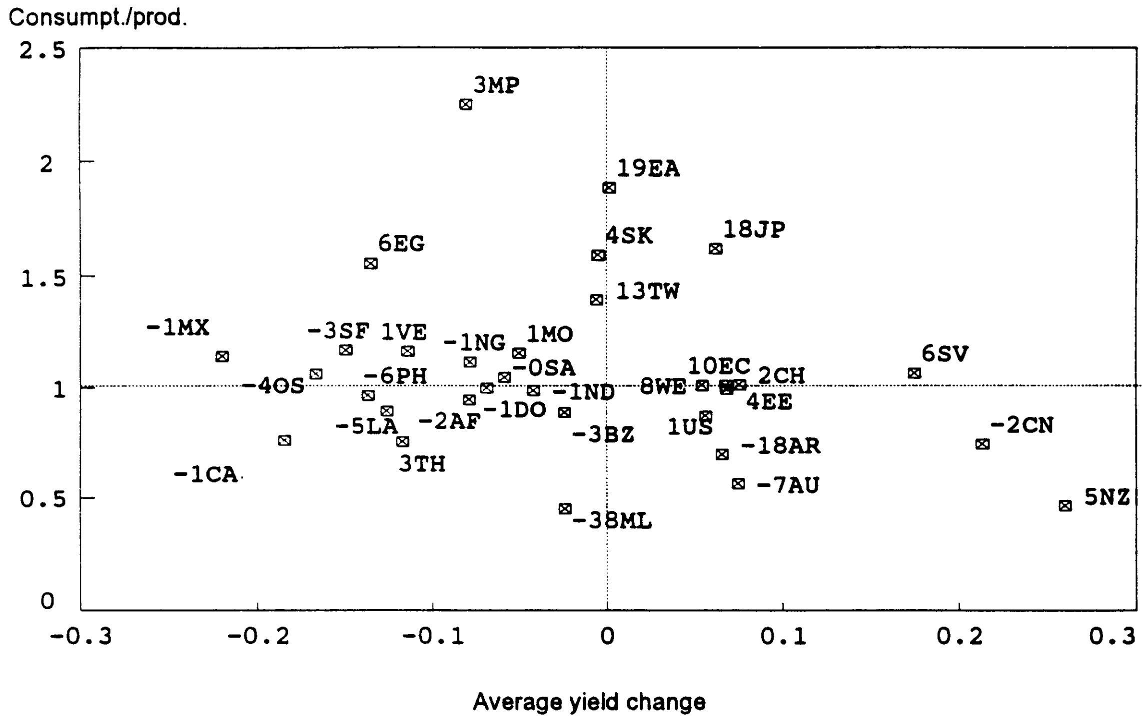
Note: see note, figure 1.

Figure 6: Per capita Welfare Change: GFDL, CO_2 Fertilization, Adaptation (1989 $ per capita)



Note: see note, figure 1.

Figure 7: Per capita Welfare Change: GISS, CO_2 Fertilization, Adaptation (1989 $ per capita)



Note: see note, figure 1.

Table 3: Country/region Coverage in SWOPSIM

Code	Country/region
US	United State
CN	Canada
EC	European Community
WE	Other Western Europe
JP	Japan
AU	Australia
NZ	New Zealand
SF	South Africa
EE	Eastern Europe
SV	Soviet Union
CH	Peoples' Republic of China
MX	Mexico
CA	Central America & Caribbean: Central America, Caribbean
BZ	Brazil
AR	Argentina
VE	Venezuela
LA	Other Latin America: Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay
NG	Nigeria
AF	Other Subsaharan Africa: Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo, Central Africa, East Africa, Angola, Botswana, Comoro Islands, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Seychelles, Swaziland, Zambia, Zimbabwe
EG	Egypt
MP	Middle East & North Africa - oil producers: Syria, Iraq, Iran, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, Oman, Bahrain, Algeria, Tunisia, Libya
MO	Middle East & North Africa - other countries: Turkey, Cyprus, Lebanon, Israel, Jordan, North Yemen, South Yemen, Morocco
ND	India
OS	Other South Asia: Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka, Papua New Guinea, Fiji, West Samoa, new Caledonia, Tonga, British Solomon Islands, Gilbert & Ellice Islands, New Hebrides
DO	Indonesia
TH	Thailand
ML	Malaysia
PH	Philippines
SA	Other Southeast Asia: Brunei, Burma, Khmer Republic, Laos, Singapore, Vietnam
SK	South Korea
TW	Taiwan
EA	Other East Asia: Hong Kong, Macao, North Korea
RW	Rest-of-world

V. Some Policy Implications

The paper began by asserting that the following two principal realities must shape any consideration of policy in anticipation of climate change impacts on agriculture: (1) international trade and (2) uncertainty. The broadest conclusion of the results are that as long as there is fair confidence that CO_2 fertilization is likely to operate more or less as represented in the crop yield studies of Rosenzweig, et al., global agriculture does not appear particularly threatened by climate change. However, in the absence of the CO_2 fertilization effect, the impacts become fairly severe. Losses of $100 to $250 billion are on the order of .5 to 1.5 percent of 1989 global GNP. On the other hand, the adaptations considered by Rosenzweig, et. al. are fairly modest and probably do not come close to exhausting the number of things that millions of individual farmers (and thousands of agricultural scientists) might come up with to deal with climate change over the next 100 years. We can hope to resolve some of these issues with more extensive research and better data, but for the practical question of what to do today, we must accept that there is significant uncertainty in both the magnitude and direction of impact for the world.

The uncertainties are, however, far greater than represented in the scenarios presented. The yield scenarios are all associated with equilibrium doubling of CO_2 and the model used to simulate effects is an equilibrium market model. As discussed in Section I, transient climate scenarios are only now being run and presently they have extreme limitations. Assuming that all climate models agreed exactly on the equilibrium effects of doubled trace gases and that this projected climate was a relevant indicator of some point in a transient path, the effects at other points on the path are purely speculative. The specific nature of climate is such that change in climate can have either positive or negative effects, particularly in agriculture when considering the generally positive direct CO_2 fertilization effect. If transient climate scenarios exhibit a basically gradual (if somewhat variable and erratic) pattern of transition as current transient GCM runs indicate) then extremely severe effects on agriculture seem unlikely through a doubling of trace gases In fact these effects may even be positive if the GISS model is illustrative of smaller (nearer term) impacts and the UKMO scenario is illustrative of larger (longer term) impacts. The GCMs, however, have far from fully explored features of the earth system that could generate discontinuities. Even a gradual change in global average conditions may consist of large regional/local discontinuities that are spread evenly over time. In such a case, significant adjustment costs could be borne by the world agricultural system. One hypothesis is that ocean circulation could change suddenly in a way that would, ironically, lead to severe cooling in Northern Europe. Climate model output that describes the likelihood and degree of such discontinuities for regions is needed to realistically evaluate the issue of adjustment costs.

The policy implications of these results include:

1. Trade is able to play a significant adaptive role, allowing farmers in countries less severely affected by climate change to profit by selling production to consumers in the more severely affected regions. In this way, markets act to pool the risk of locally severe effects. Even with highly uncertain scenarios, regionally differentiated effects are highly likely. Can markets continue to play this risk pooling role? One scenario that could arise that would prevent markets from operating as effective risk pooling mechanisms would be if countries intervened to prevent adjustment in trade flows. Why would countries do this? Producer groups are relatively well organized political forces. A growing loss of comparative advantage suggesting that a country's agricultural resources should shift to other activities could easily generate pressure for import restrictions or domestic subsidies to maintain the domestic agricultural industry. Sometimes the protection of domestic agriculture is cast as supporting national food security. To maintain a national "comfort level" in food security, whether that comfort level is 120 percent, 100 percent, 80 percent or 25 percent of domestic consumption, trade restrictions would have to increase if the country's basic ability to produce is degrading relative to the rest of the world. Whether couched as food security or domestic industry protection, one policy implication resulting from significant changes in regional comparative advantage could be increased pressure for trade barriers, even though this would lead to larger economic losses overall. These pressures depend on relative, not absolute, changes in productivity, and hence, could operate equally strongly even when worldwide production capability is increasing.
2. The significant uncertainty in both global and regional effects of climate change could perniciously interact with efforts to protect the domestic industry. If deteriorating agricultural conditions were predicted for a nation, a reasonable strategy may be to expand research into improved crops, and

cropping techniques, develop irrigation resources, and expand cropped area. If, however, these adaptations represent public funded responses that occur while the rest of world's agriculture is doing quite well, this country would be throwing good money after bad. A better use of the funds would be to develop new skills among the rural population so that they might not labor indefinitely without hope of overcoming the worsening relative agricultural position. With export earnings from new industries the country could import food for less than producing it domestically. If the same climate conditions face the country, but now the rest of the world is more severely affected by climate change the conclusion is reversed. The country cannot only produce food more cheaply itself but may find itself with a growing and profitable agricultural export industry. In other words, the changing and uncertain comparative advantage among countries suggests that one should, if some type of national agricultural climate adjustment policy is considered, view the policy in the terms of strategic trade policies--Is it a good strategic investment based on the ability to compete in the future or is it costly support that will prolong an industry that will only grow less competitive? Moreover, in a broad context, cultural values and environmental policy goals need to be considered.

3. Given these huge uncertainties, flexibility must be a key consideration, but what does flexibility mean and what does it cost? Flexibility and diversity are frequently linked but are not necessarily the same concept. One can imagine a very diverse agricultural sector but one with little flexibility. Rather than producing only wheat and rice, one might produce maize, rice, wheat, and groundnuts as well. Thus, if conditions deteriorate for rice, only one-fifth of the crop would be at risk rather than one-half the crop. Flexibility, on the other hand might involve assuring that all farmers could grow both rice and wheat. Hence, if conditions deteriorate for rice, one need lose very little because everyone could grow wheat instead. However, because agricultural conditions for different crops are closely correlated (few crops grow well under extreme drought), neither diversity nor flexibility within agriculture alone is likely to be particularly effective. Being able to grow both corn and wheat or growing corn, rice, wheat, and groundnuts is not an effective risk strategy if none of the crops do well. Thus, again, access to markets (both within countries and among countries) seems to provide a more likely opportunity to avoid local crop failure (both due to short-term drought conditions and

long-term climatic trends). Development of other employment opportunities (unrelated to agriculture) and improved education and training probably provide more effective diversification and flexibility to insure farmers against financial risk. Furthermore, these human capital investments are consistent with any overall development program.

4. Subsistence farms and farming communities merit special policy consideration because the risks are starvation and malnutrition rather than financial loss. By definition, such groups are unaffected by commodity markets, either domestic or global. Being both the supplier and demander of the products, the implicit price of commodities is fully determined within the subsistence farm. The farm must fully bear the risk of local bad years (food storage is the private insurance mechanism). Subsistence agriculture is also, by definition, near the edge. If climatic resources and other resources such as skill levels and financial capital were better, the amount of food produced would exceed the amount needed by the household and the farm could enter commercial markets and thus financial savings could allow the farmer to take advantage of markets in times of food shortage. On the other hand, any worsening of climatic conditions means that the household must use whatever resources at hand (largely their own labor) more intensively or face hunger, malnutrition, and starvation. These same groups are subject to the current vagaries of climate which includes cycles of drought. While the risks are greater for such groups, the general direction of policy is probably no different than in the general case discussed above under 3; i.e. policies that improve skill levels and integrate these groups into markets. General education and training will allow these peoples to become better farmers (or potentially enter a manufacturing workforce). With better incomes and improved skills they will be in a better position to deal with climate changes.[11]

[11]Special problems are introduced by consideration of indigenous peoples who live in a subsistence manner. Preservation of their rights to their culture may conflict with an adaptive insurance strategy of economic development, diversification, and integration. These very things may be antithetical to preserving the culture. Because regional conditions are likely to change, it is fairly certain that for some such peoples conditions will worsen while for others conditions may improve by some measures. Whether these peoples could be compensated for these losses is likely overwhelmed by the process of bargaining for compensation with unequal power of the bargaining participants and the difficulty of evaluating the extent of loss.

5. The modeling results suggest a fairly consistent picture of negative effects in the developing countries in the aggregate. What does this mean for adaptive policy response for individual developing countries? Unfortunately, very little. Even across the three scenarios that one might consider "reasonable" projections rather than thought experiments (i.e. the 3 climate scenarios with fertilization and modest adaptation) the direction of effect varies for individual developing countries and among developing countries. For example, the Other sub-Saharan region shows net welfare losses in all three scenarios but under the GISS scenario consumers benefit from lower food prices while producers suffer from the same lower prices plus degraded climatic conditions. In the GFDL scenario, there are both producer and consumer losses whereas under the UKMO scenario there are producer gains and consumers losses. Further the results probably create more uniformity of effect than one might actually expect because 1) the climate models themselves are coarsely resolved, 2) the Rosenzweig et. al. approach of extrapolating from a relatively few sites tends to create uniformity that may not occur, and 3) the SWOPSIM model aggregates countries. Thus, again the watchword appears to be uncertainty.

6. Can adjustment to new crops and cropping practices be fostered? Forecasts of climate and weather over a season or over a few years is improving, but the links to long term change are still not well understood. What farmers are directly interested in, of course, is not climate itself but instead successful (agronomically and financially) agricultural practices. In the context of changing climate, successful practices may change. Climate will not be the only factor that changes over the next one-hundred years. There may be new crops, new technologies, changing local demands (as incomes rise), and changing input and output prices. The U.S. agricultural experiment station, similar approaches in other countries, and the international network of crop research institutes[12] serve to biologically integrate the local climatic information into the cultivar selection process by selecting those that do well at the site. This crop selection process can be an essentially autonomous

[12]Examples include. CIMMYT: the International Maize and Wheat Improvement Center, IRRI: International Rice Research Institute, IARC: International Agricultural Research Centres, ICARDA: International Center for Agricultural Research in the Dry Areas. One international agricultural research institutions is FAO, 1989.

adjustment process: the crop breeder and selector need not recognize that a choice was in part determined by the fact that climate had changed (or that CO_2 levels had increased). Countries with an effective network of such stations will be more likely to deliver to local farmers crop varieties which are better adapted to the changing climate. Thus, supporting the existing network and expanding it appears to be a reasonable response. (For other approaches, see Jodha, 1989.)

7. Climate change may introduce some additional considerations in the existing crop development system. Selection criterion among cultivars has generally been on the basis of yields under somewhat idealized conditions. Such an approach may be justifiable if one is comparing one cultivar against a set of unchanging alternatives and climatic conditions. Under a situation of climate change where the yields of all crops may be changing simultaneously there is probably a need to compare farming strategies rather than the yield of a single crop against the existing standard. Such farming strategies may include switches to different crops, different cropping practices, new rotation schemes, etc. Comparing among farming strategies will further require a measure of success that is broader than yield (e.g. profitability). The need to make such comparisons is already recognized as part of the move to evaluate sustainable agricultural practices that involve comparing performance of a mixed farming enterprise with commercial agricultural enterprises that involve greater specialization. Thus, consideration of climate change encourages momentum in a direction that sustainable agriculture has already begun.

8. Considerations of climate change may also suggest some alterations in the specific strategies for selecting experimental sites. In the absence of climate change the experiment site tends to be located in the heart of a particular agronomic belt and crops are selected that are known to be relatively well-adapted to the "known" climatic conditions. With the prospects of climate change, there may be an advantage to locate sites at the edges of agronomic zones or near the transition between zones. It may further be an advantage to select a range of crops and practices that include some that may be maladapted to the "known" climate. These may prove to be surprisingly successful if climate has, in fact, changed but the change has not been broadly detected or recognized.

VI. Conclusions

Considerable progress has been made in evaluating the potential effects of climate change on global agriculture but significant uncertainties remain. Based on current understanding of climate change as represented by equilibrium GCM scenarios, the potential magnitude of impacts on agriculture generally show that the economic losses are manageable and in some cases the effects are positive. The reasonably modest negative and in some cases positive impacts in these scenarios depend on the estimated positive direct effect of CO_2 on plant growth. If the direct fertilization effect is far less positive then currently estimated, then the economic effects could be substantial. The analyses presented in this paper were based on analysis of equilibrium climate scenarios associated with a doubling of trace gas concentrations. The IPCC projected that the global temperature increase like that shown in the equilibrium scenarios may not occur until nearly 2100. To consider the implications of such changes on agricultural policy, one must consider the nearer term effects. Until specific transient climate runs can be evaluated, the nearer term effects of climate change are speculative. The nature of climate change in transient scenarios remains a significant uncertainty in addition to many other uncertainties within the narrower scope of specific modeling studies of agricultural effects.

The policy relevant conclusions are:

- Based on current analyses, climate change effects on global agriculture appear manageable and possibly beneficial for an equilibrium doubled trace gas climate, but the possibility of more severe effects cannot be ruled out until more is known about the nature of transient climate and economic models are designed that can better consider adjustment costs.
- International trade is an important risk pooling mechanism.
- Significant relative change in agricultural productivity is likely whether the net effect on global agricultural production potential is negative or positive. Attempts by countries to protect domestic agricultural producers could interfere with international trade and such trade interventions would create additional losses.
- The difficulty of predicting climate change at relevant scales and time frames for agricultural decision-making suggests that regional experiment stations should continue to play an important role

in evaluating and selecting crops and agricultural production strategies. Considerations of climate change place greater emphasis on evaluating broader measures of success such as profitability rather than narrower measures such as yield.

- It is difficult to predict with confidence the direction of economic impact for specific areas; flexibility is a key to minimizing the cost of adjustment. For developing countries, increased education and economic development that includes development of manufacturing appears to increase flexibility and serve as an insurance against climatic conditions that may turn unfavorable for agriculture.
- Subsistence agricultural systems are most at risk because they cannot avail themselves of the risk pooling value of markets. Education, economic development, and integration of these areas into national commodity and labor markets appear to be successful insurance policies against the possibility that agricultural conditions could degrade substantially in some areas.

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Appendix A
Derivation of SWOPSIM Yield Responses

Appendix A contains tables of crop yield responses to climate change from Rosenzweig et al. and corresponding tables of yield responses which served as inputs in the SWOPSIM model. Additional documentation on the coordination of the two sets of crop yield responses is also provided. Tables A1 to A18 document yield responses in climate change scenarios in which no adaptation is assumed to occur. Tables A19 to A36 document yield responses for various crops assuming moderate adaptation.

Estimation of yield changes associated with climate change

Data on changes in crop yields resulting from climate change are drawn from Rosenzweig, et al. (1993). This study assesssed yield changes for the entire world using equilibrium, doubled-trace-gas climates as predicted by the GISS, GFDL, and the United Kingdom Meterological Office (UKMO) GCM's. Yield changes were estimated for each GCM scenario on the basis of new crop response models in 23 countries. These results were combined with existing estimates for other regions to estimate yield changes worldwide for all crops. Shifts in production and other economic adjustments resulting from yield changes were modeled using the "basic linked system" (BLS) model developed at the International Institute for Applied Systems Analysis (IIASA).

The present study incorporates yield change estimates from Rosenzweig, et al. into the Static World Policy Simulation (SWOPSIM) model. The principle advantage in using the SWOPSIM model over the BLS model is that production and price changes are summarized as changes in welfare. Welfare measures are useful for comparing the benefits of avoiding climate change with the costs of reducing emissions. In order to simulate the effects of climate change on agriculture using the SWOPSIM model, data on changes in crop yields were transferred from the format in Rosenzweig, et al. into a usable format in SWOPSIM. Most of the large regions in Rosenzweig, et al. corresponded to identical regions in the SWOPSIM model (see below). In instances where the crop types and regions in the SWOPSIM model did not completely correspond with regional and crop breakdowns of the Rosenzweig yield data, the following procedures were used:

A. If one region in the Rosenzweig data set was completely inclusive of a region in SWOPSIM, then yield changes were mapped directly into the SWOPSIM region. (e.g. the region of Venezuela in the SWOPSIM model is included in the region of Latin American High Income Caloric Exporters in the Rosenzweig data set)

B. If a SWOPSIM region was divided among more than one region in the Rosenzweig data set, then the assigned yield change is a weighted average of the yield changes in each of the subsidiary regions in the Rosenzweig set. The weights are based on the relative size of production of the given crop in each of the subsidiary regions. (e.g. yield changes for wheat in the SWOPSIM region "Other Southeast Asia" are a weighted average of the yield changes for wheat in two regions of the Rosenzweig data set: Far East Asia Low Income and Far East Asia High Income Caloric Importer)

C. If no corresponding regions existed in the Rosenzweig data set for a given SWOPSIM region, then a climatically similar region was chosen as a proxy and yield changes in the proxy region were mapped directly into the SWOPSIM region. (e.g. the SWOPSIM region "South Africa" takes the region African Middle Income Caloric Importer as a proxy)

Discrepancies in crop categories were dealt with similarly. Wheat, rice and sugar categories existed in both the SWOPSIM and Rosenzweig formats. Yield changes for the coarse grain category were applied to both the corn and other coarse grains categories in SWOPSIM. The protein feed category from the Rosenzweig data set corresponds to soybeans and other oilseeds categories in SWOPSIM. The non-food category corresponds to tobacco and cotton categories in SWOPSIM. Where more information was available, for example in the United States, closer correspondences were established.

The results are crop yield changes by country and crop for each of nine different climate scenarios. These results served as inputs into the SWOPSIM model. Tables A1 to A36 document yield changes for regions in the study by Rosenzweig, at al. and the SWOPSIM model.

Regions common to both SWOPSIM and Rosenzweig et al.:

Australia, Argentina, Brazil, Canada, China, Commonwealth of Independent States, European Community, India, Indonesia, Japan, Mexico, New Zealand, Nigeria, Thailand, United States

Regions specific to Rosenzweig, et al.:

Austria
Pakistan
Turkey
Kenya

Africa:
Oil exporters: Algeria, Angola, Congo, Gabon
Medium income/calorie exporters: Ghana, Ivory Coast, Senegal, Cameroon, Mauritius, Zimbabwe
Medium income/calorie importers: Morocco, Tunisia, Liberia, Mauritania, Zambia
Low income/calorie exporters: Benin, Gambia, Togo, Ethiopia, Malawi, Mozambique, Uganda, Sudan
Low income/calorie exporters: Guinea, Mali, Niger, Sierra Leone, Upper Volta, Central African Republic, Chad, Zaire, Burundi, Madagascar, Rwanda, Somalia, Tanzania

Latin America:
High income/calorie exporters: Costa Rica, Panama, Cuba, Dominican Republic, Ecuador, Surinam, Uruguay
High income/calorie importers: Jamaica, Trinidad and Tobago, Chile, Peru, Venezuela
Medium-low income: El Salvador, Guatemala, Honduras, Nicaragua, Colombia, Guyana, Paraguay, Haiti, Bolivia

Far East Asia:
High-Medium income/calorie exporters: Malaysia, Philippines
High-medium income/calorie importers: Republic of Korea, Laos, Vietnam, Korea DPR, Kampuchea
Low income: Nepal, Burma, Sri Lanka, Bangladesh

Near East Asia:
Oil exporters/high income: Libya, Iran, Iraq, Saudi Arabia, Cyprus, Lebanon, Syria
Medium-low income: Jordan, Yemen Arab Republic, Peoples' Democratic Republic of Yemen, Afghanistan

Regions specific to SWOPSIM:

Other Western Europe
South Africa
Eastern Europe
Central America & Caribbean: Central America, Caribbean
Venezuela
Other Latin America: Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay
Other Subsaharan Africa: Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Senegal, Sierra leone, Togo,Central Africa, East Africa, Angola, Botswana, Comoro Islands, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Seychelles, Swaziland, Zambia, Zimbabwe
Middle East & North Africa - oil producers: Syria, Iraq, Iran, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, Oman, Bahrain, Algeria, Tunisia, Libya
Middle East & North Africa - other countries: Turkey, Cyprus, Lebanon, Israel, Jordan, North Yemen, South Yemen, Morocco

Other South Asia: Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka, Papua New Guinea, Fiji, West Samoa, New Caledonia, Tonga, British Solomon Islands, Gilbert & Ellice Islands, New Hebrides
Malaysia
Philippines
Other Southeast Asia: Brunei, Burma, Khmer Republic, Laos, Singapore, Vietnam
South Korea
Taiwan
Other East Asia: Hong Kong, Macao, North Korea
Rest-of-world

Table A1: Percentage yield changes: Wheat, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.21	-.02	-.23	-.02	-.33	-.14
Canada	-.12	.27	-.10	.27	-.38	-.07
European Community	-.12	.08	-.28	-.15	-.23	-.09
Oth. West. Europe	-.12	.08	-.28	-.15	-.23	-.09
Japan	-.18	-.01	-.21	-.05	-.40	-.27
Australia	-.18	.08	-.16	.11	-.14	.09
New Zealand	.02	.29	-.02	.25	-.13	.11
South Africa	-.35	-.13	-.35	-.13	-.40	-.18
Eastern Europe	-.12	.08	-.28	-.15	-.23	-.09
Former Soviet Union	-.08	.25	-.21	.06	-.35	-.20
P. Rep. of China	-.05	.16	-.12	.08	-.17	.00
Mexico	-.53	-.31	-.46	-.24	-.55	-.33
Cen.Amer. & Carib.	-.51	-.29	-.38	-.16	-.53	-.31
Brazil	-.51	-.33	-.38	-.17	-.53	-.31
Argentina	-.46	-.24	-.43	-.21	-.52	-.30
Venezuela	-.46	-.24	-.43	-.21	-.52	-.30
Oth. Latin America	-.47	-.25	-.42	-.20	-.52	-.30
Nigeria	-.25	-.03	-.35	-.13	-.25	-.03
Subsaharan Africa	-.37	-.15	-.42	-.20	-.42	-.20
Egypt	-.36	-.31	-.28	-.26	-.54	-.51
Middle East, Oil	-.35	-.13	-.40	-.18	-.45	-.23
Middle East, Other	-.31	-.09	-.39	-.17	-.40	-.18
India	-.32	.03	-.38	-.09	-.56	-.26
Other South Asia	-.53	-.19	-.32	-.10	-.69	-.50
Indonesia	-.34	-.12	-.26	-.04	-.23	-.01
Thailand	-.40	-.18	-.29	-.07	-.42	-.20
Malaysia	-.54	-.32	-.46	-.24	-.42	-.20
Philippines	-.54	-.32	-.46	-.24	-.42	-.20
Other SE Asia	-.32	-.10	-.38	-.16	-.56	-.34
South Korea	-.12	.10	-.17	.05	-.29	-.07
Taiwan	-.12	.10	-.17	.05	-.29	-.07
Other East Asia	-.12	.10	-.17	.05	-.29	-.07
Rest of World	-.33	-.09	-.33	-.10	-.42	-.20

Table A2: Percentage yield changes: Corn, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.20	-.16	-.29	-.21	-.36	-.29
Canada	-.05	.15	-.03	.17	-.34	-.14
European Community	-.08	.01	-.08	.01	-.07	.02
Oth. West. Europe	-.08	.01	-.08	.01	-.07	.02
Japan	-.02	.23	-.05	.20	-.10	.15
Australia	-.16	.05	-.17	.04	-.16	.05
New Zealand	.05	.25	.00	.20	-.05	.15
South Africa	-.30	-.21	-.30	-.21	-.35	-.26
Eastern Europe	-.08	.01	-.08	.01	-.07	.02
Former Soviet Union	-.08	.12	-.21	-.05	-.35	-.15
P. Rep. of China	-.21	-.14	-.20	-.12	-.22	-.14
Mexico	-.43	-.35	-.36	-.28	-.45	-.37
Cen.Amer. & Carib.	-.19	-.11	-.20	-.12	-.27	-.19
Brazil	-.19	-.12	-.20	-.13	-.27	-.20
Argentina	-.17	-.09	-.28	-.20	-.25	-.17
Venezuela	-.19	-.11	-.20	-.12	-.27	-.19
Oth. Latin America	-.19	-.11	-.20	-.12	-.27	-.19
Nigeria	-.25	-.18	-.35	-.28	-.25	-.18
Subsaharan Africa	-.32	-.23	-.34	-.25	-.38	-.29
Egypt	-.25	-.17	-.25	-.17	-.38	-.30
Middle East, Oil	-.30	-.13	-.35	-.18	-.40	-.23
Middle East, Other	-.26	-.08	-.34	-.16	-.35	-.17
India	-.22	-.15	-.28	-.20	-.46	-.39
Other South Asia	-.43	-.32	-.32	-.21	-.55	-.44
Indonesia	-.34	-.27	-.26	-.19	-.07	.00
Thailand	-.40	-.33	-.29	-.22	-.42	-.35
Malaysia	-.49	-.41	-.41	-.33	-.47	-.39
Philippines	-.49	-.41	-.41	-.33	-.47	-.39
Other SE Asia	-.17	-.09	-.17	-.09	-.22	-.14
South Korea	-.12	-.04	-.13	-.05	-.16	-.08
Taiwan	-.12	-.04	-.13	-.05	-.16	-.08
Other East Asia	-.12	-.04	-.13	-.05	-.16	-.08
Rest of World	-.25	-.13	-.25	-.14	-.32	-.21

Table A3: Percentage yield changes: Other coarse grains, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.20	-.16	-.29	-.21	-.36	-.29
Canada	-.05	.15	-.03	.17	-.34	-.14
European Community	-.08	.01	-.08	.01	-.07	.02
Oth. West. Europe	-.08	.01	-.08	.01	-.07	.02
Japan	-.02	.23	-.05	.20	-.10	.15
Australia	-.16	.05	-.17	.04	-.16	.05
New Zealand	.05	.25	.00	.20	-.05	.15
South Africa	-.30	-.21	-.30	-.21	-.35	-.26
Eastern Europe	-.08	.01	-.08	.01	-.07	.02
Former Soviet Union	-.08	.12	-.21	-.05	-.35	-.15
P. Rep. of China	-.21	-.14	-.20	-.12	-.22	-.14
Mexico	-.43	-.35	-.36	-.28	-.45	-.37
Cen.Amer. & Carib.	-.19	-.11	-.20	-.12	-.27	-.19
Brazil	-.19	-.12	-.20	-.13	-.27	-.20
Argentina	-.17	-.09	-.28	-.20	-.25	-.17
Venezuela	-.19	-.11	-.20	-.12	-.27	-.19
Oth. Latin America	-.19	-.11	-.20	-.12	-.27	-.19
Nigeria	-.25	-.18	-.35	-.28	-.25	-.18
Subsaharan Africa	-.34	-.25	-.37	-.28	-.39	-.30
Egypt	-.25	-.17	-.25	-.17	-.38	-.30
Middle East, Oil	-.30	-.13	-.35	-.18	-.40	-.23
Middle East, Other	-.28	-.12	-.34	-.18	-.36	-.20
India	-.32	-.07	-.38	-.13	-.56	-.31
Other South Asia	-.45	-.34	-.31	-.20	-.57	-.46
Indonesia	-.34	-.27	-.26	-.19	-.07	.00
Thailand	-.40	-.33	-.29	-.22	-.42	-.35
Malaysia	-.49	-.41	-.41	-.33	-.47	-.39
Philippines	-.49	-.41	-.41	-.33	-.47	-.39
Other SE Asia	-.29	-.21	-.28	-.20	-.38	-.30
South Korea	-.12	-.04	-.13	-.05	-.16	-.08
Taiwan	-.12	-.04	-.13	-.05	-.16	-.08
Other East Asia	-.12	-.04	-.13	-.05	-.16	-.08
Rest of World	-.25	-.13	-.26	-.14	-.32	-.20

Table A4: Precentage yield changes: Rice, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.18	.01	-.26	-.07	-.42	-.23
Canada	.00	.00	.00	.00	.00	.00
European Community	.00	.00	.00	.00	.00	.00
Oth. West. Europe	.00	.00	.00	.00	.00	.00
Japan	-.10	.09	-.23	-.06	-.16	.02
Australia	-.13	-.12	-.17	-.17	-.18	-.17
New Zealand	.00	.00	.00	.00	.00	.00
South Africa	.00	.00	.00	.00	.00	.00
Eastern Europe	.00	.00	.00	.00	.00	.00
Former Soviet Union	-.08	.11	-.21	-.02	-.35	-.16
P. Rep. of China	-.24	-.03	-.25	-.05	-.25	-.05
Mexico	-.43	-.24	-.36	-.17	-.45	-.35
Cen.Amer. & Carib.	-.31	-.12	-.28	-.09	-.42	-.23
Brazil	-.35	-.16	-.26	-.07	-.44	-.25
Argentina	.00	.00	.00	.00	.00	.00
Venezuela	-.30	-.11	-.28	-.09	-.41	-.22
Oth. Latin America	-.34	-.15	-.29	-.10	-.45	-.26
Nigeria	-.15	.04	-.25	-.06	-.15	.04
Subsaharan Africa	.00	.00	.00	.00	.00	.00
Egypt	-.32	-.13	-.26	-.07	-.46	-.27
Middle East, Oil	.00	.00	.00	.00	.00	.00
Middle East, Other	.00	.00	.00	.00	.00	.00
India	-.27	-.08	-.33	-.14	-.51	-.26
Other South Asia	-.37	-.18	-.26	-.07	-.37	-.18
Indonesia	-.34	-.07	-.26	.02	-.15	-.06
Thailand	-.40	-.09	-.29	.02	-.42	-.23
Malaysia	-.34	-.15	-.26	-.07	-.32	-.13
Philippines	-.34	-.15	-.26	-.07	-.32	-.13
Other SE Asia	-.28	-.09	-.26	-.07	-.31	-.12
South Korea	-.25	-.06	-.26	-.07	-.30	-.11
Taiwan	-.25	-.06	-.26	-.07	-.30	-.11
Other East Asia	-.25	-.06	-.26	-.07	-.30	-.11
Rest of World	-.17	-.06	-.16	-.05	-.22	-.11

Table A5: Percentage yield changes: Soybeans, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.14	.17	-.27	.03	-.58	-.40
Canada	.02	.27	.04	.29	-.34	.06
European Community	-.10	-.18	-.18	.07	-.07	.10
Oth. West. Europe	-.10	.15	-.18	.07	-.07	.10
Japan	-.10	.24	-.16	.18	-.10	.12
Australia	-.16	.09	-.17	.08	-.16	.09
New Zealand	.05	.32	.00	.25	-.05	.20
South Africa	-.30	-.05	-.30	-.05	-.35	-.10
Eastern Europe	-.10	.15	-.18	.07	-.07	.10
Former Soviet Union	-.08	.17	-.21	.13	-.35	-.01
P. Rep. of China	-.15	.17	-.19	.15	-.21	.13
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Cen.Amer. & Carib.	-.35	-.10	-.20	.05	-.53	-.28
Brazil	-.35	.13	-.20	.11	-.27	-.07
Argentina	-.17	.17	-.28	.06	-.25	.09
Venezuela	-.35	-.10	-.20	.05	-.53	-.28
Oth. Latin America	-.35	-.10	-.20	.05	-.53	-.28
Nigeria	-.30	-.05	-.40	-.15	-.25	-.05
Subsaharan Africa	-.17	.08	-.15	.10	-.27	-.02
Egypt	-.31	-.06	-.26	-.01	-.38	-.21
Middle East, Oil	-.25	.00	-.30	-.05	-.35	-.10
Middle East, Other	-.25	.00	-.35	-.10	-.35	-.10
India	-.27	-.02	-.33	-.08	-.51	-.26
Other South Asia	-.22	.03	-.19	.07	-.35	-.09
Indonesia	-.34	-.09	-.26	-.01	-.07	.10
Thailand	-.40	-.15	-.29	-.04	.42	-.17
Malaysia	-.34	-.09	-.26	-.01	-.32	-.07
Philippines	-.34	-.09	-.26	-.01	-.32	-.07
Other SE Asia	-.14	.11	-.17	.09	-.24	.03
South Korea	-.13	.12	-.16	.09	-.22	.05
Taiwan	-.13	.12	-.16	.09	-.22	.05
Other East Asia	-.13	.12	-.16	.09	-.22	.05
Rest of World	-.24	.03	-.24	.04	-.33	-.07

Table A6: Percentage yield changes: Other oilseeds, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.14	.17	-.27	.03	-.58	-.40
Canada	.02	.27	.04	.29	-.34	.06
European Community	-.10	.15	-.18	.07	-.07	.10
Oth. West. Europe	-.10	.15	-.18	.07	-.07	.10
Japan	-.10	.24	-.16	.18	-.10	.12
Australia	-.16	.09	-.17	.08	-.16	.09
New Zealand	.05	.32	.00	.25	-.05	.20
South Africa	-.30	-.05	-.30	-.05	-.35	-.10
Eastern Europe	-.10	.15	-.18	.07	-.07	.10
Former Soviet Union	-.08	.17	-.21	.13	-.35	-.01
P. Rep. of China	-.15	.17	-.19	.15	-.21	.13
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Cen.Amer. & Carib.	-.35	-.10	-.20	.05	-.53	-.28
Brazil	-.35	.13	-.20	.11	-.27	-.07
Argentina	-.17	.17	-.28	.06	-.25	.09
Venezuela	-.35	-.10	-.20	05	-.53	-.28
Oth. Latin America	-.35	-.10	-.20	.05	-.53	-.28
Nigeria	-.30	-.05	-.40	-.15	-.25	-.05
Subsaharan Africa	-.26	-.01	-.29	-.04	-.32	-.07
Egypt	-.31	-.06	-.26	-.01	-.38	-.21
Middle East, Oil	-.25	.00	-.30	-.05	-.35	-.10
Middle East, Other	-.25	.00	-.35	-.10	-.35	-.10
India	-.27	-.02	-.33	-.08	-.51	-.26
Other South Asia	-.40	-.15	-.15	.10	-.64	-.30
Indonesia	-.34	-.09	-.26	-.01	-.07	.10
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
Malaysia	-.34	-.09	-.26	-.01	-.32	-.07
Philippines	-.34	-.09	-.26	-.01	-.32	-.07
Other SE Asia	-.19	.06	-.19	.07	-.30	-.05
South Korea	-.13	.12	-.16	.09	-.22	.05
Taiwan	-.13	.12	-.16	.09	-.22	.05
Other East Asia	-.13	.12	-.16	.09	-.22	.05
Rest of World	-.24	.03	-.24	.04	-.33	-.07

Table A7: Percentage yield changes: Cotton, no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.18	.16	-.26	.08	-.42	-.08
Canada	-.03	.22	-.01	.24	-.34	-.09
European Community	-.10	.15	-.18	.07	-.15	.10
Oth. West. Europe	-.10	.15	-.18	.07	-.15	.10
Japan	-.10	.15	-.16	.09	-.22	.03
Australia	-.16	.09	-.17	.08	-.16	.09
New Zealand	.00	.25	-.05	.20	-.10	.15
South Africa	-.30	-.05	-.30	-.05	-.35	-.10
Eastern Europe	-.10	.15	-.18	.07	-.15	.10
Former Soviet Union	-.08	.17	-.21	.04	-.35	-.10
P. Rep. of China	-.15	.17	-.19	.15	-.21	.13
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Cen.Amer. & Carib.	-.37	-.12	-.23	.02	-.42	-.17
Brazil	-.35	-.10	-.26	-.01	-.44	-.19
Argentina	-.17	.08	-.28	-.03	-.25	.00
Venezuela	-.35	-.10	-.33	-.08	-.46	-.21
Oth. Latin America	-.36	-.11	-.26	-.01	-.43	-.18
Nigeria	-.20	.05	-.30	-.05	-.20	.05
Subsaharan Africa	-.28	-.03	-.30	-.05	-.35	-.10
Egypt	-.31	-.06	-.26	-.01	-.46	-.21
Middle East, Oil	-.25	.00	-.30	-.05	-.35	-.10
Middle East, Other	-.25	.00	-.35	-.15	-.35	-.10
India	-.27	.07	-.33	.01	-.51	-.17
Other South Asia	-.42	-.17	-.14	.11	-.58	-.33
Indonesia	-.34	-.09	-.26	-.01	-.15	.10
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
Malaysia	-.39	-.14	-.31	-.06	-.37	-.12
Philippines	-.39	-.14	-.31	-.06	-.37	-.12
Other SE Asia	-.23	.02	-.22	.03	-.33	-.08
South Korea	-.13	.12	-.16	.09	-.22	.03
Taiwan	-.13	.12	-.16	.09	-.22	.03
Other East Asia	-.13	.12	-.16	.09	-.22	.03
Rest of World	-.26	.01	-.26	.01	-.34	-.08

Table A8: Percentage yield changes: Sugar (refined) no adaptation, SWOPSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.20	-.04	-.29	-.13	-.36	-.20
Canada	-.03	.22	-.01	.24	-.34	-.09
European Community	-.10	.15	-.18	.07	-.15	.10
Oth. West. Europe	-.10	.15	-.18	.07	-.15	.10
Japan	-.10	.15	-.16	.09	-.22	.03
Australia	-.16	.09	-.17	.08	-.16	.09
New Zealand	-.05	.20	-.10	.15	-.15	.10
South Africa	-.35	-.26	-.35	-.26	-.35	-.31
Eastern Europe	-.10	.15	-.18	.07	-.15	.10
Former Soviet Union	-.02	.27	-.11	14	-.25	.00
P. Rep. of China	-.15	.08	-.19	.06	-.21	.04
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Cen.Amer. & Carib.	-.31	-.23	-.28	-.20	-.46	-.34
Brazil	-.35	-.10	-.26	-.01	-.44	-.19
Argentina	-.17	.08	-.28	-.03	-.25	.00
Venezuela	-.30	-.22	-.28	-.20	-.46	-.33
Oth. Latin America	-.37	-.29	-.31	-.23	-.47	-.40
Nigeria	-.20	.05	-.30	-.05	-.20	.05
Subsaharan Africa	-.23	-.12	-.24	-.12	-.34	-.18
Egypt	-.31	-.06	-.26	-.01	-.46	-.21
Middle East, Oil	-.25	-.08	-.30	-.13	-.35	-.18
Middle East, Other	-.32	-.12	-.38	-.18	-.38	-.20
India	-.27	-.20	-.33	-.26	-.51	-.44
Other South Asia	-.41	-.17	-.15	.09	-.56	-.33
Indonesia	-.34	-.09	-.26	-.01	-.15	.10
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
Malaysia	-.34	-.26	-.26	-.18	-.37	-.24
Philippines	-.34	-.26	-.26	-.18	-.37	-.24
Other SE Asia	-.14	-.05	-.17	-.09	-.28	-.15
South Korea	-.13	-.04	-.16	-.08	-.27	-.14
Taiwan	-.13	-.04	-.16	-.08	-.27	-.14
Other East Asia	-.13	-.04	-.16	-.08	-.27	-.14
Rest of World	-.25	-.06	-.26	-.07	-.34	-.15

Table A9: Percentage yield changes: Tobacco, no adaptation, SWOPOSIM regions

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
United States	-.18	.07	-.26	-.01	-.42	-.17
Canada	-.03	.22	-.01	.24	-.34	-.09
European Community	-.10	.15	-.18	.07	-.15	.10
Oth. West. Europe	-.10	.15	-.18	.07	-.15	.10
Japan	-.10	.15	-.16	.09	-.22	.03
Australia	-.16	.09	-.17	.08	-.16	.09
New Zealand	.00	.25	-.05	.20	-.10	.15
South Africa	-.30	-.05	-.30	-.05	-.35	-.10
Eastern Europe	-.10	.15	-.18	.07	-.15	.10
Former Soviet Unio	-.08	.17	-.21	.04	-.35	-.10
P. Rep. of China	-.15	.08	-.19	.06	-.21	.04
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Cen.Amer. & Carib.	-.35	-.10	-.31	-.06	-.45	-.20
Brazil	-.35	-.10	-.26	-.01	-.44	-.19
Argentina	-.17	.08	-.28	-.03	-.25	.00
Venezuela	-.35	-.10	-.33	-.08	-.46	-.21
Oth. Latin America	-.36	-.11	-.26	-.01	-.43	-.18
Nigeria	-.20	.05	-.30	-.05	-.20	.05
Subsaharan Africa	-.25	.00	-.26	-.01	-.33	-.08
Egypt	-.31	-.06	-.26	-.01	-.46	-.21
Middle East, Oil	-.25	.00	-.30	-.05	-.35	-.10
Middle East, Other	-.26	-.01	-.35	-.14	-.35	-.10
India	-.22	.03	-.28	-.03	-.46	-.21
Other South Asia	-.35	-.10	-.18	.07	-.48	-.23
Indonesia	-.34	-.09	-.26	-.01	-.15	.10
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
Malaysia	-.39	-.14	-.31	-.06	-.37	-.12
Philippines	-.39	-.14	-.31	-.06	-.37	-.12
Other SE Asia	-.19	.06	-.20	.05	-.29	-.04
South Korea	-.13	.12	-.16	.09	-.22	.03
Taiwan	-.13	.12	-.16	.09	-.22	.03
Other East Asia	-.13	.12	-.16	.09	-.22	.03
Rest of World	-.25	.00	-.26	.00	-.34	-.08

Table A10: Percentage yield changes: Wheat, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.46	-.24	-.43	-.21	-.52	-.30
Australia	-.18	.08	-.16	.11	-.14	.09
Austria	-.12	.04	-.28	-.15	-.23	-.09
Brazil	-.51	-.33	-.38	-.17	-.53	-.31
Canada	-.12	.27	-.10	.27	-.38	-.07
Egypt	-.36	-.31	-.28	-.26	-.54	-.51
Indonesia	-.34	-.12	-.26	-.04	-.23	-.01
Japan	-.18	-.01	-.21	-.05	-.40	-.27
Mexico	-.53	-.31	-.46	-.24	-.55	-.33
Nigeria	-.25	-.03	-.35	-.13	-.25	-.03
Pakistan	-.57	-.19	-.29	-.07	-.73	-.55
Turkey	-.30	-.08	-.40	-.18	-.40	-.18
EC	-.12	.08	-.28	-.15	-.23	-.09
Kenya	-.35	-.13	-.35	-.13	-.35	-.13
New Zealand	.02	.29	-.02	.25	-.13	.11
Thailand	-.40	-.18	-.29	-.07	-.42	-.20
USA	-.21	-.02	-.23	-.02	-.33	-.14
CMEA	-.08	.25	-.21	.06	-.35	-.20
India	-.32	.03	-.38	-.09	-.56	-.26
China	-.05	.16	-.12	.08	-.17	.00
AfOE	-.35	-.13	-.40	-.18	-.45	-.23
AfMICE	-.23	-.01	-.19	.04	-.34	-.12
AfMICI	-.35	-.13	-.35	-.13	-.40	-.18
AfLICE	-.4	-.18	-.50	-.28	-.45	-.23
AfLICI	-.45	-.23	-.45	-.23	-.5	-.28
LaHICE	-.46	-.24	-.43	-.21	-.52	-.30
LaHICI	-.46	-.24	-.43	-.21	-.52	-.3
LaMLI	-.51	-.29	-.38	-.16	-.53	-.31
FEHICE	-.54	-.32	-.46	-.24	-.42	-.20
FEHICI	-.12	.10	-.17	.05	-.29	-.07
FELI	-.32	-.10	-.38	-.16	-.56	-.34
NEOE	-.35	-.13	-.40	-.18	-.45	-.23
NEMLI	-.45	-.23	-.45	-.23	-.50	-.28
RW	-.33	-.09	-.33	-.10	-.42	-.20

Table A11: Percentage yield changes: Corn, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	-.09	-.28	-.20	-.25	-.17
Australia	-.16	.05	-.17	.04	-.16	.05
Austria	-.08	.01	-.08	.01	-.07	.02
Brazil	-.19	-.12	-.20	-.13	-.27	-.20
Canada	-.05	.15	-.03	.17	-.34	-.14
Egypt	-.25	-.17	-.25	-.17	-.38	-.3
Indonesia	-.34	-.27	-.26	-.19	-.07	.00
Japan	-.02	.23	-.05	.20	-.10	.15
Mexico	-.43	-.35	-.36	-.28	-.45	-.37
Nigeria	-.25	-.18	-.35	-.28	-.25	-.18
Pakistan	-.52	-.43	-.24	-.15	-.68	-.59
Turkey	-.25	-.05	-.35	-.15	-.35	-.15
EC	-.08	.01	-.08	.01	-.07	.02
Kenya	-.35	-.28	-.35	-.28	-.35	-.28
New Zealand	.05	.25	.00	.20	-.05	.15
Thailand	-.40	-.33	-.29	-.22	-.42	-.35
USA	-.20	-.16	-.29	-.21	-.36	-.29
CMEA	-.08	.12	-.21	-.05	-.35	-.15
India	-.22	-.15	-.28	-.20	-.46	-.39
China	-.21	-.14	-.20	-.12	-.22	-.14
AfOE	-.20	-.11	-.25	-.16	-.30	-.21
AfMICE	-.23	-.14	-.19	-.10	-.34	-.25
AfMICI	-.30	-.21	-.30	-.21	-.35	-.26
AfLICE	-.30	-.21	-.40	-.31	-.35	-.26
AfLICI	-.40	-.31	-.40	-.31	-.45	-.36
LaHICE	-.19	-.11	-.20	-.12	-.27	-.19
LaHICI	-.19	-.11	-.20	-.12	-.27	-.19
LaMLI	-.19	-.11	-.20	-.12	-.27	-.19
FEHICE	-.49	-.41	-.41	-.33	-.47	-.39
FEHICI	-.12	-.04	-.13	-.05	-.16	-.08
FELI	-.35	-.27	-.34	-.26	-.46	-.38
NEOE	-.30	-.13	-.35	-.18	-.40	-.23
NEMLI	-.40	-.23	-.40	-.23	-.45	-.28
RW	-.25	-.13	-.25	-.14	-.32	-.21

Table A12: Percentage yield changes: Other coarse grains, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	-.09	-.28	-.20	-.25	-.17
Australia	-.16	.05	-.17	.04	-.16	.05
Austria	-.08	.01	-.08	.01	-.07	.02
Brazil	-.19	-.12	-.2	-.13	-.27	-.20
Canada	-.05	.15	-.03	.17	-.34	-.14
Egypt	-.25	-.17	-.25	-.17	-.38	-.30
Indonesia	-.34	-.27	-.26	-.19	-.07	.00
Japan	-.02	.23	-.05	.20	-.10	.15
Mexico	-.43	-.35	-.36	-.28	-.45	-.37
Nigeria	-.25	-.18	-.35	-.28	-.25	-.18
Pakistan	-.52	-.43	-.24	-.15	-.68	-.59
Turkey	-.25	-.05	-.35	-.15	-.35	-.15
EC	-.08	.01	-.08	.01	-.07	.02
Kenya	-.35	-.28	-.35	-.28	-.35	-.28
New Zealand	.05	.25	.00	.20	-.05	.15
Thailand	-.40	-.33	-.29	-.22	-.42	-.35
USA	-.20	-.16	-.29	-.21	-.36	-.29
CMEA	-.08	.12	-.21	-.05	-.35	-.15
India	-.32	-.07	-.38	-.13	-.56	-.31
China	-.21	-.14	-.20	-.12	-.22	-.14
AfOE	-.20	-.11	-.25	-.16	-.30	-.21
AfMICE	-.23	-.14	-.19	-.10	-.34	-.25
AfMICI	-.30	-.21	-.30	-.21	-.35	-.26
AfLICE	-.30	-.21	-.40	-.31	-.35	-.26
AfLICI	-.40	-.31	-.40	-.31	-.45	-.36
LaHICE	-.19	-.11	-.20	-.12	-.27	-.19
LaHICI	-.19	-.11	-.20	-.12	-.27	-.19
LaMLI	-.19	-.11	-.20	-.12	-.27	-.19
FEHICE	-.49	-.41	-.41	-.33	-.47	-.39
FEHICI	-.12	-.04	-.13	-.05	-.16	-.08
FELI	-.35	-.27	-.34	-.26	-.46	-.38
NEOE	-.30	-.13	-.35	-.18	-.40	-.23
NEMLI	-.40	-.23	-.40	-.23	-.45	-.28
RW	-.25	-.13	-.26	-.14	-.32	-.20

Table A13: Percentage yield changes: Rice, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	.00	.00	.00	.00	.00	.00
Australia	-.13	-.12	-.17	-.17	-.18	-.17
Austria	.00	.00	.00	.00	.00	.00
Brazil	-.35	-.16	-.26	-.07	-.44	-.25
Canada	.00	.00	.00	.00	.00	.00
Egypt	-.32	-.13	-.26	-.07	-.46	-.27
Indonesia	-.34	-.07	-.26	.02	-.15	-.06
Japan	-.10	.09	-.23	-.06	-.16	.02
Mexico	-.43	-.24	-.36	-.17	-.45	-.35
Nigeria	-.15	.04	-.25	-.06	-.15	.04
Pakistan	-.57	-.38	-.29	-.1	-.73	-.54
Turkey	.00	.00	.00	.00	.00	.00
EC	.00	.00	.00	.00	.00	.00
Kenya	.00	.00	.00	.00	.00	.00
New Zealand	.00	.00	.00	.00	.00	.00
Thailand	-.40	-.09	-.29	.02	-.42	-.23
USA	-.18	.01	-.26	-.07	-.42	-.23
CMEA	-.08	.11	-.21	-.02	-.35	-.16
India	-.27	-.08	-.33	-.14	-.51	-.26
China	-.24	-.03	-.25	-.05	-.25	-.05
AfOE	.00	.00	.00	.00	.00	.00
AfMICE	.00	.00	.00	.00	.00	.00
AfMICI	.00	.00	.00	.00	.00	.00
AfLICE	.00	.00	.00	.00	.00	.00
AfLICI	.00	.00	.00	.00	.00	.00
LaHICE	-.30	-.11	-.28	-.09	-.41	-.22
LaHICI	-.35	-.16	-.33	-.14	-.46	-.27
LaMLI	-.37	-.18	-.28	-.09	-.47	-.28
FEHICE	-.34	-.15	-.26	-.07	-.32	-.13
FEHICI	-.25	-.06	-.26	-.07	-.30	-.11
FELI	-.34	-.15	-.26	-.07	-.32	-.13
NEOE	.00	.00	.00	.00	.00	.00
NEMLI	.00	.00	.00	.00	.00	.00
RW	-.17	-.06	-.16	-.05	-.22	-.11

Table A14: Percentage yield changes: Soybeans, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	.17	-.28	.06	-.25	.09
Australia	-.16	.09	-.17	.08	-.16	.09
Austria	-.10	.15	-.18	.07	-.07	.10
Brazil	-.35	.13	-.20	.11	-.27	-.07
Canada	.02	.27	.04	.29	-.34	.06
Egypt	-.31	-.06	-.26	-.01	-.38	-.21
Indonesia	-.34	-.09	-.26	-.01	-.07	.10
Japan	-.10	.24	-.16	.18	-.10	.12
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Nigeria	-.30	-.05	-.40	-.15	-.25	-.05
Pakistan	-.42	-.17	-.14	.11	-.68	-.33
Turkey	-.25	.00	-.35	-.10	-.35	-.10
EC	-.10	.15	-.18	.07	-.07	.10
Kenya	-.25	.00	-.25	.00	-.35	.00
New Zealand	.05	.32	.00	.25	-.05	.20
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
USA	-.14	.17	-.27	.03	-.58	-.40
CMEA	-.08	.17	-.21	.13	-.35	-.01
India	-.27	-.02	-.33	-.08	-.51	-.26
China	-.15	.17	-.19	.15	-.21	.13
AfOE	-.15	.10	-.20	.05	-.25	.00
AfMICE	-.13	.12	-.09	.16	-.24	.01
AfMICI	-.30	-.05	-.30	-.05	-.35	-.10
AfLICE	-.30	-.05	-.40	-.15	-.35	-.10
AfLICI	-.30	-.05	-.30	-.05	-.35	-.10
LaHICE	-.35	-.10	-.20	.05	-.53	-.28
LaHICI	-.35	-.10	-.20	.05	-.53	-.28
LaMLI	-.35	-.10	-.20	.05	-.53	-.28
FEHICE	-.34	-.09	-.26	-.01	-.32	-.07
FEHICI	-.13	.12	-.16	.09	-.22	.05
FELI	-.20	.05	-.19	.07	-.31	-.06
NEOE	-.25	.00	-.30	-.05	-.35	-.10
NEMLI	-.35	-.10	-.35	-.10	-.40	-.15
RW	-.24	.03	-.24	.04	-.33	-.07

Table A15: Percentage yield changes: Other oilseeds, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	.17	-.28	.06	-.25	.09
Australia	-.16	.09	-.17	.08	-.16	.09
Austria	-.10	.15	-.18	.07	-.07	.10
Brazil	-.35	.13	-.20	.11	-.27	-.07
Canada	.02	.27	.04	.29	-.34	.06
Egypt	-.31	-.06	-.26	-.01	-.38	-.21
Indonesia	-.34	-.09	-.26	-.01	-.07	.10
Japan	-.10	.24	-.16	.18	-.10	.12
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Nigeria	-.30	-.05	-.40	-.15	-.25	-.05
Pakistan	-.42	-.17	-.14	.11	-.68	-.33
Turkey	-.25	.00	-.35	-.10	-.35	-.10
EC	-.10	.15	-.18	.07	-.07	.10
Kenya	-.25	.00	-.25	.00	-.35	.00
New Zealand	.05	.32	.00	.25	-.05	.20
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
USA	-.14	.17	-.27	.03	-.58	-.40
CMEA	-.08	.17	-.21	.13	-.35	-.01
India	-.27	-.02	-.33	-.08	-.51	-.26
China	-.15	.17	-.19	.15	-.21	.13
AfOE	-.15	.10	-.20	.05	-.25	.00
AfMICE	-.13	.12	-.09	.16	-.24	.01
AfMICI	-.30	-.05	-.30	-.05	-.35	-.10
AfLICE	-.30	-.05	-.40	-.15	-.35	-.10
AfLICI	-.30	-.05	-.30	-.05	-.35	-.10
LaHICE	-.35	-.10	-.20	.05	-.53	-.28
LaHICI	-.35	-.10	-.20	.05	-.53	-.28
LaMLI	-.35	-.10	-.20	.05	-.53	-.28
FEHICE	-.34	-.09	-.26	-.01	-.32	-.07
FEHICI	-.13	.12	-.16	.09	-.22	.05
FELI	-.20	.05	-.19	.07	-.31	-.06
NEOE	-.25	.00	-.30	-.05	-.35	-.10
NEMLI	-.35	-.10	-.35	-.10	-.40	-.15
RW	-.24	.03	-.24	.04	-.33	-.07

Table A16: Percentage yield changes: Cotton, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	.08	-.28	-.03	-.25	.00
Australia	-.16	.09	-.17	.08	-.16	.09
Austria	-.10	.15	-.18	.07	-.15	.10
Brazil	-.35	-.10	-.26	-.01	-.44	-.19
Canada	-.03	.22	-.01	.24	-.34	-.09
Egypt	-.31	-.06	-.26	-.01	-.46	-.21
Indonesia	-.34	-.09	-.26	-.01	-.15	.10
Japan	-.10	.15	-.16	.09	-.22	.03
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Nigeria	-.20	.05	-.30	-.05	-.20	.05
Pakistan	-.42	-.17	-.14	.11	-.58	-.33
Turkey	-.25	.00	-.35	-.15	-.35	-.10
EC	-.10	.15	-.18	.07	-.15	.10
Kenya	-.35	-.10	-.35	-.15	-.35	-.10
New Zealand	.00	.25	-.05	.20	-.10	.15
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
USA	-.18	.16	-.26	.08	-.42	-.08
CMEA	-.08	.17	-.21	.04	-.35	-.10
India	-.27	.07	-.33	.01	-.51	-.17
China	-.15	.17	-.19	.15	-.21	.13
AfOE	-.20	.05	-.20	.05	-.30	-.05
AfMICE	-.18	.07	-.14	.11	-.29	-.04
AfMICI	-.30	-.05	-.30	-.05	-.35	-.10
AfLICE	-.30	-.05	-.40	-.15	-.35	-.10
AfLICI	-.35	-.10	-.35	-.10	-.40	-.15
LaHICE	-.35	-.10	-.33	-.08	-.46	-.21
LaHICI	-.35	-.10	-.33	-.08	-.46	-.21
LaMLI	-.37	-.12	-.23	.02	-.42	-.17
FEHICE	-.39	-.14	-.31	-.06	-.37	-.12
FEHICI	-.13	.12	-.16	.09	-.22	.03
FELI	-.25	.00	-.24	.01	-.36	-.11
NEOE	-.25	.00	-.30	-.05	-.35	-.10
NEMLI	-.35	-.10	-.35	-.10	-.40	-.15
RW	-.26	.01	-.26	.01	-.34	-.08

Table A17: Percentage yield changes: Sugar (refined), no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	.08	-.28	-.03	-.25	.00
Australia	-.16	.09	-.17	.08	-.16	.09
Austria	-.10	.15	-.18	.07	-.15	.10
Brazil	-.35	-.10	-.26	-.01	-.44	-.19
Canada	-.03	.22	-.01	.24	-.34	-.09
Egypt	-.31	-.06	-.26	-.01	-.46	-.21
Indonesia	-.34	-.09	-.26	-.01	-.15	.10
Japan	-.10	.15	-.16	.09	-.22	.03
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Nigeria	-.20	.05	-.30	-.05	-.20	.05
Pakistan	-.42	-.17	-.14	.11	-.58	-.33
Turkey	-.30	-.05	-.40	-.15	-.40	-.15
EC	-.10	.15	-.18	.07	-.15	.10
Kenya	-.25	.00	-.25	.00	-.25	.00
New Zealand	-.05	.20	-.10	.15	-.15	.10
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
USA	-.20	-.04	-.29	-.13	-.36	-.20
CMEA	-.02	.27	-.11	.14	-.25	.00
India	-.27	-.20	-.33	-.26	-.51	-.44
China	-.15	.08	-.19	.06	-.21	.04
AfOE	-.15	-.06	-.20	-.11	-.30	-.16
AfMICE	-.13	-.04	-.09	.00	-.34	-.15
AfMICI	-.35	-.26	-.35	-.26	-.35	-.31
AfLICE	-.30	-.21	-.40	-.31	-.35	-.26
AfLICI	-.35	-.26	-.35	-.26	-.40	-.31
LaHICE	-.30	-.22	-.28	-.20	-.46	-.33
LaHICI	-.40	-.32	-.38	-.30	-.46	-.43
LaMLI	-.37	-.29	-.28	-.20	-.47	-.39
FEHICE	-.34	-.26	-.26	-.18	-.37	-.24
FEHICI	-.13	-.04	-.16	-.08	-.27	-.14
FELI	-.25	-.16	-.24	-.16	-.36	-.28
NEOE	-.25	-.08	-.30	-.13	-.35	-.18
NEMLI	-.35	-.18	-.35	-.18	-.45	-.23
RW	-.25	-.06	-.26	-.07	-.34	-.15

Table A18: Percentage yield changes: Tobacco, no adapatation, regions in Rosenzweig, et al.

	GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2
Argentina	-.17	.08	-.28	-.03	-.25	.00
Australia	-.16	.09	-.17	.08	-.16	.09
Austria	-.10	.15	-.18	.07	-.15	.10
Brazil	-.35	-.10	-.26	-.01	-.44	-.19
Canada	-.03	.22	-.01	.24	-.34	-.09
Egypt	-.31	-.06	-.26	-.01	-.46	-.21
Indonesia	-.34	-.09	-.26	-.01	-.15	.10
Japan	-.10	.15	-.16	.09	-.22	.03
Mexico	-.43	-.18	-.36	-.11	-.45	-.20
Nigeria	-.20	.05	-.30	-.05	-.20	.05
Pakistan	-.42	-.17	-.14	.11	-.58	-.33
Turkey	-.25	.00	-.35	-.15	-.35	-.10
EC	-.10	.15	-.18	.07	-.15	.10
Kenya	-.35	-.10	-.35	-.15	-.35	-.10
New Zealand	.00	.25	-.05	.20	-.10	.15
Thailand	-.40	-.15	-.29	-.04	-.42	-.17
USA	-.18	.07	-.26	-.01	-.42	-.17
CMEA	-.08	.17	-.21	.04	-.35	-.10
India	-.22	.03	-.28	-.03	-.46	-.21
China	-.15	.08	-.19	.06	-.21	.04
AfOE	-.20	.05	-.20	.05	-.30	-.05
AfMICE	-.18	.07	-.14	.11	-.29	-.04
AfMICI	-.30	-.05	-.30	-.05	-.35	-.10
AfLICE	-.30	-.05	-.40	-.15	-.35	-.10
AfLICI	-.35	-.10	-.35	-.10	-.40	-.15
LaHICE	-.35	-.10	-.33	-.08	-.46	-.21
LaHICI	-.35	-.10	-.33	-.08	-.46	-.21
LaMLI	-.37	-.12	-.23	.02	-.42	-.17
FEHICE	-.39	-.14	-.31	-.06	-.37	-.12
FEHICI	-.13	.12	-.16	.09	-.22	.03
FELI	-.25	.00	-.24	.01	-.36	-.11
NEOE	-.25	-.10	-.35	-.10	-.40	-.15
NEMLI	-.35	-.1	-.35	-.1	-.4	-.15
RW	-.25	.00	-.26	.00	-.34	-.08

Table A19: Percentage yield changes: Wheat, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.00	.00	-.07
Canada	.27	.27	.00
European Community	.08	.00	.00
Oth. West. Europe	.08	.00	.00
Japan	.00	.00	.00
Australia	.08	.11	.09
New Zealand	.29	.25	.11
South Africa	-.13	-.13	-.18
Eastern Europe	.08	.00	.00
Former Soviet Union	.25	.06	-.10
P. Rep. of China	.16	.08	.00
Mexico	-.31	-.24	-.33
Cen.Amer. & Carib.	-.29	-.16	-.31
Brazil	-.33	-.17	-.31
Argentina	-.15	-.11	-.20
Venezuela	-.24	-.21	-.30
Oth. Latin America	-.25	-.20	-.30
Nigeria	-.03	-.13	-.30
Subsaharan Africa	-.15	-.20	-.20
Egypt	-.31	-.26	-.51
Middle East, Oil	-.13	-.18	-.23
Middle East, Other	-.09	-.17	-.18
India	.03	-.09	-.26
Other South Asia	-.19	-.10	-.50
Indonesia	-.12	-.04	-.01
Thailand	-.18	-.07	-.20
Malaysia	-.32	-.24	-.20
Philippines	-.32	-.24	-.20
Other SE Asia	-.10	-.16	-.34
South Korea	.10	.05	-.03
Taiwan	.10	.05	-.03
Other East Asia	.10	.05	-.03
Rest of World	-.09	-.09	-.19

Table A20: Percentage yield changes: Corn, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.00	-.10	-.14
Canada	.13	.17	.00
European Community	.01	.01	.02
Oth. West. Europe	.01	.01	.02
Japan	.23	.20	.15
Australia	.05	.04	.05
New Zealand	.25	.20	.15
South Africa	-.21	-.21	-.26
Eastern Europe	.01	.01	.02
Former Soviet Union	.12	.00	-.07
P. Rep. of China	.00	.00	.00
Mexico	-.35	-.28	-.37
Cen.Amer. & Carib.	-.11	-.12	-.19
Brazil	-.12	-.13	-.20
Argentina	.00	-.10	-.07
Venezuela	-.11	-.12	-.19
Oth. Latin America	-.11	-.12	-.19
Nigeria	-.18	-.28	-.18
Subsaharan Africa	-.23	-.25	-.29
Egypt	-.17	-.17	-.30
Middle East, Oil	-.13	-.18	-.23
Middle East, Other	-.08	-.16	-.17
India	-.15	-.20	-.39
Other South Asia	-.32	-.21	-.44
Indonesia	-.27	-.19	.00
Thailand	-.33	-.22	-.35
Malaysia	-.41	-.33	-.39
Philippines	-.41	-.33	-.39
Other SE Asia	-.07	-.21	-.11
South Korea	-.02	-.20	-.04
Taiwan	-.02	-.20	-.04
Other East Asia	-.02	-.20	-.04
Rest of World	-.12	-.13	-.19

Table A21: Potential yield changes: Other coarse grains, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.00	-.10	-.14
Canada	.13	.17	.00
European Community	.01	.01	.02
Oth. West. Europe	.01	.01	.02
Japan	.23	.20	.15
Australia	.05	.04	.05
New Zealand	.25	.20	.15
South Africa	-.21	-.21	-.26
Eastern Europe	.01	.01	.02
Former Soviet Union	.12	.00	-.07
P. Rep. of China	.00	.00	.00
Mexico	-.35	-.28	-.37
Cen.Amer. & Carib.	-.11	-.12	-.19
Brazil	-.12	-.13	-.20
Argentina	.00	-.10	-.07
Venezuela	-.11	-.12	-.19
Oth. Latin America	-.11	-.12	-.19
Nigeria	-.18	-.28	-.18
Subsaharan Africa	-.25	-.28	-.30
Egypt	-.17	-.17	-.30
Middle East, Oil	-.13	-.18	-.23
Middle East, Other	-.12	-.18	-.20
India	-.15	-.20	-.39
Other South Asia	-.34	-.20	-.46
Indonesia	-.27	-.19	.00
Thailand	-.33	-.22	-.35
Malaysia	-.41	-.33	-.39
Philippines	-.41	-.33	-.39
Other SE Asia	-.20	-.24	-.29
South Korea	-.02	-.20	-.04
Taiwan	-.02	-.20	-.04
Other East Asia	-.02	-.20	-.04
Rest of World	-.12	-.13	-.19

Table A22: Potential yield changes: Rice, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.01	.00	-.11
Canada	.00	.00	.00
European Community	.00	.00	.00
Oth. West. Europe	.00	.00	.00
Japan	.09	.00	.02
Australia	.00	.00	.00
New Zealand	.00	.00	.00
South Africa	.00	.00	.00
Eastern Europe	.00	.00	.00
Former Soviet Union	.11	.00	-.08
P. Rep. of China	.00	.00	.00
Mexico	-.24	-.17	-.35
Cen.Amer. & Carib.	-.12	-.09	-.23
Brazil	-.16	-.07	-.25
Argentina	.00	.00	.00
Venezuela	-.11	-.09	-.22
Oth. Latin America	-.15	-.10	-.26
Nigeria	.04	-.06	.04
Subsaharan Africa	.00	.00	.00
Egypt	-.13	-.07	-.27
Middle East, Oil	.00	.00	.00
Middle East, Other	.00	.00	.00
India	-.08	-.14	-.26
Other South Asia	-.18	-.07	-.18
Indonesia	-.07	.02	-.06
Thailand	-.09	.02	-.23
Malaysia	-.15	-.07	-.13
Philippines	-.15	-.07	-.13
Other SE Asia	-.08	-.05	-.08
South Korea	-.03	-.03	-.05
Taiwan	-.03	-.03	-.05
Other East Asia	-.03	-.03	-.05
Rest of World	-.05	-.03	-.10

Table A23: Percentage yield changes: Soybeans, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.17	.03	-.20
Canada	.27	.29	.06
European Community	.15	.07	.10
Oth. West. Europe	.15	.07	.10
Japan	.24	.18	.12
Australia	.09	.08	.09
New Zealand	.32	.25	.20
South Africa	-.05	-.05	-.10
Eastern Europe	.15	.07	.10
Former Soviet Union	.17	.13	-.01
P. Rep. of China	.17	.15	.13
Mexico	-.18	-.11	-.20
Cen.Amer. & Carib.	-.10	.05	-.28
Brazil	.13	.11	-.07
Argentina	.17	.06	.09
Venezuela	-.10	.05	-.28
Oth. Latin America	-.10	.05	-.28
Nigeria	-.05	-.15	-.05
Subsaharan Africa	.08	.10	-.02
Egypt	-.06	-.01	-.21
Middle East, Oil	.00	-.05	-.10
Middle East, Other	.00	-.10	-.10
India	-.02	-.08	-.26
Other South Asia	.03	.07	-.09
Indonesia	-.09	-.01	.10
Thailand	-.15	-.04	-.17
Malaysia	-.09	-.01	-.07
Philippines	-.09	-.01	-.07
Other SE Asia	.11	.09	.03
South Korea	.12	.09	.05
Taiwan	.12	.09	.05
Other East Asia	.12	.09	.05
Rest of World	.03	.04	-.06

Table A24: Percentage yield changes: Other oilseeds, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.17	.03	-.20
Canada	.27	.29	.06
European Community	.15	.07	.10
Oth. West. Europe	.15	.07	.10
Japan	.24	.18	.12
Australia	.09	.08	.09
New Zealand	.32	.25	.20
South Africa	-.05	-.05	-.10
Eastern Europe	.15	.07	.10
Former Soviet Union	.17	.13	-.01
P. Rep. of China	.17	.15	.13
Mexico	-.18	-.11	-.20
Cen.Amer. & Carib.	-.10	.05	-.28
Brazil	.13	.11	-.07
Argentina	.17	.06	.09
Venezuela	-.10	.05	-.28
Oth. Latin America	-.10	.05	-.28
Nigeria	-.05	-.15	-.05
Subsaharan Africa	-.01	-.04	-.07
Egypt	-.06	-.01	-.21
Middle East, Oil	.00	-.05	-.10
Middle East, Other	.00	-.10	-.10
India	-.02	-.08	-.26
Other South Asia	-.15	.10	-.30
Indonesia	-.09	-.01	.10
Thailand	-.15	-.04	-.17
Malaysia	-.09	-.01	-.07
Philippines	-.09	-.01	-.07
Other SE Asia	.06	.07	-.05
South Korea	.12	.09	.05
Taiwan	.12	.09	.05
Other East Asia	.12	.09	.05
Rest of World	.03	.04	-.06

Table A25: Percentage yield changes: Cotton, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.16	.09	.01
Canada	.22	.24	.00
European Community	.15	.07	.10
Oth. West. Europe	.15	.07	.10
Japan	.15	.09	.03
Australia	.09	.08	.09
New Zealand	.25	.20	.15
South Africa	-.05	-.05	-.10
Eastern Europe	.15	.07	.10
Former Soviet Union	.17	.04	-.05
P. Rep. of China	.17	.15	.13
Mexico	-.18	-.11	-.20
Cen.Amer. & Carib.	-.12	.02	-.17
Brazil	-.10	-.01	-.19
Argentina	.08	.00	.00
Venezuela	-.10	-.08	-.21
Oth. Latin America	-.11	-.01	-.18
Nigeria	.05	-.05	.05
Subsaharan Africa	-.03	-.05	-.10
Egypt	-.06	-.01	-.21
Middle East, Oil	.00	-.05	-.10
Middle East, Other	.00	-.15	-.10
India	.07	.01	-.17
Other South Asia	-.17	.11	-.33
Indonesia	-.09	-.01	.10
Thailand	-.15	-.04	-.17
Malaysia	-.14	-.06	-.12
Philippines	-.14	-.06	-.12
Other SE Asia	.02	.03	-.08
South Korea	.12	.09	.03
Taiwan	.12	.09	.03
Other East Asia	.12	.09	.03
Rest of World	.01	.01	-.07

Table A26: Yield changes resulting from climate change: Sugar, all scenarios, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.00	.00	-.10
Canada	.22	.24	.00
European Community	.15	.07	.10
Oth. West. Europe	.15	.07	.10
Japan	.15	.09	.03
Australia	.09	.08	.09
New Zealand	.20	.15	.10
South Africa	-.26	-.26	-.31
Eastern Europe	.15	.07	.10
Former Soviet Union	.27	.14	.00
P. Rep. of China	.08	.06	.04
Mexico	-.18	-.11	-.20
Cen.Amer. & Carib.	-.23	-.20	-.34
Brazil	-.10	-.01	-.19
Argentina	.08	.00	.00
Venezuela	-.22	-.20	-.33
Oth. Latin America	-.29	-.23	-.40
Nigeria	.05	-.05	.05
Subsaharan Africa	-.12	-.12	-.18
Egypt	-.06	-.01	-.21
Middle East, Oil	-.08	-.13	-.18
Middle East, Other	-.12	-.18	-.20
India	-.20	-.26	-.44
Other South Asia	-.17	.09	-.33
Indonesia	-.09	-.01	.10
Thailand	-.15	-.04	-.17
Malaysia	-.26	-.18	-.24
Philippines	-.26	-.18	-.24
Other SE Asia	-.03	-.05	-.09
South Korea	-.02	-.04	-.07
Taiwan	-.02	-.04	-.07
Other East Asia	-.02	-.04	-.07
Rest of World	-.06	-.06	-.14

Table A27: Yield changes: Tobacco, level one adaptation, SWOPSIM regions

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	.07	.01	-.08
Canada	.22	.24	.00
European Community	.15	.07	.10
Oth. West. Europe	.15	.07	.10
Japan	.15	.09	.03
Australia	.09	.08	.09
New Zealand	.25	.20	.15
South Africa	-.05	-.05	-.10
Eastern Europe	.15	.07	.10
Former Soviet Union	.17	.04	-.05
P. Rep. of China	.17	.15	.13
Mexico	-.18	-.11	-.20
Cen.Amer. & Carib.	-.10	-.06	-.20
Brazil	-.10	-.01	-.19
Argentina	.08	.00	.00
Venezuela	-.10	-.08	-.21
Oth. Latin America	-.11	-.01	-.18
Nigeria	.05	-.05	.05
Subsaharan Africa	.00	-.01	-.08
Egypt	-.06	-.01	-.21
Middle Eas, Oilt	.00	-.05	-.10
Middle East, Other	-.01	-.14	-.10
India	.07	.01	-.17
Other South Asia	-.10	.07	-.23
Indonesia	-.09	-.01	.10
Thailand	-.15	-.04	-.17
Malaysia	-.14	-.06	-.12
Philippines	-.14	-.06	-.12
Other SE Asia	.06	.05	-.04
South Korea	.12	.09	.03
Taiwan	.12	.09	.03
Other East Asia	.12	.09	.03
Rest of World	.01	.00	-.07

Table A28: Percentage yield change: Wheat, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	-.15	-.11	-.20
Australia	.08	.11	.09
Austria	.04	.00	.00
Brazil	-.33	-.17	-.31
Canada	.27	.27	.00
Egypt	-.31	-.26	-.51
Indonesia	-.12	-.04	-.01
Japan	.00	.00	.00
Mexico	-.31	-.24	-.33
Nigeria	-.03	-.13	-.30
Pakistan	-.19	-.07	-.55
Turkey	-.08	-.18	-.18
EC	.08	.00	.00
Kenya	-.13	-.13	-.13
New Zealand	.29	.25	.11
Thailand	-.18	-.07	-.20
USA	.00	.00	-.07
CMEA	.25	.06	-.10
India	.03	-.09	-.26
China	.16	.08	.00
Africa, Oil export	-.13	-.18	-.23
Africa,MedIncCalEx	-.01	.04	-.12
Africa,MedIncCalIm	-.13	-.13	-.18
Africa,LowIncCalEx	-.18	-.28	-.23
Africa,LowIncCalIm	-.23	-.23	-.28
LatAm,HighIncCalEx	-.24	-.21	-.30
LatAm,HighIncCalIm	-.24	-.21	-.30
LatAm,Middle-LowIn	-.29	-.16	-.31
FrEast,H-MIncCalEx	-.32	-.24	-.2
FrEast,H-MIncCalIm	.10	.05	-.03
FrEast,LowInc	-.10	-.16	-.34
NrEast,OilExHighIn	-.13	-.18	-.23
NrEast,Med-LowInc	-.23	-.23	-.28
Rest of the World	-.09	-.09	-.19

Table A29: Percentage yield changes: Corn,
level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	0	-.1	-.07
Australia	.05	.04	.05
Austria	.01	.01	.02
Brazil	-.12	-.13	-.2
Canada	.13	.17	0
Egypt	-.17	-.17	-.3
Indonesia	-.27	-.19	0
Japan	.23	.2	.15
Mexico	-.35	-.28	-.37
Nigeria	-.18	-.28	-.18
Pakistan	-.43	-.15	-.59
Turkey	-.05	-.15	-.15
EC	.01	.01	.02
Kenya	-.28	-.28	-.28
New Zealand	.25	.2	.15
Thailand	-.33	-.22	-.35
USA	0	-.1	-.14
CMEA	.12	0	-.07
India	-.15	-.2	-.39
China	0	0	0
Africa, Oil export	-.11	-.16	-.21
Africa,MedIncCalEx	-.14	-.1	-.25
Africa,MedIncCalIm	-.21	-.21	-.26
Africa,LowIncCalEx	-.21	-.31	-.26
Africa,LowIncCalIm	-.31	-.31	-.36
LatAm,HighIncCalEx	-.11	-.12	-.19
LatAm,HighIncCalIm	-.11	-.12	-.19
LatAm,Middle-LowIn	-.11	-.12	-.19
FrEast,H-MIncCalEx	-.41	-.33	-.39
FrEast,H-MIncCalIm	-.02	-.2	-.04
FrEast,LowInc	-.27	-.26	-.38
NrEast,OilExHighIn	-.13	-.18	-.23
NrEast,Med-LowInc	-.23	-.23	-.28
Rest of the World	-.12	-.13	-.19

Table A30: Percentage yield changes: Other coarse grains,
level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.00	-.10	-.07
Australia	.05	.04	.05
Austria	.01	.01	.02
Brazil	-.12	-.13	-.20
Canada	.13	.17	.00
Egypt	-.17	-.17	-.30
Indonesia	-.27	-.19	.00
Japan	.23	.20	.15
Mexico	-.35	-.28	-.37
Nigeria	-.18	-.28	-.18
Pakistan	-.43	-.15	-.59
Turkey	-.05	-.15	-.15
EC	.01	.01	.02
Kenya	-.28	-.28	-.28
New Zealand	.25	.20	.15
Thailand	-.33	-.22	-.35
USA	.00	-.10	-.14
CMEA	.12	.00	-.07
India	-.15	-.20	-.39
China	.00	.00	.00
Africa, Oil export	-.11	-.16	-.21
Africa,MedIncCalEx	-.14	-.10	-.25
Africa,MedIncCalIm	-.21	-.21	-.26
Africa,LowIncCalEx	-.21	-.31	-.26
Africa,LowIncCalIm	-.31	-.31	-.36
LatAm,HighIncCalEx	-.11	-.12	-.19
LatAm,HighIncCalIm	-.11	-.12	-.19
LatAm,Middle-LowIn	-.11	-.12	-.19
FrEast,H-MIncCalEx	-.41	-.33	-.39
FrEast,H-MIncCalIm	-.02	-.2	-.04
FrEast,LowInc	-.27	-.26	-.38
NrEast,OilExHighIn	-.13	-.18	-.23
NrEast,Med-LowInc	-.23	-.23	-.28
Rest of the World	-.12	-.13	-.19

Table A31: Percentage yield changes: Rice, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.00	.00	.00
Australia	.00	.00	.00
Austria	.00	.00	.00
Brazil	-.16	-.07	-.25
Canada	.00	.00	.00
Egypt	-.13	-.07	-.27
Indonesia	-.07	.02	-.06
Japan	.09	.00	.02
Mexico	-.24	-.17	-.35
Nigeria	.04	-.06	.04
Pakistan	-.38	-.10	-.54
Turkey	.00	.00	.00
EC	.00	.00	.00
Kenya	.00	.00	.00
New Zealand	.00	.00	.00
Thailand	-.09	.02	-.23
USA	.01	.00	-.11
CMEA	.11	.00	-.08
India	-.08	-.14	-.26
China	.00	.00	.00
Africa, Oil export	.00	.00	.00
Africa,MedIncCalEx	.00	.00	.00
Africa,MedIncCalIm	.00	.00	.00
Africa,LowIncCalEx	.00	.00	.00
Africa,LowIncCalIm	.00	.00	.00
LatAm,HighIncCalEx	-.11	-.09	-.22
LatAm,HighIncCalIm	-.16	-.14	-.27
LatAm,Middle-LowIn	-.18	-.09	-.28
FrEast,H-MIncCalEx	-.15	-.07	-.13
FrEast,H-MIncCalIm	-.03	-.03	-.05
FrEast,LowInc	-.15	-.07	-.13
NrEast,OilExHighIn	.00	.00	.00
NrEast,Med-LowInc	.00	.00	.00
Rest of the World	-.05	-.03	-.10

Table A32: Percentage yield changes: Soybeans, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.17	.06	.09
Australia	.09	.08	.09
Austria	.15	.07	.10
Brazil	.13	.11	-.07
Canada	.27	.29	.06
Egypt	-.06	-.01	-.21
Indonesia	-.09	-.01	.10
Japan	.24	.18	.12
Mexico	-.18	-.11	-.20
Nigeria	-.05	-.15	-.05
Pakistan	-.17	.11	-.33
Turkey	.00	-.10	-.10
EC	.15	.07	.10
Kenya	.00	.00	.00
New Zealand	.32	.25	.20
Thailand	-.15	-.04	-.17
USA	.17	.03	-.20
CMEA	.17	.13	-.01
India	-.02	-.08	-.26
China	.17	.15	.13
Africa, Oil export	.10	.05	.00
Africa,MedIncCalEx	.12	.16	.01
Africa,MedIncCalIm	-.05	-.05	-.10
Africa,LowIncCalEx	-.05	-.15	-.10
Africa,LowIncCalIm	-.05	-.05	-.10
LatAm,HighIncCalEx	-.10	.05	-.28
LatAm,HighIncCalIm	-.10	.05	-.28
LatAm,Middle-LowIn	-.10	.05	-.28
FrEast,H-MIncCalEx	-.09	-.01	-.07
FrEast,H-MIncCalIm	.12	.09	.05
FrEast,LowInc	.05	.07	-.06
NrEast,OilExHighIn	.00	-.05	-.10
NrEast,Med-LowInc	-.10	-.10	-.15
Rest of the World	.03	.04	-.06

Table A33: Percentage yield changes: Other oilseeds, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.17	.06	.09
Australia	.09	.08	.09
Austria	.15	.07	.10
Brazil	.13	.11	-.07
Canada	.27	.29	.06
Egypt	-.06	-.01	-.21
Indonesia	-.09	-.01	.10
Japan	.24	.18	.12
Mexico	-.18	-.11	-.2
Nigeria	-.05	-.15	-.05
Pakistan	-.17	.11	-.33
Turkey	.00	-.10	-.10
EC	.15	.07	.10
Kenya	.00	.00	.00
New Zealand	.32	.25	.20
Thailand	-.15	-.04	-.17
USA	.17	.03	-.20
CMEA	.17	.13	-.01
India	-.02	-.08	-.26
China	.17	.15	.13
Africa, Oil export	.10	.05	.00
Africa,MedIncCalEx	.12	.16	.01
Africa,MedIncCalIm	-.05	-.05	-.10
Africa,LowIncCalEx	-.05	-.15	-.1
Africa,LowIncCalIm	-.05	-.05	-.10
LatAm,HighIncCalEx	-.10	.05	-.28
LatAm,HighIncCalIm	-.10	.05	-.28
LatAm,Middle-LowIn	-.10	.05	-.28
FrEast,H-MIncCalEx	-.09	-.01	-.07
FrEast,H-MIncCalIm	.12	.09	.05
FrEast,LowInc	.05	.07	-.06
NrEast,OilExHighIn	.00	-.05	-.10
NrEast,Med-LowInc	-.10	-.10	-.15
Rest of the World	.03	.04	-.06

Table A34: Percentage yield changes: Cotton, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.08	.00	.00
Australia	.09	.08	.09
Austria	.15	.07	.10
Brazil	-.10	-.01	-.19
Canada	.22	.24	.00
Egypt	-.06	-.01	-.21
Indonesia	-.09	-.01	.10
Japan	.15	.09	.03
Mexico	-.18	-.11	-.20
Nigeria	.05	-.05	.05
Pakistan	-.17	.11	-.33
Turkey	.00	-..15	-.10
EC	.15	.07	.10
Kenya	-.10	-.15	-.10
New Zealand	.25	.20	.15
Thailand	-.15	-.04	-.17
USA	.16	.09	.01
CMEA	.17	.04	-.05
India	.07	.01	-.17
China	.17	.15	.13
Africa, Oil export	.05	.05	-.05
Africa,MedIncCalEx	.07	.11	-.04
Africa,MedIncCalIm	-.05	-.05	-.10
Africa,LowIncCalEx	-.05	-.15	-.10
Africa,LowIncCalIm	-.10	-.10	-.15
LatAm,HighIncCalEx	-.10	-.08	-.21
LatAm,HighIncCalIm	-.10	-.08	-.21
LatAm,Middle-LowIn	-.12	.02	-.17
FrEast,H-MIncCalEx	-.14	-.06	-.12
FrEast,H-MIncCalIm	.12	.09	.03
FrEast,LowInc	.00	.01	-.11
NrEast,OilExHighIn	.00	-.05	-.10
NrEast,Med-LowInc	-.10	-.10	-.15
Rest of the World	.01	.01	-.07

Table A35: Percentage yield changes: Sugar, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.08	.00	.00
Australia	.09	.08	.09
Austria	.15	.07	.10
Brazil	-.10	-.01	-.19
Canada	.22	.24	.00
Egypt	-.06	-.01	-.21
Indonesia	-.09	-.01	.10
Japan	.15	.09	.03
Mexico	-.18	-.11	-.20
Nigeria	.05	-.05	.05
Pakistan	-.17	.11	-.33
Turkey	-.05	-.15	-.15
EC	.15	.07	.10
Kenya	.00	.00	.00
New Zealand	.20	.15	.10
Thailand	-.15	-.04	-.17
USA	.00	.00	-.10
CMEA	.27	.14	.00
India	-.20	-.26	-.44
China	.08	.06	.04
Africa, Oil export	-.06	-.11	-.16
Africa,MedIncCalEx	-.04	.00	-.15
Africa,MedIncCalIm	-.26	-.26	-.31
Africa,LowIncCalEx	-.21	-.31	-.26
Africa,LowIncCalIm	-.26	-.26	-.31
LatAm,HighIncCalEx	-.22	-.20	-.33
LatAm,HighIncCalIm	-.32	-.30	-.43
LatAm,Middle-LowIn	-.29	-.20	-.39
FrEast,H-MIncCalEx	-.26	-.18	-.24
FrEast,H-MIncCalIm	-.02	-.04	-.07
FrEast,LowInc	-.16	-.16	-.28
NrEast,OilExHighIn	-.08	-.13	-.18
NrEast,Med-LowInc	-.18	-.18	-.23
Rest of the World	-.06	-.06	-.14

Table A36: Percentage yield changes: Tobacco, level one adaptation, regions in Rosenzweig, et al.

	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Argentina	.08	.00	.00
Australia	.09	.08	.09
Austria	.15	.07	.10
Brazil	-.10	-.01	-.19
Canada	.22	.24	0
Egypt	-.06	-.01	-.21
Indonesia	-.09	-.01	.10
Japan	.15	.09	.03
Mexico	-.18	-.11	-.20
Nigeria	.05	-.05	.05
Pakistan	-.17	.11	-.33
Turkey	.00	-.15	-.10
EC	.15	.07	.10
Kenya	-.10	-.15	-.10
New Zealand	.25	.20	.15
Thailand	-.15	-.04	-.17
USA	.07	.01	-.08
CMEA	.17	.04	-.05
India	.07	.01	-.17
China	.17	.15	.13
Africa, Oil export	.05	.05	-.05
Africa,MedIncCalEx	.07	.11	-.04
Africa,MedIncCalIm	-.05	-.05	-.10
Africa,LowIncCalEx	-.05	-.15	-.10
Africa,LowIncCalIm	-.10	-.10	-.15
LatAm,HighIncCalEx	-.10	-.08	-.21
LatAm,HighIncCalIm	-.10	-.08	-.21
LatAm,Middle-LowIn	-.12	.02	-.17
FrEast,H-MIncCalEx	-.14	-.06	-.12
FrEast,H-MIncCalIm	12	.09	.03
FrEast,LowInc	.00	.01	-.11
NrEast,OilExHighIn	.00	-.05	-.10
NrEast,Med-LowInc	-.10	-.10	-.15
Rest of the World	.01	.00	-.07

Appendix B
Detailed SWOPSIM Results

Appendix B contains detailed results of the SWOPSIM model runs. Tables B.1 -B.9 contain consumer, producer, and other surplus changes and the net welfare change for each of the 9 scenarios for each of the 33 countries/regions in SWOPSIM. Tables B.10-B.18 provided aggregated welfare results by country income group. Table B.19 presents the world price changes for the 9 scenarios as a percentage change from the base. We do not report individual country price changes because country prices are linked directly to world prices (see SWOPSIM model discussion); changes in domestic prices closely parallel changes in the world price even though price levels differ between countries. Table B.20 provides base production levels for each country/region and percentage changes in production for the 9 scenarios.

Table B.1 Welfare Effects of Climate Change: GISS, No CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	4,534	(6,725)	77	(2,114)
Argentina (AR)	3,467	(2,926)	2,701	3,242
Australia (AU)	7,082	(2,592)	(40)	4,450
Brazil (BZ)	3,957	(7,405)	781	(2,666)
Central America (CA)	1,671	(1,824)	1,131	977
China (CH)	13,211	(22,339)	(25,422)	(34,549)
Canada (CN)	6,677	(4,863)	(119)	1,696
Indonesia (DO)	6,295	(9,837)	(608)	(4,150)
Other East Asia (EA)	1,357	(2,325)	(645)	(1,613)
European Community --EC-12 (EC)	41,305	(51,442)	(914)	(11,051)
Eastern Europe (EE)	2,698	(4,358)	(1,967)	(3,627)
Egypt (EG)	1,217	(3,438)	(1,405)	(3,626)
Japan (JP)	15,158	(27,337)	(649)	(12,827)
Other Latin America (LA)	1,837	(3,187)	(69)	(1,420)
Malaysia (ML)	1,546	(1,593)	385	338
Mid-East /N. Africa (MO)	2,398	(5,402)	(1,780)	(4,785)
Mid-East/N. Africa, Oil Exp. (MP)	1,404	(6,096)	(4,984)	(9,677)
Mexico (MX)	707	(3,275)	(1,303)	(3,872)
India (ND)	22,822	(33,633)	6,695	(4,116)
Nigeria (NG)	628	(1,123)	(227)	(722)
New Zealand (NZ)	153	(280)	1	(126)
Other South Asia (OS)	6,334	(13,384)	(1,877)	(8,927)
Philippines (PH)	1,949	(3,719)	(840)	(2,610)
Rest of World (RW)	680	(981)	(237)	(537)
Other Southeast Asia (SA)	6,221	(8,328)	532	(1,575)
South Africa (SF)	705	(1,558)	(277)	(1,130)
South Korea (SK)	1,786	(4,628)	(1,610)	(4,452)
Former Soviet Union (SV)	4,801	(7,381)	(6,286)	(8,866)
Thailand (TH)	1,666	(2,448)	898	116
Taiwan (TW)	984	(2,234)	(926)	(2,175)
United States (US)	53,695	(46,661)	13	7,048
Venezuela (VE)	293	(660)	(244)	(610)
Other Western Europe (WE)	3,818	(5,222)	(108)	(1,512)
Total	223057	-299205	-39323	-115471

Table B.2 Welfare Effects of Climate Change: GISS, With CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	(772)	41	(239)	(970)
Argentina (AR)	(466)	520	(427)	(373)
Australia (AU)	(224)	195	(17)	(47)
Brazil (BZ)	(854)	289	246	(319)
Central America (CA)	(201)	(65)	146	(120)
China (CH)	1,752	(499)	(214)	1,039
Canada (CN)	139	144	(292)	(9)
Indonesia (DO)	366	(744)	79	(299)
Other East Asia (EA)	150	(139)	38	48
European Community --EC-12 (EC)	(118)	3,204	(859)	2,228
Eastern Europe (EE)	383	253	(119)	517
Egypt (EG)	(265)	53	332	119
Japan (JP)	2,159	(502)	(368)	1,290
Other Latin America (LA)	(412)	(5)	(25)	(442)
Malaysia (ML)	(512)	131	(303)	(684)
Mid-East /N. Africa (MO)	(823)	696	78	(49)
Mid-East/N. Africa, Oil Exp. (MP)	(369)	304	88	23
Mexico (MX)	(543)	(33)	193	(383)
India (ND)	-275	-376.6	38	-614
Nigeria (NG)	(84)	(17)	(12)	(114)
New Zealand (NZ)	12	6	0	19
Other South Asia (OS)	(1,048)	(263)	145	(1,166)
Philippines (PH)	(253)	(188)	(84)	(525)
Rest of World (RW)	(37)	137	99	198
Other Southeast Asia (SA)	646	(886)	96	(144)
South Africa (SF)	(181)	14	(24)	(191)
South Korea (SK)	135	(308)	(3)	(176)
Former Soviet Union (SV)	1,828	565	(1,027)	1,367
Thailand (TH)	40	(130)	305	215
Taiwan (TW)	83	(90)	76	69
United States (US)	(1,257)	(24)	506	(775)
Venezuela (VE)	(28)	(1)	10	(19)
Other Western Europe (WE)	45	163	(48)	160
Total	-981	2444	-1589	-126

Table B.3 Welfare Effects of Climate Change: GFDL, No CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	5,458	(8,098)	2	(2,638)
Argentina (AR)	4,123	(3,780)	3,432	3,775
Australia (AU)	11,450	(3,543)	(40)	7,868
Brazil (BZ)	7,243	(9,199)	2,627	672
Central America (CA)	2,120	(2,150)	1,318	1,287
China (CH)	14,659	(25,660)	(32,602)	(43,603)
Canada (CN)	10,596	(6,525)	(234)	3,836
Indonesia (DO)	8,238	(10,585)	1,435	(912)
Other East Asia (EA)	1,472	(2,596)	(802)	(1,927)
European Community --EC-12 (EC)	53,336	(69,230)	(490)	(16,384)
Eastern Europe (EE)	2,723	(5,640)	(4,646)	(7,562)
Egypt (EG)	1,816	(4,254)	(1,921)	(4,359)
Japan (JP)	13,438	(32,555)	(692)	(19,809)
Other Latin America (LA)	2,792	(3,795)	339	(664)
Malaysia (ML)	2,164	(1,896)	775	1,043
Mid-East /N. Africa (MO)	2,727	(7,044)	(2,883)	(7,201)
Mid-East/N. Africa, Oil Exp. (MP)	1,761	(7,673)	(6,499)	(12,412)
Mexico (MX)	1,492	(4,113)	(1,468)	(4,088)
India (ND)	23,233	(38,973)	1,515	(14,224)
Nigeria (NG)	633	(1,378)	(395)	(1,141)
New Zealand (NZ)	244	(374)	0	(130)
Other South Asia (OS)	11,474	(15,148)	1,912	(1,762)
Philippines (PH)	2,801	(4,181)	(329)	(1,709)
Rest of World (RW)	837	(1,288)	(450)	(901)
Other Southeast Asia (SA)	6,876	(8,767)	961	(930)
South Africa (SF)	1,025	(1,996)	(274)	(1,245)
South Korea (SK)	1,893	(5,154)	(2,029)	(5,290)
Former Soviet Union (SV)	3,985	(9,500)	(15,777)	(21,292)
Thailand (TH)	2,548	(2,702)	2,345	2,190
Taiwan (TW)	1,103	(2,650)	(1,266)	(2,814)
United States (US)	67,397	(61,483)	314	6,228
Venezuela (VE)	408	(815)	(289)	(695)
Other Western Europe (WE)	5,267	(6,999)	(117)	(1,849)
Total	277332	-369742	-56231	-148640

Table B.4 Welfare Effects of Climate Change: GFDL, With CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	(107)	(924)	(382)	(1,413)
Argentina (AR)	147	(65)	69	151
Australia (AU)	1,327	(421)	(18)	887
Brazil (BZ)	834	(1,069)	254	19
Central America (CA)	70	(321)	116	(135)
China (CH)	3,895	(3,594)	(221)	80
Canada (CN)	2,230	(968)	(414)	848
Indonesia (DO)	1,370	(1,325)	153	198
Other East Asia (EA)	251	(351)	(48)	(147)
European Community --EC-12 (EC)	6,941	(8,193)	(234)	(1,487)
Eastern Europe (EE)	519	(951)	(115)	(547)
Egypt (EG)	97	(569)	(66)	(538)
Japan (JP)	1,488	(3,497)	(7)	(2,016)
Other Latin America (LA)	158	(480)	(83)	(405)
Malaysia (ML)	(168)	(66)	(221)	(455)
Mid-East /N. Africa (MO)	(304)	(575)	(264)	(1,143)
Mid-East/N. Africa, Oil Exp. (MP)	36	(1,022)	(752)	(1,738)
Mexico (MX)	(17)	(659)	(107)	(783)
India (ND)	1,790	(4,679)	(458)	(3,347)
Nigeria (NG)	(40)	(204)	(50)	(294)
New Zealand (NZ)	52	(50)	(0)	3
Other South Asia (OS)	1,350	(1,683)	(64)	(397)
Philippines (PH)	195	(523)	(116)	(445)
Rest of World (RW)	61	(99)	(21)	(59)
Other Southeast Asia (SA)	1,067	(1,255)	98	(89)
South Africa (SF)	45	(308)	(72)	(334)
South Korea (SK)	243	(710)	(191)	(658)
Former Soviet Union (SV)	1,514	(1,508)	(6)	(1,502)
Thailand (TH)	495	(318)	478	655
Taiwan (TW)	194	(402)	(63)	(271)
United States (US)	6,893	(8,842)	575	(1,374)
Venezuela (VE)	44	(121)	(42)	(119)
Other Western Europe (WE)	855	(987)	(40)	(172)
Total	33523	-46737	-3814	-17028

Table B.5 Welfare Effects of Climate Change: UKMO, No CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	8,947	(12,012)	1,509	(1,556)
Argentina (AR)	8,012	(6,038)	9,445	11,419
Australia (AU)	24,281	(5,620)	(76)	18,585
Brazil (BZ)	10,592	(14,503)	3,537	(374)
Central America (CA)	2,463	(3,177)	1,475	761
China (CH)	22,030	(35,635)	(53,104)	(66,708)
Canada (CN)	12,197	(10,298)	174	2,073
Indonesia (DO)	16,038	(15,138)	11,489	12,389
Other East Asia (EA)	2,158	(3,820)	(1,256)	(2,918)
European Community --EC-12 (EC)	102,377	(111,305)	(2,549)	(11,476)
Eastern Europe (EE)	5,239	(8,050)	(5,493)	(8,304)
Egypt (EG)	1,891	(6,402)	(3,946)	(8,457)
Japan (JP)	27,373	(55,173)	(1,282)	(29,082)
Other Latin America (LA)	3,378	(5,697)	(448)	(2,768)
Malaysia (ML)	3,326	(2,852)	1,321	1,794
Mid-East /N. Africa (MO)	5,174	(10,809)	(4,045)	(9,679)
Mid-East/N. Africa, Oil Exp. (MP)	2,857	(11,435)	(10,590)	(19,169)
Mexico (MX)	2,255	(6,212)	(2,666)	(6,622)
India (ND)	23,913	(56,531)	(14,815)	(47,433)
Nigeria (NG)	1,442	(2,023)	(210)	(791)
New Zealand (NZ)	428	(606)	(1)	(179)
Other South Asia (OS)	10,726	(22,141)	(3,727)	(15,142)
Philippines (PH)	4,077	(6,039)	(387)	(2,349)
Rest of World (RW)	1,339	(1,995)	(726)	(1,382)
Other Southeast Asia (SA)	9,791	(12,444)	2,193	(460)
South Africa (SF)	1,673	(2,956)	(98)	(1,381)
South Korea (SK)	2,951	(7,734)	(3,834)	(8,617)
Former Soviet Union (SV)	3,834	(13,634)	(39,366)	(49,166)
Thailand (TH)	3,200	(4,064)	2,176	1,312
Taiwan (TW)	1,606	(4,094)	(2,511)	(4,999)
United States (US)	107,090	(102,234)	558	5,413
Venezuela (VE)	509	(1,217)	(591)	(1,299)
Other Western Europe (WE)	9,966	(11,220)	(306)	(1,560)
Total	443133	-573107	-118150	-248124

Table B.6 Welfare Effects of Climate Change: UKMO, With Physical Effects of CO2, No Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	2,148	(3,530)	(368)	(1,750)
Argentina (AR)	2,818	(1,668)	2,633	3,782
Australia (AU)	5,444	(1,633)	(43)	3,768
Brazil (BZ)	3,620	(4,922)	1,152	(150)
Central America (CA)	526	(1,036)	269	(242)
China (CH)	10,818	(11,611)	518	(275)
Canada (CN)	4,225	(3,255)	(74)	896
Indonesia (DO)	4,141	(4,171)	574	545
Other East Asia (EA)	679	(1,102)	(294)	(717)
European Community --EC-12 (EC)	28,758	(33,345)	(1,463)	(6,051)
Eastern Europe (EE)	2,701	(3,077)	(180)	(556)
Egypt (EG)	325	(2,009)	(732)	(2,416)
Japan (JP)	6,227	(13,551)	(515)	(7,839)
Other Latin America (LA)	838	(1,780)	(162)	(1,104)
Malaysia (ML)	716	(721)	100	95
Mid-East /N. Africa (MO)	1,504	(3,133)	(929)	(2,558)
Mid-East/N. Africa, Oil Exp. (MP)	869	(3,654)	(2,660)	(5,446)
Mexico (MX)	658	(2,196)	(688)	(2,227)
India (ND)	7,086	(16,690)	(2,514)	(12,118)
Nigeria (NG)	450	(657)	(90)	(297)
New Zealand (NZ)	136	(173)	(0)	(38)
Other South Asia (OS)	2,316	(6,189)	(1,194)	(5,068)
Philippines (PH)	1,090	(1,731)	(218)	(859)
Rest of World (RW)	352	(623)	(247)	(517)
Other Southeast Asia (SA)	2,824	(3,397)	225	(347)
South Africa (SF)	506	(1,010)	(134)	(639)
South Korea (SK)	873	(2,218)	(841)	(2,185)
Former Soviet Union (SV)	1,966	(5,143)	(7,226)	(10,403)
Thailand (TH)	930	(1,119)	651	463
Taiwan (TW)	578	(1,368)	(550)	(1,340)
United States (US)	26,528	(31,915)	800	(4,586)
Venezuela (VE)	152	(412)	(175)	(435)
Other Western Europe (WE)	2,953	(3,403)	(162)	(611)
Total	125753	-172441	-14537	-61225

Table B.7 Welfare Effects of Climate Change: GISS, With CO_2 Effects, Level 1 Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	(1,177)	492	(193)	(878)
Argentina (AR)	(704)	692	(567)	(579)
Australia (AU)	(491)	390	(16)	(116)
Brazil (BZ)	(1,553)	974	93	(486)
Central America (CA)	(304)	70	171	(63)
China (CH)	1,384	1,284	(133)	2,535
Canada (CN)	(397)	608	(267)	(56)
Indonesia (DO)	(30)	(309)	84	(254)
Other East Asia (EA)	67	11	78	157
European Community --EC-12 (EC)	(3,289)	7,414	(744)	3,381
Eastern Europe (EE)	(42)	735	(129)	564
Egypt (EG)	(420)	316	406	303
Japan (JP)	1,494	1,066	(390)	2,170
Other Latin America (LA)	(594)	196	(22)	(421)
Malaysia (ML)	(551)	197	(276)	(630)
Mid-East /N. Africa (MO)	(1,073)	1,004	131	61
Mid-East/N. Africa, Oil Exp. (MP)	(485)	660	316	490
Mexico (MX)	(729)	301	360	(68)
India (ND)	(1,923)	1,286	(149)	(787)
Nigeria (NG)	(161)	77	0	(84)
New Zealand (NZ)	(10)	27	0	18
Other South Asia (OS)	(1,499)	291	224	(983)
Philippines (PH)	(409)	36	(26)	(400)
Rest of World (RW)	(79)	214	122	257
Other Southeast Asia (SA)	381	(515)	117	(17)
South Africa (SF)	(307)	197	13	(98)
South Korea (SK)	101	(24)	97	174
Former Soviet Union (SV)	1,292	1,260	(692)	1,859
Thailand (TH)	(107)	4	244	141
Taiwan (TW)	23	108	140	271
United States (US)	(5,217)	5,540	(69)	253
Venezuela (VE)	(65)	57	25	17
Other Western Europe (WE)	(270)	578	(38)	270
Total	-17144	25238	-10090	7003

Table B.8 Welfare Effects of Climate Change: GFDL, With CO_2 Effects, Level 1 Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	(667)	(253)	(287)	(1,207)
Argentina (AR)	(170)	182	(120)	(107)
Australia (AU)	488	(93)	(18)	378
Brazil (BZ)	(54)	(208)	69	(194)
Central America (CA)	(99)	(122)	132	(89)
China (CH)	2,818	(890)	271	2,199
Canada (CN)	1,032	(277)	(365)	390
Indonesia (DO)	622	(579)	71	114
Other East Asia (EA)	88	(126)	4	(34)
European Community --EC-12 (EC)	2,650	(1,516)	(506)	628
Eastern Europe (EE)	398	(240)	10	168
Egypt (EG)	(130)	(148)	111	(167)
Japan (JP)	1,067	(1,211)	(357)	(501)
Other Latin America (LA)	(116)	(160)	(66)	(343)
Malaysia (ML)	(254)	42	(199)	(410)
Mid-East /N. Africa (MO)	(747)	57	(89)	(778)
Mid-East/N. Africa, Oil Exp. (MP)	(219)	(276)	(254)	(749)
Mexico (MX)	(276)	(234)	73	(436)
India (ND)	(1,101)	(1,541)	(632)	(3,274)
Nigeria (NG)	(135)	(73)	(23)	(230)
New Zealand (NZ)	23	(15)	0	8
Other South Asia (OS)	336	(552)	(33)	(249)
Philippines (PH)	(67)	(190)	(61)	(318)
Rest of World (RW)	0	27	31	58
Other Southeast Asia (SA)	542	(615)	89	15
South Africa (SF)	(115)	(77)	(36)	(229)
South Korea (SK)	108	(288)	14	(166)
Former Soviet Union (SV)	883	(383)	(793)	(293)
Thailand (TH)	229	(119)	288	398
Taiwan (TW)	90	(150)	53	(7)
United States (US)	1,521	(2,341)	154	(667)
Venezuela (VE)	(4)	(41)	(15)	(60)
Other Western Europe (WE)	377	(315)	(44)	18
Total	9119	-12726	-2528	-6135

Table B.9 Welfare Effects of Climate Change: UKMO, With CO_2 Effects, Level 1 Adaptation
In Millions of 1989 U.S. Dollars
(negative numbers in parentheses)

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Other Sub-Saharan Africa (AF)	1,071	(2,329)	(355)	(1,613)
Argentina (AR)	1,689	(1,002)	1,352	2,039
Australia (AU)	3,235	(987)	(42)	2,206
Brazil (BZ)	1,560	(2,961)	493	(908)
Central America (CA)	293	(697)	347	(58)
China (CH)	8,673	(7,514)	2,025	3,183
Canada (CN)	2,619	(1,893)	(133)	593
Indonesia (DO)	2,936	(3,022)	226	141
Other East Asia (EA)	488	(727)	(173)	(411)
European Community --EC-12 (EC)	17,723	(19,214)	(1,400)	(2,890)
Eastern Europe (EE)	1,984	(1,880)	41	144
Egypt (EG)	(25)	(1,262)	(328)	(1,615)
Japan (JP)	4,411	(8,442)	(655)	(4,686)
Other Latin America (LA)	328	(1,198)	(167)	(1,037)
Malaysia (ML)	459	(492)	60	28
Mid-East /N. Africa (MO)	647	(1,950)	(669)	(1,973)
Mid-East/N. Africa, Oil Exp. (MP)	406	(2,374)	(1,743)	(3,711)
Mexico (MX)	194	(1,378)	(298)	(1,482)
India (ND)	2,739	(11,452)	(2,704)	(11,417)
Nigeria (NG)	236	(419)	(81)	(265)
New Zealand (NZ)	67	(106)	0	(39)
Other South Asia (OS)	947	(4,342)	(876)	(4,270)
Philippines (PH)	656	(1,190)	(155)	(690)
Rest of World (RW)	226	(351)	(97)	(221)
Other Southeast Asia (SA)	2,148	(2,476)	204	(124)
South Africa (SF)	213	(601)	(95)	(483)
South Korea (SK)	772	(1,472)	(468)	(1,169)
Former Soviet Union (SV)	1,610	(3,236)	(3,394)	(5,020)
Thailand (TH)	570	(768)	480	281
Taiwan (TW)	443	(846)	(268)	(671)
United States (US)	16,611	(17,527)	128	(788)
Venezuela (VE)	70	(267)	(116)	(313)
Other Western Europe (WE)	1,782	(2,037)	(128)	(383)
Total	77780	-106415	-8989	-37623

Table B.10 Welfare Effects of Climate Change: GISS, No CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	60724.	-96349	-21067	-56692
Middle Income Developing Countries, $500-$2000/capita	15751	-33309	-8613	-26171
Upper Income Developing Countries, >$2000/capita	10488	-17852	703	-6661
Eastern Europe and Former USSR	7500	-11740	-8253	-12494
Developed Countries--OECD	128594	-139954	-2092	-13453
Total	223057	-299205	-39323	-115471

Table B.11 Welfare Effects of Climate Change: GISS, With CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	548	-2608	-9	-2070
Middle Income Developing Countries, $500-$2000/capita	-3187	623	767	-1797
Upper Income Developing Countries, >$2000/capita	-1130	410	-98	-818
Eastern Europe and Former USSR	2212	819	-1146	1885
Developed Countries--OECD	577	3201	-1103	2674
Total	-981	2444	-1589	-126

Table B.12 Welfare Effects of Climate Change: GFDL, No CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	71408	-109897	-27622	-66110
Middle Income Developing Countries, $500-$2000/capita	21693	-40405	-9127	-27839
Upper Income Developing Countries, >$2000/capita	14771	-21597	2475	-4351
Eastern Europe and Former USSR	6708	-15140	-20424	-28854
Developed Countries--OECD	162752	-182704	-1533	-21485
Total	277333	-369742	-56231	-148640

Table B.13 Welfare Effects of Climate Change: GFDL, With CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	9384	-13761	-945	-5322
Middle Income Developing Countries, $500-$2000/capita	812	-4884	-1063	-5135
Upper Income Developing Countries, >$2000/capita	1462	-2367	27	-878
Eastern Europe and Former USSR	2033	-2458	-1623	-2048
Developed Countries--OECD	19831	-23266	-210	-3644
Total	33523	-46737	-3814	-17028

Table B.14 Welfare Effects of Climate Change: UKMO, No CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	94226	-157919	-57390	-121083
Middle Income Developing Countries, $500-$2000/capita	30780	-60507	-18367	-48095
Upper Income Developing Countries, >$2000/capita	23670	-33586	6046	-3870
Eastern Europe and Former USSR	9072	-21684	-44859	-57471
Developed Countries--OECD	285386	-299411	-3580	-17606
Total	443133	-573107	-118150	-248124

Table B.15 Welfare Effects of Climate Change: UKMO, With CO_2 Effects, No Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	30135	-46867	-3094	-19827
Middle Income Developing Countries, $500-$2000/capita	8135	-18482	-4664	-15010
Upper Income Developing Countries, >$2000/capita	8040	-10587	2219	-328
Eastern Europe and Former USSR	4666	-8220	-7406	-10959
Developed Countries--OECD	74777	-88285	-1592	-15101
Total	125753	-172441	-14537	-61225

Table B.16 Welfare Effects of Climate Change: GISS, With CO_2 Effects, Level 1 Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	-3104	2822	73	-210
Middle Income Developing Countries, $500-$2000/capita	-4605	2795	1382	-429
Upper Income Developing Countries, >$2000/capita	-2198	1807	-212	-603
Eastern Europe and Former USSR	1249	1995	-821	2423
Developed Countries--OECD	-8486	15820	-1511	5822
Total	-17144	25238	-1090	7003

Table B.17 Welfare Effects of Climate Change: GFDL, With CO_2 Effects, Level 1 Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	2416	-4475	-514	-2573
Middle Income Developing Countries, $500-$2000/capita	-1591	-1276	-60	-2927
Upper Income Developing Countries, >$2000/capita	-30	-505	1	-534
Eastern Europe and Former USSR	1282	-623	-784	-125
Developed Countries--OECD	7043	-5846	-1171	25
Total	9119	-12726	-2528	-6135

Table B.18 Welfare Effects of Climate Change: UKMO, With CO_2 Effects, Level 1 Adaptation
In Millions of 1989 U.S. Dollars

Country/Region	Producer Surplus	Consumer Surplus	Other Surplus	Net Welfare Change
Poor Developing Countries, <$500/capita	18975	-31905	-1658	-14588
Middle Income Developing Countries, $500-$2000/capita	4016	-12038	-2647	-10669
Upper Income Developing Countries, >$2000/capita	4534	-6549	993	-1021
Eastern Europe and Former USSR	3594	-5116	-3353	-4875
Developed Countries--OECD	46662	-50807	-2324	-6470
Total	77780	-106415	-8989	-37623

Table B.19 Percentage Price Change from Base Resulting from Climate Change

Commodity\GCM	With CO_2 and Adaptation GISS	GFDL	UKMO	With CO_2, No Adaptation GISS	GFDL	UKMO	No CO_2, No Adaptation GISS	GFDL	UKMO
Beef	-.39	.98	2.68	.74	2.19	4.82	5.30	7.17	10.30
Pork	-1.76	2.79	9.27	1.38	6.62	16.33	19.31	25.98	37.98
Lamb	-.51	-.02	-.33	-.14	.14	.41	-1.21	-.17	.96
Poultry Meat	-1.52	2.95	9.22	1.84	6.88	16.43	19.14	25.74	37.72
Poultry Eggs	-1.60	2.33	7.86	1.00	5.58	13.96	16.46	22.56	33.50
Milk - whole	.00	.00	.00	.00	.00	.00	.00	.00	.00
Butter	-.05	-.97	-2.72	-.56	-1.94	-3.79	-5.77	-6.53	-7.97
Cheese	-.15	.10	.36	.04	.28	.75	.67	1.08	1.70
Milk Powder	-.17	.72	2.06	.40	1.55	3.28	4.25	5.35	7.18
Wheat	-21.84	2.18	49.70	-17.83	20.41	88.20	130.48	207.18	351.58
Maize	1.30	19.59	44.21	24.35	43.80	91.66	98.55	137.94	219.41
Sorghum	-6.72	12.79	42.35	1.02	27.19	74.10	95.55	141.77	235.64
Rice	24.15	22.84	78.09	34.01	41.17	109.12	359.66	371.59	618.18
Soybeans	-20.26	-7.15	28.31	-17.14	-3.66	63.42	73.74	102.60	248.94
Soybean Meal	-5.51	3.49	19.14	.45	10.22	37.22	42.15	57.40	98.26
Soybean Oil	-18.57	-10.50	12.92	-19.04	-11.21	27.76	38.14	50.48	109.93
Groundnuts	-22.76	-11.96	23.48	-21.38	-8.90	36.19	111.93	156.65	289.13
Groundnut Cake	-7.27	1.05	17.44	-2.71	6.80	30.15	48.66	66.35	105.38
Groundnut Oil	-12.43	-6.97	9.51	-12.22	-6.19	14.31	39.78	51.78	83.49
Cotton	-22.22	-14.23	26.61	-21.32	-12.09	42.47	131.75	164.76	393.41
Sugar	14.48	20.10	78.15	16.30	25.99	87.29	179.24	196.52	359.49
Tobacco	-42.02	-32.89	-5.39	-26.43	-13.90	28.11	222.32	298.29	550.78

Table B.20 Base Production and Percentage Change in Production under Climate Change: All Scenarios

		No adaptation						Level 1 adaptation		
		GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
United States	Base									
Wheat (1000MT)	55428.0	3.2	-15.6	12.5	-1.8	13.8	2.5	-12.0	-3.6	4.5
Coarse grains (1000MT)	221358.0	-7.6	-7.2	-15.0	-11.3	-19.8	-17.6	3.8	-3.8	-6.6
Rice (1000MT)	5115.0	35.8	10.1	23.7	3.0	13.4	-3.3	7.5	6.1	6.0
Other crops (Mil.US$)	27039.5	8.5	3.9	-.7	-2.1	-19.8	-21.0	3.9	-1.6	-7.5
Secondary (Mil.US$)	98663.3	-3.9	-.8	-4.7	-1.5	-6.7	-3.5	.2	-.7	-2.0
Canada	Base									
Wheat (1000MT)	24578.0	4.9	20.9	15.9	34.8	-14.1	9.0	20.0	28.3	10.3
Coarse grains (1000MT)	23463.0	5.4	23.1	11.0	28.0	-20.3	-2.8	17.2	24.7	7.7
Rice (1000MT)	.0	16.5	3.0	16.8	3.5	21.8	7.7	2.2	2.1	5.9
Other crops (Mil.US$)	2934.3	5.2	18.5	4.2	9.8	-28.7	-8.9	20.3	16.1	-3.1
Secondary (Mil.US$)	10635.5	-9.3	.2	-12.0	-3.1	-15.8	-7.6	1.4	-1.3	4.8
European Community	Base									
Wheat (1000MT)	82037.0	10.1	-.4	-1.4	-11.9	17.2	7.4	-.7	-.9	11.0
Coarse grains (1000MT)	89624.0	4.7	6.7	8.9	9.2	18.5	16.0	3.1	6.1	9.8
Rice (1000MT)	1386.0	46.9	6.3	48.0	7.5	68.5	18.1	4.5	4.3	13.5
Other crops (Mil.US$)	12738.4	1.9	12.3	-5.1	3.8	13.9	12.1	12.0	4.2	11.6
Secondary (Mil.US$)	133039.9	-3.1	.6	-4.3	-.5	-6.3	-2.3	.7	-.0	-1.4
Oth. West. Europe	Base									
Wheat (1000MT)	4389.0	21.2	-5.5	12.6	-12.4	40.8	13.1	-5.2	-3.0	14.9
Coarse grains (1000MT)	12368.0	9.6	5.1	15.8	9.6	29.0	19.3	1.7	6.1	12.1
Rice (1000MT)	.0	35.7	6.0	36.4	7.1	48.3	15.9	4.4	4.2	12.2
Other crops (Mil.US$)	758.3	15.2	13.1	9.2	8.4	36.7	24.3	12.6	7.2	21.6
Secondary (Mil.US$)	11920.8	-2.5	.2	-3.4	-.6	-4.8	-1.9	.4	-.3	-1.2
Japan	Base									
Wheat (1000MT)	985.0	-15.9	-2.8	-15.8	-4.6	-33.3	-24.6	-1.9	-.4	1.6
Coarse grains (1000MT)	379.0	-.8	23.0	-1.4	22.2	-4.3	19.5	22.2	21.2	17.3
Rice (1000MT)	9416.0	14.3	12.3	-1.7	-2.7	19.8	10.9	11.4	2.0	8.5
Other crops (Mil.US$)	634.4	12.5	13.4	9.0	10.4	18.0	14.6	11.2	7.8	10.4
Secondary (Mil.US$)	15852.5	-4.1	-.2	-5.4	-1.0	-8.5	-3.1	.4	-.4	-1.7
Australia	Base									
Wheat (1000MT)	14121.0	48.8	-8.8	89.8	26.9	153.1	73.0	-11.6	11.8	46.2
Coarse grains (1000MT)	6897.0	4.5	16.5	9.4	18.8	24.4	29.4	10.7	14.9	19.8
Rice (1000MT)	660.0	78.2	6.6	64.4	-3.1	94.7	11.9	17.1	11.3	28.0
Other crops (Mil.US$)	2030.7	22.2	8.6	24.8	9.0	55.2	29.6	8.2	8.4	27.0
Secondary (Mil.US$)	9850.9	-1.0	.7	-1.2	.2	-1.6	-.3	.4	.2	-.3

		No adaptation						Level 1 adaptation		
		GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
New Zealand	Base									
Wheat (1000MT)	135.0	75.0	8.7	103.6	37.5	131.6	64.7	6.8	23.9	43.2
Coarse grains (1000MT)	536.0	54.6	32.4	65.4	41.7	89.3	61.1	23.2	31.0	41.5
Rice (1000MT)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Other crops (Mil.US$)	3.9	26.4	17.6	25.2	16.5	30.9	20.9	12.1	10.8	13.8
Secondary (Mil.US$)	6422.6	.1	.0	.5	.2	.9	.4	-.1	.1	.1
South Africa	Base									
Wheat (1000MT)	2026.0	-26.3	-20.1	-22.8	-12.9	-24.8	-11.2	-19.0	-14.7	-13.1
Coarse grains (1000MT)	9514.0	-23.1	-16.3	-21.4	-15.7	-24.0	-18.4	-19.5	-18.1	-22.0
Rice (1000MT)	.0	28.6	4.9	29.2	5.9	38.4	12.9	3.6	3.5	10.0
Other crops (Mil.US$)	1462.1	-17.0	-15.1	-14.9	-13.1	-9.9	-10.8	-15.7	-14.1	-12.5
Secondary (Mil.US$)	4334.4	-1.1	-.2	-1.3	-.3	-1.7	-.8	.1	-.1	-.5
Eastern Europe	Base									
Wheat (1000MT)	40868.0	-9.2	6.9	-24.9	-14.5	-18.6	-6.9	6.8	-.1	1.5
Coarse grains (1000MT)	60730.0	-6.5	1.8	-6.2	2.1	-4.5	3.7	1.3	1.7	3.0
Rice (1000MT)	202.0	8.8	1.6	8.8	1.7	11.3	3.8	1.3	1.1	3.1
Other crops (Mil.US$)	5304.2	-6.3	14.0	-14.0	6.6	-3.8	11.8	13.7	6.4	11.2
Secondary (Mil.US$)	38691.8	-.5	.0	-.7	-.2	-.9	-.4	.1	-.1	-.3
Former Soviet Union	Base									
Wheat (1000MT)	92307.0	-4.0	23.2	-16.3	6.9	-29.8	-17.4	23.0	5.9	-8.1
Coarse grains (1000MT)	104807.0	-6.3	12.4	-19.0	-4.2	-32.7	-13.5	12.0	.5	-6.0
Rice (1000MT)	1664.0	-4.2	12.5	-18.9	-2.1	-33.0	-16.2	13.2	.3	-7.4
Other crops (Mil.US$)	16468.2	-4.6	17.7	-16.8	10.0	-30.2	-2.6	17.6	9.8	-1.4
Secondary (Mil.US$)	93493.8	-.6	.1	-.7	-.1	-1.0	-.4	.1	-.0	-.3
P. Rep. of China	Base									
Wheat (1000MT)	90800.0	-3.5	15.0	-9.9	8.3	-14.3	1.4	14.9	7.9	.9
Coarse grains (1000MT)	93466.0	-20.1	-13.5	-18.8	-11.3	-20.3	-12.8	.1	.5	.7
Rice (1000MT)	126091.0	-18.8	-1.6	-19.8	-3.5	-18.5	-1.8	1.1	1.0	2.6
Other crops (Mil.US$)	31889.1	-13.1	13.2	-16.8	11.5	-17.9	10.7	15.6	14.0	12.9
Secondary (Mil.US$)	74326.6	.9	.0	1.2	.4	1.8	.8	-.1	.2	.5
Mexico	Base									
Wheat (1000MT)	4000.0	-44.2	-34.3	-31.6	-21.3	-37.7	-23.2	-34.9	-24.0	-27.2
Coarse grains (1000MT)	14090.0	-37.9	-33.1	-28.0	-24.0	-35.6	-31.1	-34.8	-25.9	-33.8
Rice (1000MT)	360.0	-12.1	-16.5	-2.5	-9.2	-7.0	-21.5	-18.0	-12.2	-24.1
Other crops (Mil.US$)	2179.8	-35.1	-19.8	-25.7	-11.4	-30.9	-14.9	-19.9	-11.9	-16.1
Secondary (Mil.US$)	14633.4	-.5	.2	-.7	.1	-1.0	-.3	.2	.1	-.2

		No adaptation						Level 1 adaptation		
		GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Cen.Amer. & Carib.	**Base**									
Wheat (1000MT)	34.0	-49.9	-34.1	-33.3	-16.3	-48.4	-28.4	-34.2	-18.1	30.7
Coarse grains (1000MT)	3517.0	-17.6	-10.0	-17.1	-9.8	-23.4	-15.9	-11.6	-11.1	-17.9
Rice (1000MT)	1118.0	-.4	-5.8	4.6	-1.4	-7.9	-9.3	-7.4	-4.7	-12.6
Other crops (Mil.US$)	3644.0	-21.7	-20.3	-16.4	-15.5	-33.3	-26.4	-20.5	-16.1	-27.0
Secondary (Mil.US$)	1584.9	-2.9	-.1	-3.6	-.8	-5.1	-2.3	.4	-.3	-1.4
Brazil	**Base**									
Wheat (1000MT)	5550.0	-46.6	-35.3	-30.2	-16.8	-43.8	-26.6	-35.2	-17.7	-28.4
Coarse grains (1000MT)	22512.0	-8.0	-5.2	-6.0	-3.9	-11.3	-8.4	-10.3	-8.2	-13.7
Rice (1000MT)	4896.0	-17.1	-11.0	-6.2	-1.6	-25.8	-17.2	-11.8	-3.7	-18.6
Other crops (Mil.US$)	11462.6	-25.7	-.1	-9.4	5.4	-15.3	-3.9	-.5	4.8	-7.0
Secondary (Mil.US$)	25824.0	-1.2	-.0	-1.4	-.2	-2.3	-1.2	.2	-.0	-.6
Argentina	**Base**									
Wheat (1000MT)	10150.0	-28.3	-33.4	-16.8	-17.5	-21.0	-12.9	-25.8	-12.3	-7.6
Coarse grains (1000MT)	8333.0	-10.3	6.0	-21.7	-9.5	-17.8	-7.0	8.5	-1.5	-.6
Rice (1000MT)	215.0	65.1	12.3	63.7	11.4	85.4	24.2	9.8	6.9	18.7
Other crops (Mil.US$)	7251.4	3.6	7.3	-5.3	2.8	15.1	25.5	6.0	1.7	17.5
Secondary (Mil.US$)	14370.5	-.3	.6	-.3	.5	-.6	.0	.4	.4	.0
Venezuela	**Base**									
Wheat (1000MT)	.0	-41.7	-29.7	-34.9	-20.9	-42.4	-24.9	-29.4	-22.5	-27.0
Coarse grains (1000MT)	1595.0	-13.6	-9.4	-11.6	-7.6	-16.3	-11.7	-12.0	-10.0	-15.4
Rice (1000MT)	203.0	6.3	-3.4	8.0	-1.5	-2.6	-7.7	-4.5	-4.5	-10.4
Other crops (Mil.US$)	383.1	-20.2	-16.1	-10.0	-7.6	-30.9	-21.6	-16.4	-8.2	-22.9
Secondary (Mil.US$)	2542.7	.1	.2	.1	.2	.2	.2	.1	.1	.1
Oth. Latin America	**Base**									
Wheat (1000MT)	2895.0	-45.3	-29.6	-37.8	-20.5	-47.2	-27.6	-29.1	-21.5	-28.7
Coarse grains (1000MT)	6143.0	-17.9	-8.8	-17.8	-9.4	-23.9	-15.8	-10.6	-10.5	-17.6
Rice (1000MT)	2859.0	-5.3	-8.3	1.5	-2.8	-13.4	-12.8	-9.7	-5.7	-15.5
Other crops (Mil.US$)	3047.2	-27.5	-18.3	-13.1	-5.7	-34.9	-23.7	-18.6	-6.3	-25.2
Secondary (Mil.US$)	8039.5	-.1	.2	-.0	.3	-.1	.2	.1	.2	.1
Nigeria	**Base**									
Wheat (1000MT)	60.0	-22.4	-3.6	-31.9	-12.4	-19.8	-.6	-3.8	-12.9	-28.9
Coarse grains (1000MT)	8100.0	-14.2	-17.3	-22.5	-24.1	-4.6	-8.1	-18.9	-26.1	-11.9
Rice (1000MT)	540.0	6.9	8.7	-5.4	-1.0	14.2	16.2	7.4	-3.1	13.4
Other crops (Mil.US$)	528.6	-24.3	-4.2	-34.1	-13.4	-17.0	-1.0	-4.3	-13.5	-1.5
Secondary (Mil.US$)	513.9	-1.6	.3	-2.1	.1	-3.0	-.7	.4	.2	-.5

		No adaptation						Level 1 adaptation		
		GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
ubsaharan Africa	Base									
Vheat (1000MT)	1918.0	-25.5	-18.0	-27.3	-15.9	-22.2	-8.2	-19.0	-19.1	-12.8
oarse grains (1000MT)	32054.0	-25.6	-22.0	-26.3	-22.5	-26.4	-22.3	-24.0	-24.5	-25.3
ice (1000MT)	4231.0	25.1	4.4	25.5	5.2	33.4	11.4	3.2	3.0	8.7
ther crops (Mil.US$)	6963.8	-19.8	-5.0	-21.2	-6.3	-23.2	-7.0	-5.3	-6.7	-8.0
econdary (Mil.US$)	1669.1	-6.0	1.8	-7.5	.7	-10.8	-2.2	1.9	1.0	-1.6
gypt	Base									
Vheat (1000MT)	3183.0	-32.1	-31.9	-21.7	-24.9	-48.4	-48.7	-32.1	-25.8	-49.6
oarse grains (1000MT)	5280.0	-20.0	-15.5	-18.6	-14.2	-30.8	-25.6	-16.9	-15.6	-27.5
ice (1000MT)	1427.0	-18.2	-9.6	-10.7	-2.7	-31.8	-19.9	-10.5	-4.4	-21.4
ther crops (Mil.US$)	1156.7	-27.1	-7.6	-20.9	-1.9	-36.7	-19.2	-7.7	-2.0	-19.7
econdary (Mil.US$)	2815.6	-2.6	-.2	-3.3	-.9	-4.5	-2.1	.3	-.3	-1.2
Aiddle East, Oil	Base									
Vheat (1000MT)	11806.0	-26.3	-15.5	-29.0	-15.7	-31.0	-15.3	-16.2	-17.7	-18.2
oarse grains (1000MT)	5275.0	-24.0	-12.7	-27.6	-15.5	-30.5	-17.6	-13.7	-16.7	-19.6
ice (1000MT)	1148.0	12.1	2.2	12.3	2.6	15.9	5.7	1.6	1.6	4.4
ther crops (Mil.US$)	1142.6	-16.2	-3.9	-20.2	-7.3	-19.8	-6.8	-4.2	-7.8	-8.3
econdary (Mil.US$)	2556.9	-3.3	-.3	-4.1	-1.1	-5.5	-2.6	.3	-.4	-1.6
Aiddle East, Other	Base									
Wheat (1000MT)	16738.0	-24.3	-11.4	-30.5	-14.9	-29.0	-11.6	-11.9	-16.7	-14.0
Coarse grains (1000MT)	11160.0	-21.3	-9.5	-26.2	-13.8	-25.4	-12.8	-11.0	-15.3	-15.4
Rice (1000MT)	153.0	11.5	2.1	11.7	2.5	15.1	5.4	1.6	1.5	4.1
Other crops (Mil.US$)	4178.1	-20.0	-3.8	-29.2	-14.5	-25.4	-9.0	-4.1	-14.8	-9.9
Secondary (Mil.US$)	4466.9	-2.8	.4	-3.5	-.3	-4.8	-1.6	.6	.0	-1.1
ndia	Base									
Wheat (1000MT)	54110.0	-21.7	-3.4	-23.8	-5.0	-42.6	-15.6	-4.4	-8.9	-19.8
Coarse grains (1000MT)	34559.0	-26.5	-5.5	-30.6	-8.6	-49.0	-26.9	-13.9	-16.3	-36.0
Rice (1000MT)	74053.0	-1.8	-.8	-10.3	-7.3	-29.9	-14.8	-2.2	-9.7	-17.1
Other crops (Mil.US$)	20206.8	-21.1	-6.8	-26.7	-12.3	-42.8	-25.8	-6.1	-11.3	-25.6
Secondary (Mil.US$)	19791.2	-3.6	.7	-4.3	-.0	-5.8	-1.7	.8	.2	-1.2
Other South Asia	Base									
Wheat (1000MT)	18084.0	-48.0	-21.5	-19.7	-6.5	-61.7	-45.0	-22.0	-9.1	-47.0
Coarse grains (1000MT)	4016.0	-41.6	-28.8	-27.8	-15.3	-52.1	-40.0	-31.3	-17.3	-42.3
Rice (1000MT)	24713.0	-16.1	-12.4	-2.1	-.7	-10.5	-6.4	-13.7	-3.2	-9.0
Other crops (Mil.US$)	6209.4	-32.4	-19.4	-1.0	6.9	-47.9	-27.8	-19.6	6.6	-28.9
Secondary (Mil.US$)	912.5	-5.8	2.1	-7.2	1.2	-10.4	-1.8	2.1	1.3	-1.3

		No adaptation						Level 1 adaptation		
		GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
Indonesia	Base									
Wheat (1000MT)	.0	-28.3	-13.7	-17.2	-2.2	-10.5	5.5	-14.1	-3.8	3.1
Coarse grains (1000MT)	5000.0	-32.6	-25.4	-21.9	-15.1	.8	7.6	-28.0	-17.3	3.0
Rice (1000MT)	29072.0	-15.8	-2.5	-5.3	7.8	16.0	5.7	-3.6	5.5	3.2
Other crops (Mil.US$)	3068.5	-23.0	-12.0	-10.9	-1.9	17.6	17.0	-12.9	-3.3	14.2
Secondary (Mil.US$)	2760.6	-2.6	.6	-3.3	.2	-4.8	-1.0	.7	.3	-.7
Thailand	Base									
Wheat (1000MT)	.0	-32.0	-20.4	-16.0	-4.4	-27.3	-12.0	-21.0	-6.7	-15.0
Coarse grains (1000MT)	4330.0	-34.4	-29.2	-18.4	-14.3	-29.9	-24.7	-32.9	-17.9	-30.0
Rice (1000MT)	13317.0	-23.5	-4.7	-9.2	7.5	-20.8	-13.7	-5.7	5.3	-15.7
Other crops (Mil.US$)	1814.1	-27.9	-15.1	-13.1	-2.3	-22.5	-8.5	-15.6	-3.4	-10.2
Secondary (Mil.US$)	968.5	-2.2	-.0	-2.7	-.3	-4.0	-1.5	.4	.0	-.8
Malaysia	Base									
Wheat (1000MT)	.0	-52.0	-32.7	-42.9	-23.3	-37.5	-17.4	-32.8	-23.9	-18.4
Coarse grains (1000MT)	35.0	-48.1	-40.2	-38.6	-30.9	-43.8	-35.9	-41.6	-32.1	-37.7
Rice (1000MT)	1147.0	-3.9	-8.4	8.3	1.4	10.3	4.5	-10.0	-1.9	.5
Other crops (Mil.US$)	1378.4	-24.5	-13.3	-12.4	-3.1	-13.4	-2.3	-13.7	-3.9	-4.1
Secondary (Mil.US$)	5979.9	-.4	.0	-.6	-.0	-.9	-.2	.1	.0	-.1
Philippines	Base									
Wheat (1000MT)	.0	-50.0	-33.3	-39.6	-22.6	-32.6	-14.8	-33.7	-23.8	-16.7
Coarse grains (1000MT)	4500.0	-47.4	-39.6	-37.6	-30.2	-42.8	-35.1	-41.3	-31.7	-37.3
Rice (1000MT)	5785.0	-21.5	-12.2	-11.9	-3.5	-15.3	-5.8	-12.8	-4.9	-7.4
Other crops (Mil.US$)	2064.3	-23.8	-16.6	-11.6	-6.5	-13.4	-5.6	-17.2	-7.5	-7.4
Secondary (Mil.US$)	3096.0	-1.6	.3	-2.0	.1	-2.9	-.6	.4	.2	-.4
Other SE Asia	Base									
Wheat (1000MT)	200.0	-28.1	-15.6	-31.2	-15.9	-49.1	-30.1	-15.3	-17.2	-31.7
Coarse grains (1000MT)	1313.0	-16.5	-7.8	-13.7	-5.8	-17.0	-8.9	-10.1	-19.7	-10.4
Rice (1000MT)	22614.0	-10.8	-5.2	-7.5	-2.0	-8.2	-1.8	-4.4	-1.4	.0
Other crops (Mil.US$)	1134.0	-12.6	-.7	-10.5	1.4	-17.5	-4.5	-1.4	1.1	-5.2
Secondary (Mil.US$)	520.8	-3.2	.9	-4.0	.4	-5.7	-1.2	1.0	.5	-.8
South Korea	Base									
Wheat (1000MT)	1.0	.9	4.7	.7	8.1	-8.3	4.1	3.9	4.8	4.1
Coarse grains (1000MT)	842.0	-12.0	-4.0	-12.1	-4.2	-14.9	-6.9	-2.3	-19.6	-3.4
Rice (1000MT)	5898.0	-17.0	-4.5	-18.0	-5.3	-19.5	-7.1	-1.9	-1.9	-1.9
Other crops (Mil.US$)	377.5	2.5	7.2	2.1	6.7	2.1	7.5	4.0	3.4	3.2
Secondary (Mil.US$)	2546.2	-.5	.2	-.6	.0	-1.1	-.2	.2	.1	-.1

		No adaptation						Level 1 adaptation		
		GISS	GISS w/CO2	GFDL	GFDL w/CO2	UKMO	UKMO w/CO2	GISS w/CO2	GFDL w/CO2	UKMO w/CO2
'aiwan	Base									
Vheat (1000MT)	4.0	-16.0	7.4	-19.5	4.0	-31.3	-7.8	7.6	4.0	-4.1
;oarse grains (1000MT)	416.0	-17.4	-4.6	-17.4	-5.1	-21.4	-9.0	-3.3	-20.3	-5.8
lice (1000MT)	1716.0	-18.3	-4.6	-19.4	-5.4	-21.6	-7.6	-1.8	-2.0	-2.1
)ther crops (Mil.US$)	295.2	-7.8	.9	-10.1	-2.0	-17.1	-5.4	1.8	.1	-1.5
iecondary (Mil.US$)	3427.0	2.2	.1	2.8	.8	3.6	1.8	-.3	.3	1.2
)ther East Asia	Base									
Vheat (1000MT)	800.0	3.7	3.7	4.8	8.7	-2.6	6.2	2.9	4.8	5.4
;oarse grains (1000MT)	3465.0	-6.2	-1.2	-3.4	.9	-2.6	2.0	-3.2	-17.7	.8
lice (1000MT)	3864.0	-7.4	-2.1	-8.7	-2.9	-8.8	-2.2	.3	-.3	2.6
)ther crops (Mil.US$)	281.5	3.2	6.9	3.1	6.9	4.9	10.3	3.9	3.8	5.0
iecondary (Mil.US$)	188.6	-3.9	1.4	-5.1	-.0	-8.1	-3.2	1.5	.4	-1.8