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University of Alberta  
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Linking fossil fuel resource development with food security of committed global warming

Dr. Peter Carter  
Environmental health policy
Linking fossil fuel resource development with key social impacts of committed global warming

Dr. Peter Carter
Environmental health policy
petercarter46@shaw.ca

Thank you, ISSRM, for inviting me!
June 2012

Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)

Arctic sea ice extent

18 June 2012

Arctic atmospheric methane
Barrow, Alaska
1900 ppb

Atmospheric methane

800,000 year ice core

CSIRO
Arctic atmospheric methane - Barrow Alaska
18 June 2012
1900 ppb

Upper limit of atmospheric methane over past 800,000 years is 800 ppb

Methane increase since 2007 is due to feedback emissions

CSIRO

800,000 year ice core

Atmospheric methane

Upper limit of atmospheric methane over past 800,000 years is 800 ppb

Methane increase since 2007 is due to feedback emissions

800 ppb

1900 ppb

1900 ppb
Websites for further background

For calculations sources and references
ClimateEmergencyInstitute.com/resources

OnlyZeroCarbon.org

ClimateChange-FoodSecurity.org

ArcticClimateEmergency.com

National Research Council
Climate Stabilization Targets 2010
http://www.nap.edu/openbook.php?record_id=12877&page=R1

IPCC 2007 Technical Summaries
Global climate change implications of food security is a neglected area of research when it should be priority research

OCEAN THERMAL LAG AND COMPARATIVE DYNAMICS OF DAMAGE TO AGRICULTURE FROM GLOBAL WARMING

Darwin C. Hall (2001)

Professor of Economics
Professor of Environmental Science & Policy

California State University
Emerald Group Publishing Limited
10.1016/S1569-3740(01)03018-8

Advances in the Economics of Environmental Resources book series
ISSN: 1569-3740
Series editor(s): Professor Richard Howarth
Why climate change commitment for natural resource managers?

• Our number one natural resource is food.

• Today’s situation on global climate change policy is that there is no limit on global warming and climate change commitment.

• Therefore the only source of possible global climate change mitigation (for mitigating world food losses) is the fossil fuel energy resource sector.

• We need to communicate the essential science to the energy resource sector.
Key Messages

Today's' commitment

Cumulative atmospheric GHGs | GHG emissions

4X Heat

Climate disruption

Extreme weather
Key Messages

• We must approach global climate change today – from today’s committed global warming (not just today’s global average temperature increase).

• Today we are in a committed climate change world food security emergency.
What is global warming commitment?

The future will definitely be a lot hotter than the present due to very long lag times for best mitigation to take effect.

The much greater degree of global warming / climate change will last ‘forever’.
Climate change scientists warn of 4C global temperature rise

The Guardian  29 November 2010
At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases – global from pre-industrial 1 °C.

Al crops decline at 2°C.

IPCC 2007 impacts chart showing impacts of climate change on food and health security
- The two impacts are negatively synergistic
- These impacts increase with temperature

Most vulnerable populations

**Summary for Policymakers**

**Key impacts as a function of increasing global average temperature change**

(Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway)

**FOOD**
- Complex, localised negative impacts on small holders, subsistence farmers and fishers
- Cereal productivity decrease in low latitudes
- Productivity of all cereals decreases in low latitudes

**HEALTH**
- Increasing burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases
- Increased morbidity and mortality from heat waves, floods and droughts

**Global mean annual temperature change relative to pre-industrial (°C)**

Figure SPM.2. Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century [T20.8]. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact.
Today’s global warming commitment

according to our calculation from the climate system science

Global warming commitment by 2100  3.5° C

Eventual full warming commitment after 2100  5.4° C
Combination of ocean heat retention + long atmospheric lifetime of CO2 (20% lasts 1000 years)

"Climate changes that occur because of carbon dioxide increases are expected to persist for thousands of years even if emissions were to be halted at any point in time."

Susan Solomon, Irreversible climate change due to carbon dioxide emissions, PNAS 2009
What is global warming commitment?

“If carbon dioxide equivalent concentrations were to be stabilized at some point in the future, there would be a lock-in to further warming of comparable magnitude to that already occurring at the time of stabilization.”
– National Research Council, Climate Stabilization Targets, 2010

“Models predict that the realized temperature rise at any time is about 50% of the committed temperature rise.”
– IPCC First Assessment Report, 1990
Committed global temperature increase: according to climate system science

Lags or delayed effects

1. Time from slashing emissions to atmospheric GHG & global temperature stabilization

2. Delayed warming from ocean heat lag

3. Deferred warming due to air pollution aerosol cooling

4. Additional warming from feedbacks
What is global warming commitment?

Climate system science
long lag times

Temperature increase
$X2$
takes 100s years

lasts for 1000s of years
Temperature change over preindustrial degrees C

No sign of temperature stabilization

Most stringent IPCC scenario takes 60 years to zero carbon.

Highly optimistic 40 years is another 0.8°C.

40 years or +0.8°C

95% reduction of emissions in 20 years

Source: Climate Interactive IPCC 2007
Note: it takes zero carbon emissions to stabilize atmospheric CO2

Till the policy target is zero carbon there is no limit to warming
Temperature change over preindustrial degrees C

Atmospheric CO2 ppm

CO2 emissions billions tons

95% reduction of emissions in 20 years

Temperature increase at 2100 is committed to almost double after 2100 and to last 1000s years

Source: Climate Interactive IPCC 2007
**3°C Commitment Forever**

**Total long-term commitment**

Today

\[0.8 °C\]

Emissions cut to stabilization

\[+ 0.8 °C\]

\[1.6 °C\]

Ocean lag almost double

\[3.0 °C\]

**Commitment by 2100**

Ocean heat lag

\[0.5 °C\] to 2100

\[2.1 °C\] by 2100

Temperature increase at 2100 is committed to almost double after 2100 and to last 1000s years

95% reduction of emissions in 20 years

Source: Climate Interactive IPCC 2007
Aerosol cooling – large effect

0.9°C (Ramanathan 2008)
Add committed deferred warming due to aerosol cooling 4°C for ever

(It’s a definite commitment because of zero carbon.)

<table>
<thead>
<tr>
<th>Total long-term commitment</th>
<th>Add in deferred warming of aerosol cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Today</strong> 0.8°C</td>
<td></td>
</tr>
<tr>
<td>Emissions cut to stabilization + 0.8°C 1.6°C</td>
<td>3.0 + 0.9°C 3.9°C</td>
</tr>
<tr>
<td>Ocean lag almost double 3.0°C</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Commitment by 2100</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean heat lag 0.5°C 2100 2.1°C by 2100</td>
<td>2.1 + 0.9°C 3.0°C</td>
</tr>
</tbody>
</table>
Add committed warming due to feedbacks

Commitment by 2100

Terrestrial carbon feedback

\[
\begin{align*}
3.0^\circ C \\
+0.5^\circ C \quad (\text{IPCC } 1^\circ C \text{ by 2100}) \\
3.5^\circ C
\end{align*}
\]

Total long-term commitment after 2100

With Arctic feedbacks

\[
\begin{align*}
3.9^\circ C \\
+1.5^\circ C \\
5.4^\circ C
\end{align*}
\]
Committed global temperature increase: current energy economy scenario

Fixed on the worst case high emissions scenario

+2–3°C by 2050
+5.5°C by 2100
+10°C after 2100

CO2 emissions Global average temperature increase

Source: UK Met office 2009
Committed global temperature increase due to climate policy

Combined national United Nations emissions cut pledges assuming all pledges are implemented in full

4.5°C by 2100

Ocean heat lag

Climate system inertia

+8.5°C

Global temperature stabilized

1000 years

Increase in Global Temperature by 2100

Where will proposals from the climate negotiations lead?

Dec 9 proposals goals

Post Durban 2011
UN Climate Conference

Time lags inherent in the Earth’s climate, warming that response to a given increase in the concentration of carbon (transient climate change) reflects only about half the total warming (equilibrium climate change) that would stabilize at the same concentration.

Stabilization Targets National Research Council 2010
Committed global average surface temperature increase (and climate change)

Committed impacts and risks to environmental/population health
Any climate change compromise to the best northern hemisphere food production regions will have immediate, severe effects on the most vulnerable populations – billions of people.

High world foods prices
No food aid
Crop Intensity (NASA)
Committed global average surface temperature increase (and climate change)

Food production losses
Multiple adverse effects of global warming and climate change on crop yields

(only about half are captured by the models)

(omit benefits as they are only “may be moderate” and “brief” – IPCC 2007)
Committed temperature increase from feedbacks

Warming causes more warming

Feeding

Largest positive (bad) climate system feedbacks

– Arctic –

are not in the models
Arctic Climate Feedbacks

Global warming → Melting summer Arctic sea ice and loss of cooling albedo → More warming, etc.

Removing the lid from the top of the planet. Loss of reflective ice cooling ‘albedo’ replaced by dark ocean warming.

100% 85% 7% 93%
Arctic snow and summer sea ice cooling albedo is the air conditioner of the entire northern hemisphere.
Committed global average surface temperature increase

**Feedbacks**
Largest positive (bad) climate system feedbacks
- in the Arctic

**Food production losses**
Multiple adverse effects of global warming and climate change on crop yields
Committed global average surface temperature increase

Feedbacks
Largest Arctic

Food production losses
Multiple adverse effects of global warming and climate change on crop yields

Committed impacts and risks to environmental/population health
Global climate change impacts on crops

- Multiple adverse impacts
- Reduces yields in all regions
- Some regions are affected earlier than others
- As temperatures increase, yields decrease
Any impacts to the least vulnerable regions have severe impacts to most vulnerable populations.

Any climate change compromise to the best northern hemisphere food production regions will have immediate, severe effects on the most vulnerable populations – billions of people.

High world foods prices
No food aid
- Reduces yields in all regions
- Some regions are affected earlier than others
- As temperatures increase, yields decrease
Agricultural yields are expected to decrease for all major cereal crops in all major regions of production, once the global average temperature increases more than 3°C.
Agricultural yields are expected to decrease for all major cereal crops in all major regions of production, once the global average temperature increases more than 3°C by 2100.
Global temperature increase from pre-industrial °C

Worst Affected

NRC Climate Stabilization Targets 2010

Yield change (%)

0 1 2 3 4

Africa Maize
US Maize
India Wheat
Most vulnerable region crops will have declined below baseline by $+1.0^\circ$C with a 30% loss at $+3^\circ$C.
All crops in all regions will have declined below today’s (2000) baseline at a temperature increase above 2.5°C.
Global crop yield is at risk of decline at a global temperature increase of 1.5°C and can accommodate no more than 3°C before beginning to decline (below baseline). – IPCC 2007
Arctic Positive (Bad) Climate Feedbacks
Arctic snow and summer sea ice cooling albedo is the air conditioner of the entire northern hemisphere.
Projected impacts on the northern hemisphere from loss of snow and summer sea ice albedo cooling

Increasing:
- climate variability
- extreme weather events
- drought
Operant Arctic methane feedbacks at +0.8°C

Methane (72 x CO2 over 20 years)
Feedback emissions increase rate of global warming

Warming peat wetlands adding to atmospheric methane
Thawing permafrost
Sea floor methane hydrate
Committed
global temperature increase
according to current world energy
economy scenario
Fixed on the worst case high emissions scenario

Energy Technology Perspectives 2012 excerpt as IEA input to the Clean Energy Ministerial:

“The current trend of increasing emissions is unbroken with no stabilization of GHG [greenhouse gas] concentrations in sight.”

If this continues, “energy use will almost double in 2050, compared with 2009, and total GHG emissions will rise even more.

“Long-term temperature rise (by 2100) is likely to be at least 6°C.”
Committed global temperature increase: current energy economy scenario

Fixed on the worst case high emissions scenario

+2–3°C by 2050
+5.5°C by 2100
+10°C after 2100

CO2 emissions Global average temperature increase
Committed global temperature increase: current world energy economy

Today we’re fixed on IPCC’s ‘worst case’ emissions socio-economic scenario, A1F1

Excludes Arctic methane carbon feedback emissions, which will boost rate of warming faster

UK Met Office 2009 A1F1 scenario

by 2100

+5.5°C/10°F up to 7.2°C/13°F

Ocean heat lag

Worst case IPCC scenario

UK Met Office, 2009

after 2100

10°C/18°F up to ...

7.2°C/13°F

5.5°C/10°F

Global temperature increase °C from preindustrial
Committed global temperature increase: according to climate system science
Committed global temperature increase: according to climate system science

Mean global average increase: 95th %tile probability

Current A1F1 IPCC worst case scenario
Committed global temperature increase: climate science

From emissions cut to stable CO2
0.8°C
1.6°C

Today
0.8°C

Global temperature increase °C from preindustrial
Committed global temperature increase according to the climate science

Ocean heat lag by 2100 (IPCC)
0.5°C  2.1°

From emissions cut to stable CO2
0.8°C  1.6°

Today
0.8°

Global temperature increase °C from preindustrial
Committed global temperature increase according to the climate science

OCEAN HEAT LAG

Full warming from
Ocean heat lag after 2100
1.4°C 3.1°C

Ocean heat lag by 2100 (IPCC)
0.5°C 2.1°C

From emissions cut to stable CO2
0.8°C 1.6°C

Today
0.8°C

Global temperature increase °C from preindustrial
Aerosol cooling: fossil fuel emissions effects on global temperature

**WARMING**
- CO2
- Black carbon soot (air pollution)
- Ground level ozone (air pollution)

**COOLING**
- Aerosols (air pollution)

Increasing with warming

Carbon feedback by green plant toxicity

Solar heat + Fossil fuel combustion pollution → Tropospheric (ground level) ozone: warming

Acid aerosols: cooling

Black carbon (soot): warming

Fossil fuel combustion pollution
Aerosol cooling – large effect

THE POWER OF POLLUTION
Aerosols — tiny particles from pollution, volcanoes, dust and other sources — can reflect or absorb sunlight directly, or seed cloud droplets and brighten clouds. New climate models suggest that aerosols and clouds can have bigger than expected influences.

1. A new model shows the effect of aerosols on climate in the twentieth century. Winds carried aerosols from North America and Europe towards Africa.

2. Brightened clouds along that path cooled the ocean beneath.

3. Cooling could have influenced droughts in Africa and hurricanes in the Atlantic.
Aerosol cooling – large effect

- Normal cloud: Water droplets
- Polluted cloud: Aerosol-seeded water droplets
- Less sunlight reaches Earth’s surface

Sulphate aerosol
Committed global temperature increase according to the climate science

By 2100

Unmasking fossil fuel air pollution aerosol cooling
0.9°C  3.0°

Ocean heat lag by 2100 (IPCC)
0.5°C  2.1°

From emissions cut to stable CO2
0.8°C  1.6°

Today
0.8°

Global temperature increase °C from preindustrial
Committed global temperature increase according to the climate science

Today's emissions scenario by 2100: 5.5°

Global temperature increase °C from preindustrial
Committed global temperature increase according to the climate science

Today’s emissions scenario + Arctic feedbacks: 1.5° to 7.0°

Today’s emissions scenario by 2100: 5.5°

Global temperature increase °C from preindustrial
Committed global temperature increase according to the climate science

Today's emissions scenario by 2100: 5.5°C

Full eventual warming:
- after 2100: 10°C/18°F up to 5.5°C
- Ocean heat lag:

Global temperature increase °C from preindustrial
Committed global temperature increase due to climate policy
Committed global temperature increase by climate policy

Combined national United Nations emissions cut pledges assuming all pledges are implemented in full

4.5°C by 2100
Committed global temperature increase by climate policy

Commitment by 2100

As calculated by Climate Interactive's Climate Scoreboard from the combined national government emissions reductions policy pledges formally submitted to the UN.

+ 4.5 °C by 2100 with a possible range up to 7°C

Ocean heat lag

Climate system inertia

+8.5 °C

Global temperature stabilized

Because of time lags inherent in the Earth's climate, warming that occurs in response to a given increase in the concentration of carbon dioxide ("transient climate change") reflects only about half the eventual total warming ("equilibrium climate change") that would occur for stabilization at the same concentration. Climate Stabilization Targets National Research Council 2010
Eventual full equilibrium temperature increase A1F1 emissions: 10.5°

Full equilibrium temperature increase by national UN pledges: 8.5°

Today’s emissions scenario by 2100: 5.5°

Policy commitment from combined formal UN national proposals by 2100 (Climate Interactive): 4.5°

Today: 0.8°
Committed food productivity losses

Most of the planet uninhabitable due to intolerable heat, humidity and desertification

Most of the human population will not survive.
- Kevin Anderson

40 - 70% crop losses in most regions (IPCC & NRC)

All crops in all regions decline (IPCC, Met Office)
- Depressed yields in most countries (World Bank)
- 50% loss in African regions (IPCC)
- World food at risk, low latitude crops decline (IPCC)
- Northern hemisphere climate disruption / Arctic sea ice albedo loss

Local smallholders, subsistence farmers decline (IPCC)

Increasing extremes of heat, drought, rain and floods causing episodic extreme crop losses.
Eventual full equilibrium temperature increase on today’s emissions scenario (A1F1) 10.5°C

Full equilibrium temperature increase 8.5°C by the combined national proposals formally submitted to the United Nations

Upper probability risk by 2100 from today’s global emissions scenario and from policy commitment 7.0°C

Today’s emissions scenario by 2100 5.5°C

Policy commitment from combined formal UN national proposals by 2100 4.5°C

Lag from emissions cut to CO2 stabilization
Possible increase by 2050
Climate Prediction net, upper range Met Office 3.0°C

Total Climate science commitment 2.4°C
Ramanathan, Feng Avoiding Dangerous...PNAS 2008

Climate system inertia
Arctic sea ice collapse 1.6°C

Today 0.8°C

Committed global temperature increases with losses of food productivity
DROUGHT

Drought is not captured in the climate crop models

Today’s worst case emissions scenario (A1F1)

Global drought A. Dai UCAR 2010

Increasing extremes of heat, drought, rain & floods causing episodic extreme crop losses.
Eventual full equilibrium temperature increase on today’s emissions scenario (A1F1) 10.5°

Full equilibrium temperature increase 8.5° by the combined national proposals formally submitted to the United Nations

Upper probability risk by 2100 from today’s global emissions scenario and from policy commitment 7.0°

Today’s emissions scenario by 2100 5.5°

Policy commitment from combined formal UN national proposals by 2100 4.5°

Climate system inertia (ocean heat lag) almost doubles temperature increase at GHG stabilization 3.0°

Emissions cut to CO2 stabilization. At least 40 years and 0.8°C 1.6°

Today 0.8°

Committed global temperature increases with losses of food productivity AFRICA

40 to 70 % crop losses most regions IPCC NRC

Today’s worst case emissions scenario (A1F1)

All crops all regions decline IPCC, NRC, UK Met Office Extreme world food prices, no food aid

100s of millions more Africans lack water, food IPCC

- Depressed yields most countries World Bank
- 50% loss some African regions (IPCC)
- World food at risk, low latitude crops decline IPCC
- N. hemisphere climate disruption- Arctic albedo

Local small holders, subsistence farmers decline IPCC

10s of millions more Africans lack water, more malaria IPCC

Increasing extremes of heat, drought, rain & floods causing episodic extreme crop losses.
Committed global temperature increases with losses of food productivity AFRICA

Wolfram Schlenker David Lobell 2010
Maize sorghum millet groundnut cassava

Today’s worst case emissions scenario (A1F1)

10s of millions more Africans lack water, more malaria IPCC

Increasing extremes of heat, drought, rain & floods causing episodic extreme crop losses.

Global temperature increase °C from preindustrial
The Big Picture

Eventual full equilibrium temperature increase on today's emissions scenario (A1F1) 10.5°

Full equilibrium temperature increase by national UN pledges 8.5°

Upper probability risk by 2100 from today's global emissions scenario and from policy commitment 7.0°

+1.5° (about) from Arctic feedbacks

Today's emissions scenario by 2100 5.5°

Policy commitment from combined Formal UN national proposals by 2100 4.5°

Unmasking fossil fuel air pollution aerosol cooling 0.9°C 4.0°

Ocean heat lag 0.5 by 2100 (IPCC) 3.1°

From emissions cut to stable CO2 0.8°C 1.6°

Today 0.8°

Committed global temperature increases with losses of food productivity

From results of climate, crop models lacking many adverse impacts and lacking additive impacts

Most of the planet uninhabitable due to intolerable heat humidity and desertification

Most of the human population will not survive Professor Kevin Anderson

40 to 70% crop losses most regions IPCC NRC

All crops all regions decline IPCC, NRC, UK Met Office

- Depressed yields most countries World Bank
- 50% loss some African regions (IPCC)
- World food at risk, low latitude crops decline IPCC
- N. hemisphere climate disruption: Arctic albedo

Local small holders, subsistence farmers decline IPCC

Increasing extremes of heat, drought, rain & floods causing episodic extreme crop losses.

Global temperature increase °C from preindustrial

2000 2020 2040 2060 2080 2100