# IMPLICATIONS OF CLIMATE CHANGE FOR AGRICULTURE, FOOD SUPPLY AND RISK OF HUNGER

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### ABSTRACT

This paper reviews the series of studies, from 1994 to 2007, which have evaluated the potential effects of climate change on crop yield, food production and risk of hunger. There are two global studies of crop yield responses and several additional estimates of production that are based on the first of these. The studies cover three broad types of analysis: 1) effects under climate change but with underlying socio-economic characteristics largely unspecified, 2) effects under both changes in climate and with varying development pathways assumed to affect underlying socio-economics, and 3) effects under different policies of stabilisation of greenhouse gases. There are some conclusions common to all studies: that climate change will generally reduce production potential and increase risk of hunger, and that Africa is the most adversely affected region. An additionally important initial conclusion is that pathways of sustainable economic development have a marked effect in reducing the adverse effects on climate change.

## **KEYWORDS**

Climate change, agriculture, food supply, crop yields, food prices, risk of hunger

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# Implications of climate change for agriculture, food supply and risk of hunger

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# OUTLINE

- The projected changes of climate
- The effects on food supply and risk of hunger
- Potential responses: mitigate emissions, adapt agriculture.
- Conclusions













# Other projected changes of climate (by 2100)

- Sea levels will rise 0.1 to 0.8 metres
- More tropical cyclones
- More frequent very hot days
- And... we can see some of these changes already, occurring <u>now</u>.

# Studies of climate, food supply and risk of hunger:

- <u>3 sets of futures</u>:
- A. Single 'business-as-usual' future
- B. Range of alternative development pathways
- C. Future with GHG reductions
- <u>3 approaches to estimation:</u>
- 1) crop modelling of yields
- 2) spatial shift of crop suitability
- 3) Ricardian economic analysis of land-use response



# The projection of effects on food supply: A). For single 'business-as-usual' future.

1) By crop yield modelling (Rosenzweig and Parry, 1995 et seq)

- Crop yield models (IBSNAT/DSSAT) run for 118
   sites
- Yield responses extrapolated across all cropping zones, world-wide
- Yield changes input to world food model (the Basic Linked System)
- Output: production, prices, risk of hunger







# 2. Projecting shifts of agroecological zones (Fischer, et al. 2000) Changes in length of growing season

- Shift of zones of crop suitability
- Estimation of altered yields
- Altered yields in BLS world food model













### B. FUTURES THAT INCLUDE DIFFERENT PATHWAYS OF DEVELOPMENT (IPCC's SRES scenarios)

- A1 = <u>World of Global Markets:</u> high growth, high tech, low pop,
- A2 = <u>World of Regional Enterprise</u>: high pop (11bn in 2050), high growth (but inequitable) [current pathway]
- B1 = World of Global Sustainability: low pop, moderate growth, global environmental agreements
- <u>B2 = World of Local Stewardship</u>: low pop (9 bn in 2050), moderate growth, local envt management

















# CONCLUSION: The extent of the challenge for adaptation









|            |   |   |   | station at<br>2015 levets<br>impacts in 2100             | climate change<br>impacts in 2100                              |                                      |  |  |
|------------|---|---|---|--|--|--------------------------------------|--|--|
| WATED      | Increased water availability in moint topics and high latitudes<br>Decreasing water availability and increasing drought in mini-latitudes and sami-and lose latitudes |   |   |  |  |                                      |  |  |
| HALLA      | 0.4 to 1.7 billion  | 1.8 to 2.8 billion  | -   | 11 to 3.2 billion  | Additional p<br>With Increase<br>System stress                 |                                      |  |  |
|            | Increasing amphibian extinction   | About 20 to 30% species at inc-<br>reasingly high risk of estinction Major eating ions arou |   |  |  | d the plobe                          |  |  |
| ECOSYSTEMS | Increased coral bleaching   | Most corais biesched  | Widesprea   | d coral mortality  |  |                                      |  |  |
|            | Increasing species range  | ability and wildfire risk   | Terrestrial biosphere tend<br>~15%                                  | is toward a ret carbon                                   | -40% of acceptations aff                                       | acted                                |  |  |
| 10.550     | Crop<br>productivity  | Low latitudes<br>Decreases for some cereals   |   | Ale  | ersals decrease  |                                      |  |  |
| FOOD       |   | Increases for some cereals<br>Mid to high latitudes   |   | Decr   | eases in some regions  | ->                                   |  |  |
| -          | Increased damage from   | n floods and storms   |   |  |  | ->                                   |  |  |
| COAST      | Additional people<br>coastal flooding e   | at risk of<br>ach year 0 to 3 million   | *   | About 37% loss<br>of coastal wetlands<br>2 to 15 million |  | =                                    |  |  |
|            | Increasing to   | urden from malnutrition, diaer  | hoeal, cardio-respiratory a   | od infactions disease                                    | -  | ->                                   |  |  |
| HEALTH     | Increased morbidity and   | d mortality from heatwaves, f   | loods and draughts  |  |  |                                      |  |  |
|            | Changed distribution at   | some disease vectors  | Substant  | al burden on health se                                   | ervices  | ->                                   |  |  |
| SINGULAR   | Local retreat of ice in<br>Greenland and West<br>Antarctic  |   | Long term commitment to<br>metres of sea level rise d<br>sheet loss | e several en la las                                      | Leading to reconfig<br>of coastimes work<br>inundation of low- | puration<br>I wide and<br>ying areas |  |  |
| EAFW12     |   |   | Ecosystem changes due   | to weakening of the r                                    | neridianal everyturning ch                                     | culation                             |  |  |
| _          | 0   | 1 2   |   | 3  | 4  | 5                                    |  |  |

|                        |   |   | 20% emission             | s cut state            | 100                              | unmiligates                             |              |  |
|------------------------|---|---|--------------------------|------------------------|----------------------------------|---|--------------|--|
|                        |   |   | by 2050                  | 2015 k                 | rvela ci                         | knats change                            |              |  |
|                        |   |   | impacts in 21            | 00 emplacts i          | n 2100 in                        | quecta in 2100                          |              |  |
|                        |   |   | And the second second    |                        |                                  |   | 100          |  |
|                        | Increased water availab   | sility in moist tropics and high  | h latitudels             | States States          |                                  |   |              |  |
| THE OWNER              | Decreasing water avail  | ability and increasing drough   | t in mid-lptitudes       | and semi-and low la    | tudes                            |   |              |  |
| WATER                  |   |   | 1                        |                        |                                  | Antitional name                         |              |  |
| a composition of       | A day 17 billion  | 1.0 to 7.0 billion  | in the local division of | 110.321                | 10                               | with increased                          | _            |  |
|                        |   |   | -                        | 1                      |                                  | tester stress                           |              |  |
|                        | Contraction of the local data   |   | and some of the second   |                        |                                  | Let | 1000         |  |
|                        | Increasing amphibian  | date of extention   |                          |                        | for extinctions around the globe |   |              |  |
|                        |   | Forth second and second   | 1                        | 1910 I (1921 I         |                                  |   | 1000         |  |
| ECOSYSTEMS             | Increased coral bleaching   | Most corais blasched  | 1 3                      | Videsprand coral mort  | ality                            | 1                                       |              |  |
|                        |   |   | 100                      |                        |                                  | 1                                       |              |  |
|                        | Increasion species ranges   | And within the effet  | Terrestrial blos         | phore tands toward a   | net carbon source                |   |              |  |
|                        | and the second states and a   | and the second se | ~15%                     |                        | -47%                             | of ecosystems affected                  |              |  |
|                        |   |   |                          |                        |                                  |   |              |  |
|                        | Crop<br>productivity  | Low latitudes   |                          |                        | and applied with the             | 3 S. B. S.                              |              |  |
| 100000                 |   | Decreases for some cereals  |                          |                        | All cereals d                    | HC78864                                 |              |  |
| FOOD                   |   | increases for some cereals  |                          |                        | Decreases in                     | A ACCESS CARGINGA                       | -            |  |
|                        |   | Mid to high latitudes   |                          |                        |                                  |   | 1000         |  |
|                        |   |   |                          |                        |                                  |   |              |  |
|                        |   |   |                          |                        |                                  |   |              |  |
|                        | Income of Summer Res  | and the second second second  |                          |                        |                                  | A 122                                   |              |  |
|                        | increased carriage from   | Theorem and another   |                          | Charles of the         |                                  |   |              |  |
| COAST                  |   |   |                          | About 2                | % loss                           | 1.11                                    |              |  |
|                        | A different months  | and the second se |                          | of coasts              | i wetlands                       | 10.                                     | 1341         |  |
|                        | coastal flooding e  | ach year 0 to 3 million   | 100                      | 2 to 15 mill           | lon .                            |   |              |  |
|                        |   |   |                          |                        |                                  |   |              |  |
|                        |   |   | -                        | -                      |                                  | 1 1 1 2                                 | -            |  |
|                        | Increasing be   | urden from malnutrition, diam   | thosal, catalo-rea       | piratory and infectiou | diseases                         |   |              |  |
| Constant of the second |   |   |                          |                        |                                  |   |              |  |
| HEALTH                 | Increased mortality and mortality from heatwaves, Social any draughts |   |                          |                        |                                  |   |              |  |
|                        | Changed distribution of   | some disease vectors  | 1                        | Substantial burden or  | beath services                   |   |              |  |
|                        |   |   | -                        |                        |                                  | 100                                     |              |  |
|                        |   |   |                          |                        |                                  | of Real Property lies                   |              |  |
|                        | Local retreat of ice in   |   | Long horn com            | Interest to several    |                                  | anding to reconfigurat                  | lion         |  |
|                        | Greenland and West  | Greenland and West  |                          |                        |                                  | d coastines world wid                   | e and        |  |
| SINGULAR               | Antarctic   |   | sheet lass               |                        |                                  | nundation of low-lying                  | areas        |  |
| EVENTS                 |   |   |                          |                        |                                  |   | a the second |  |
|                        |   |   | Ecosystem ch             | anges due to weaker    | ng of the meridia                | nal overfurning circula                 | DOM          |  |
|                        |   |   |                          |                        |                                  |   |              |  |
|                        | 0   |   | 2                        | 3                      |                                  | 4                                       | 5°C          |  |

|            |  | 50% emissions cut  | 20% emissions cut  | the rotation   | unmbigated   |   |
|------------|--|--|--|--|--|---|
|            |  | by 2050  | by 2050  | 2015 levels  | comine shange  |   |
|            |  | impacts in 2100  | impacts in 2100  | Impacts in 2100  | inguality in 2107  |   |
|            | And the second sec | The low second description in a first second   | 2020.00  |  |  | and the second se |
|            | Increased water available  | berry in monat propice and high  | in self-bolt and a   | and sold have been been  |  |   |
| WATER      | Decrement even search  | straid and accessed accede   | an many period and a   |  |  |   |
|            |  | and the second se  |  |  | Additional   | people  |
|            | 0.4 to 1.7 billion   | 1.0 to 2.0 billion   |  | 1.1 to 3.2 littline  | with increa  |   |
|            |  | the second s   |  |  |  |   |
|            | Increasing amphibias   | About 29 to 30   | PL species at inc-   |  | Major calling lans area  | and the plane -   |
|            | extinction   | reasingly high   | risk of eldination   | and the second se  | COLUMN DATES   | and the second second   |
| ECOSYSTEMS | Increased coral bleaching  | Must corals bleached   | Wides  | aread coral montality  |  | to be a   |
| LOUTOTLING |  | ADMINISTRATION OF  | Name of Street of Cases  | STORY AND STORY  |  |   |
|            |  | and the second second second   | Terrestrial biosphere  | tends toward a net carbon  | BOUTCH, BE:  | COLUMN TWO IS NOT   |
|            | Increasing species range   | shifts and wildles risk  | ~15%   | Service Contact and  | 40% of ecosystems at   | Rected  |
|            |  | in the second se |  |  |  |   |
|            |  | Low latitudes  |  |  |  |   |
|            | Crop   | Decreases for some cereals   |  | Al cer   | walk decrease  |   |
| FOOD       |  | Increases for some persols   |  | Decre  | ases in some regions   | -   |
|            |  | Mid to high latitudes  | 1.1.1  |  |  | 1   |
|            |  | land the share of the  |  |  |  |   |
|            |  |  |  |  |  | and the second se |
|            | Increased damage from  | n floods and storms  |  |  |  |   |
| 10000      | - Adversion of the second  | and the second s |  | and a second sec | - State of the second  |   |
| COAST      |  | the second s   |  | of coastal wetlands  |  |   |
|            | Additional people  | at risk of   | and the second se  |  | ACCOUNT OF A DESIGNATION OF A DESIGNATIO | 1.00  |
|            | coastal flooding a   | ech year 0 to 3 million  |  | 2 50 15 million  |  |   |
|            |  | PROVING THE REAL   |  |  |  |   |
|            | Incomplete Pr  | the base of the state of the   |  | an and the second s   |  | -   |
|            | Increasing by  | or other to be an addition to be a state   | the second second  | of and second the diseases   |  | -   |
| HEALTH     | Increased morbidity and  | d mortality from heat paves, if  | loods and droughts   |  |  | -   |
|            | Contraction of the   |  | 1  | Line Barris Barrison   |  | COMPANY IN  |
|            | Changed distribution of  | some disease vectors   | Sube   | tantial burden on health ser   | VICES  |   |
|            |  | 1  | 1  | 1  |  |   |
|            |  | ( i i i i i i i i i i i i i i i i i i i  | COLUMN STORAGE   | 0068 60200   | and the state of the   | Contraction of the  |
|            | Local retreat of ice in  | -  | Long term commitme   | Isteves of the   | Casting to record  | figuration and  |
| SINGULAR   | Antaretic  | 1.11   | sheet loss   | 1  | inunda lon of los  | -lying areas  |
| EVENTS     |  |  | Contraction of the second  | south diversity of the local diversity of the |  |   |
|            |  |  | Ecosyptam changes  | due to weakening of the m  | endianal averturning i   | Droutetoet  |
|            |  | 5 C C C C C C C C C C C C C C C C C C C  | The state of the s | And the second second  | 10 10  | 100   |
|            |  | 1  |  | 3  | 4  | 510   |

|           | by 20  | 50 by 2050   | by 2050  | 2015 levels  | cimate change   |   |  |  |
|-----------|--|--|--|--|---|---|--|--|
|           | impacts in   | 2100 impacts in 2100   | impacts in 2100  | impacts in 2100  | reparts in 2100   |   |  |  |
| WATER     | Increased water availability and increasing drought in mol-jutitudes and send and low lattacks |  |  |  |   |   |  |  |
|           | 0.4 to 1.7 billion   | 1.0 to 2.0 billion   | -  | 1 to 3.2 ution   | Additional people<br>with increased   |   |  |  |
|           | extinction   | About 20 to 3<br>reastingly Ng   | 0% species at inc-<br>h risk of extinction   | -  | r extinctions around the globe  |   |  |  |
| COSYSTEMS | Increased coral bleaching  | Most corais bleached   | Widesprea  | d coral mortality  |   |   |  |  |
|           | Increasing species range   | status and withdraw mak  | Terrestrial biosphere tend<br>-15%   | ts toward a net carbon sour<br>-40%                      | of ecosystems affected  |   |  |  |
| FOOD      | Crep<br>productivity   | Low latitudes<br>Decreates for some consult<br>Increases for some persais<br>Mid to pigh latitudes |  | All consults<br>Decreases                                | decrease  |   |  |  |
|           |  |  | 1  |  |   |   |  |  |
| COAST     | Additional people<br>coastal flooding  | n floodig and storms<br>at risk pf<br>each year<br>0 to 3 Aullion                                  |  | About 37% loss<br>of cossial wetlands<br>2 to 15 million |   |   |  |  |
| HEALTH    | Increasing 5<br>Increased morbidity an<br>Changed distribution o                               | orden från mainutritike, diar<br>al mortaligy from heat suaves, i<br>d some chasse vectors         | Rocal, cilvito-respiratory in<br>Rocals and droughts<br>Substanti                            | nd infectious disasses<br>al burden on health service    |   |   |  |  |
| SINGULAR  | Local retreat of ice in<br>Greenland and West<br>Antarctic                                     |  | Long term commitment to<br>metree of sea level rise d<br>sheet loss<br>Ecosyptem changes due | to weakening of the marial                               | Leading to reconfiguration<br>of cost lines world wide and<br>inundation of low-lying areas<br>onal overhuming simulation |   |  |  |
|           | 0  | 1  | 2  | 3  | 4 5   | c |  |  |





# **Conclusions : 1**

Climate change is likely <u>globally</u> to : reduce potential agricultural output in the longer term , and increase risk of hunger.
Adverse effects, <u>regionally and near-term</u>, are likely to be marked in the dry tropics and dry sub-tropics (eg especially in Africa)

# **Conclusions : 2**

- Most serious effects, <u>sub-nationally</u>, will probably be at the social and economic margins (where adaptive capacity is low).
- Early mitigation is needed (with emissions peaking by c.2015) so that adaptive capacity is not exceeded by subsequent large climate changes
- Emissions need to be cut by c. 80% (of 1990 levels) by 2050 to avoid serious damage

# **Conclusions : 3**

- A <u>combination</u> of adaptation and mitigation is necessary.
- Especially adaptation to increase resilience to climate change: a) technology (incl. crop breeding for new climates, eg drought-proofing; rural electrification ), b) management (eg farming systems that use water more efficiently), c) institutions (eg changes to market and tariff structure).
- Many adaptations can be 'win-win' (eg droughtproofing for present weather can increase resilience to effects of a long-term drying trend).

# Adapting agriculture to climate change

- New crop varieties: eg drought and heat resistant crops (either by traditional plant breeding, or genetic modification);
- Irrigation: needs rural electrification (especially in Africa= a Millenium Development Goal)
- Shift of cropping zones: eg northwards in N. Hemisphere (but limited by soils)
- Reform global food system: [today, enough food is produced for all, but still 500m are hungry]

# **Conclusions : 4**

- Need to foster adaptation in most vulnerable regions: the poorest areas, small islands, low-lying coasts, and dry/semi-arid regions.
- Should we concentrate more on non-optimising objectives? eg reducing risk, minimising yield reductions in drought years, developing resilient crop varieties and crop mixes; rather than maximising output.
- Regardless...adaptation is needed now.

# THANK YOU!