Sustainability and Climate Change: what is it all about?

An Introduction to a topic everyone should understand

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## It is about history

- We live in truly historic times
- We have sought dominion over the earth for as long as we have been a species

In the last 30 years, we have demonstrably achieved that goal

Images from European Space Agency



## Times have changed

- While all previous generations saw the earth as limitless in some way, all future generations will need to consider planetary limits
- Sustainability is our common goal
- To achieve that goal, we must understand how our planet functions

# Is it surprising that humans are changing the planet?

- Simply put...we are impressive, the biggest cause of change on the planet.
- We have altered the Earth's energy balance *and changed climate*
- We cause 10 times more erosion *than all natural processes*
- We make more fertilizer than all bacteria in the world
- We make more sulfate *than all ocean phytoplankton*
- Our current energy needs equal *all harvestable wind energy in the atmosphere*

#### How is this possible?... the power of the exponential!

#### Population



## Use per capita: the multiplier



Low income: 3.5 times below middle income India, South Asia: 5 times below Denmark China: 1.6 times less than Denmark

The Nasty Dilemma: we want others to live well, but if they do, the energy and resource needs will be staggering

#### It is about a changing world

GLOBAL

CARBON PROJECT



With leap year adjustment in 2012 growth rates are: China 5.6%, USA -4.0%, EU -1.6%, India 7.4%. Source: <u>CDIAC Data</u>; <u>Le Quéré et al 2013</u>; <u>Global Carbon Project 2013</u>

## It is about physics and free will



- Sustainability is inherently an issue of humans and the environment
- Environment operates on physical and chemical principles that are fixed, un-breakable "laws"
  - Affords a degree of predictability (SO<sub>2</sub> becomes acid rain)
- Humans operate with free will, able to set and break laws
  - Much harder to predict
  - We don't like limits

## It is about simple physics



#### Global climate depends on three factors

- 1. How much energy we get from the sun (physical law)
- 2. How much of that energy is reflected back to space by aerosols, ice, etc. (physical law)
- 3. Amount of greenhouse gases (molecular vibrations: physical law; Opera singer breaking a glass)

Greenhouse gases are a natural and important part of the Earth's climate system



- Earth's temperature without greenhouse gases = -18°C
- Too cold for advanced life?
- Earth's temperature with greenhouse gases = +15°C
- ...Cozy...
- Greenhouse gases raise the temperature of the Earth by about 33°C (about 60°F)... and make the planet habitable

## OK, then...



Continences There Free Deres Service

If we add lots of greenhouse gases to the atmosphere (and we have), there will be more energy in the atmosphere, and by definition, climate will change.

*Physical law limitation: "belief" is not an option.* 

## It is about language

Two sets of "natural laws"



- Natural Laws of the second kind, (physical laws) (physics and chemistry): gravity, thermodynamics, frequency of molecular vibrations, etc.
- Natural Laws of the first kind (value laws) (morals and values): good and bad, right and wrong, i.e. murder, stealing, etc.

## Quick comparison

#### Value Laws

- Reasonable disagreement
  on some applications
- Can disobey, have choice
- Can "believe" or "not believe" in the core principle of the law.
- Word "law" is applicable in modern context

#### **Physical Laws**

- Universal agreement, arguments very esoteric
- No choice but to obey
- Belief is not a concept that applies
- Word "law" is misapplied

## Contronyms

- Rock: An immobile mass of stone, or a shaking or unsettling movement or action
- Left: Remained, or departed
- Fix: To repair, or to castrate

It is about values: Our children

We live on a water planet

90% of the extra heat in the atmosphere from GHGs goes to warm the ocean

- It takes time to heat up the water
- The impacts come after the causes by 50 years or more

#### Physics, values and a water planet



 Until one generation is willing to forego short term gains for the long term benefit of its children, we won't be able to address climate change.

#### It is about Math: Coal Lifetime: 500 yrs, no growth in use



#### Coal Lifetime: 500 yrs, growth in use



#### It is about NOW

#### Arctic Sea Ice



## Ice melt in water is highly non-linear



## It is about the future: The long, slow retreat of sea level rise

Perhaps the most inevitable result of a warmer planet

- Warmer ocean expands
- Warmer water and air melt land ice

Miami Beach "sunny day flooding"



### It is normal on earth to trade sea water for land ice... very simple physics



Note the scale!!!



## The surprising reality of sea level change

Credit: PBS: Extremelce

The dynamic range of sea level change is difficult for people to grasp.

Over 500 feet of ocean is traded for land ice and vice versa

Major glaciations (20,000 years ago) = 400 feet lowering

Melt Greenland and Antarctica = 170 feet higher



#### "Deep time" sea level and temperature: Ultimate SLR



FIGURE 17. Covariation of sea level with global average temperature in the geologic past, compared with the IPCC forecast for sea level rise by the year 2100.

**David Archer** 

#### "Deep time" sea level and temperature: Ultimate SLR



~14 m is the sea water stored in West Antarctica and Greenland

Foster and Rohling, PNAS

#### What does ~13 meters of sea level rise look like?



#### All maps: Flood.firetree.net

#### What does 13 meters of sea level rise look like?



#### What does 20 meters (65 feet) of sea level rise look like?



#### What does 20 meters (65 feet) of sea level rise look like?





## It is about communication

Chomp This!: A Few Things Every Georgia Fan Should Know About Florida

The USGS predicts that if the ice caps were to melt completely, sea level would rise by approximately 80m. If we can get the polar ice caps to melt only halfway, sea level will rise 40m and the face of the Earth will change forever.



From Dawgsports.com

Ahhh... that's so much better.

Now is the time Georgia fans! Trade in those efficient vehicles for a gas guzzler. Spray some aerosol. Burn as much coal as possible. We can make Florida a thing of the past!!!

#### It is about more than climate change: Unsustainable groundwater

Trends in groundwater storage: 2002-2010 GRACE



Famiglietti et al., 2012

#### It is about solutions

How about an energy policy? How about a water policy? How about a food policy? How about a sustainability policy???



## It is about us



#### My 3 simple rules of sustainability:

- 1. Everything must cycle
- 2. Population must be controlled (equality of the sexes), and vary inversely with resource use per capita
- 3. Equity must be considered and acted upon