AFRICA
IAHR 2022 Online Summer School

CLIMATE CHANGE ADAPTATION

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State of the Science

Our Common Challenges

Coastal Adaptation

Selected Resources and Opportunities to Network
carlsagandotcom
https://www.youtube.com/watch?v=kjtuVvfRhHs
The Twin Crises: Climate Change and Loss of Biodiversity

Crisis:
Society pulls together to seek solutions
COVID-19, Ukraine

Predicament (a wicked problem):
Society divided on solutions
Who is responsible for identifying and implementing solutions?

Douglas Tomkins
1943-2015
World Scientists’ Warning of a Climate Emergency

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, PHOEBE BARNARD, WILLIAM R. MOOMAW, AND 11,258 SCIENTIST SIGNATORIES FROM 153 COUNTRIES (LIST IN SUPPLEMENTAL FILE S1)

Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to “tell it like it is.” On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.

Exactly 40 years ago, scientists from 50 nations met at the First World Conference on the Environment and Development in Stockholm to describe the effects of human activity on the environment. They warned of a “tipping point” that would lead to “irreversible changes” if the rate of environmental degradation continued unchecked. The dangers of such an outcome were especially pronounced in the context of global warming and climate change.

In the years since, we have seen the “tipping point” crossed and the consequences of those warnings become all too clear. The Science and Skepticism sections in this special issue of BioScience highlight the rapid pace of climate change and the sensitivity of the planet’s ecosystems to human activity.

As actual climatic impacts (figure 2). We use only relevant data sets that are clear, understandable, systematically collected for at least the last 5 years, and updated at least annually.

The climate crisis is closely linked to excessive consumption of the wealthy lifestyle. The most affluent countries are mainly responsible for the historical GHG emissions and generally have the greatest per capita emissions (table S1). In the recent article, our forest loss in Brazil’s Amazon has now started to increase again (figure 1g). Consumption of solar and wind energy has increased 373% per decade, but in 2018, it was still 28 times smaller than fossil fuel consumption (combined gas, coal, oil; figure 1h). As of 2018, approximately 14.0% of global GHG emissions were covered by carbon pricing (figure 1m), but the global emissions-weighted average price of carbon declined...
Stationarity is Dead

Cause of Global Warming

The Greenhouse Effect

IAHR.org
Emissions of Greenhouse Gases Continue to Rise
Global Temperatures Continue to Rise

[Graph showing global average temperature over time from 1880 to 2020, with a trend line indicating a consistent rise.]
Accuracy of Global Warming Predictions

10 of 17 forecasts from 1970-2001 showed no statistical difference between observations and predictions.

5 of 7 – corrected for actual pollutants gave accurate predictions.

New knowledge of physics explains discrepancies.

Even 50-year-old climate models correctly predicted global warming.

By Warren Cornwall | Science Dec. 4, 2019
Polar Jet Stream meanders & moves

Summer

Winter

Warm Ridge

Cool Trough

Meandering “Rossby Waves”
Negative PDO

“Ridiculously Resilient Ridge”

Negative NAO

Jan. 2014
The United Nations Intergovernmental Panel on Climate Change (IPCC) released the Physical Science Basis Report (PSB Report) Sixth Assessment in August 2021.

234 contributing authors synthesizing more than 14,000 scientific references.

- *It is unequivocal that human influence has warmed the atmosphere, ocean, and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred.* [Finding A.1]

- *Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events.* [Finding B.3]
• Things are worse than projected or understood.
  
  *40% of world population is highly vulnerable*

• Loss and damages are real and significant. *Who pays?*

• Technology is not a magic fix.
  
  *Example: machines for direct carbon capture may emit a good % of the extracted carbon*

• Cities offer opportunity. Smart cities, transportation in high density population areas can have big benefits

• **The time for action is now.**
  
  We can still avoid the worst effects if concerted and significant action is taken now

Political and Agency Leadership

The evidence detailed by IPCC is a code red for humanity:

An atlas of human suffering and a damning indictment of failed climate leadership.

- Nearly half of humanity is living in the danger zone – now.
- Many ecosystems are at the point of no return – now.
- Unchecked carbon pollution is forcing the world’s most vulnerable on a frog march to destruction – now.”

UN Secretary-General António Guterres
August 9, 2021
G20 Countries

75% Global Greenhouse Gas Emissions

For a 67% chance of limiting global warming to 1.5°C it is necessary to limit carbon emissions to 400 GtCO₂

This is 10 years of emissions at 2020 levels

Current National Determined Contribution (NDC) Targets will result in 2.7°C increase in global temperature by 2100.

In 2020, under COVID, the world saw a 6% reduction in GHG emissions over 2019 levels but an increase in 2021.
Joint Statement:
The United States and China are committed to cooperating with each other and with other countries to tackle the climate crisis, which must be addressed with the seriousness and urgency that it demands.

April 17, 2021 and November 10, 2021
President Xi Jinping and President Biden
Conference of Parties (COP26) Goals

1. Secure global net zero by mid century - keep 1.5°C within reach
2. Adapt to protect communities and natural habitats
3. Mobilize finance. - **EQUITY. Countries most affected did least to cause problem**
4. Work together to deliver
Climate Tipping Points

Global
Greenland Ice Sheet Collapse
West Antarctic Ice Sheet Collapse
Amazon Rainforest dieback
Boreal Permafrost Collapse
Atlantic Circulation Collapse
Arctic Winter Ice Sheet Collapse
East Antarctic Ice Sheet Collapse
Low Latitude Coral Reef Die-offs

Regional
Boreal Permafrost abrupt thaw
Mountain Glacier loss
Sahel and W. Africa Monsoon (greening)
Southern Boreal Forest dieback
Northern Boreal Forest expansion

Armstrong McKay et al., Science. September 9, 2022
Zhengzhou, China 22nd July 2021

Erfstadt-Blessam, Germany 16th July 2021

Vancouver, Canada November 20, 2021

24th March 2022

Heat Dome: 24th July 2021
Sindh Province
Pakistan
August 2022
NASA Earth Observatory
https://earthobservatory.nasa.gov/
NOAA: US Billion-Dollar Climate and Weather Disasters
www.climate.gov
Common Myths on Social Media

• Global warming is a result of fluctuations in the sun’s energy
• The sun’s energy goes through cycles [True]

BUT:

• A weaker phase in the sun’s energy is expected to cause a 0.1-0.2°C change later this century
• Entire atmosphere is affected by sun’s fluctuations
• The stratosphere (closest to the sun is cooling)
• Atmosphere closest to the earth is warming (heat normally released to stratosphere is trapped)
Common Myths on Social Media

• Global warming is a good thing

• Extreme cold weather kills more people than extreme warm weather (True – through 2019)

But:

• Heat deaths are projected to increase (example: 2021 Heat Dome North America)
• More extreme flooding, droughts, famine
• Low-lying countries like the Maldives face extinction
Common Myths on Social Media

• Climate change action will result in a decline in standard of living. Fossil fuels are essential for economic growth
• Industrial revolution – enabled society to manufacture and innovate [True]

BUT:
• Renewable electricity is now cheaper than coal, oil and gas in some regions. Innovations in energy storage are emerging.
• Global economy could shrink by 18% due to natural disasters and more extreme temperatures if no significant changes by 2050
• University of Oxford paper, September 2022

Poorest communities and countries are the most vulnerable
Transition to Green Energy

- Oil & gas costs have not changed much when adjusted for inflation
- Renewables cost is decreasing
- Fossil fuel to green energy could save $12 trillion by 2050


Photo credit: Jane Thomas, Integration and Application Network (ian.umces.edu/media-library)
Managing our Environment for the Future

‘Drivers of complexity’ will include:

- Climate Change
- Population Growth
- Land Use Change
- Relative Sea Level Rise
- Catastrophic Events in Stressed Eco-Systems (floods, earthquakes, droughts, contaminant spills)
- Invasive Species
- Emerging contaminants
California Precipitation and Population
San Francisco Bay Delta
The Water Problems facing California

→ 2/3 of California residents rely on Delta water
→ Irrigates up to 4 million acres of California farmland

→ 80% of California's commercial fishery species rely on the Bay-Delta
→ Habitat for 700 species, including 50+ threatened or endangered
→ Hotspot for biodiversity
→ Greatest loss of biodiversity
Delta Inflows

- Sacramento River: ~ 80% inflow, good quality
- San Joaquin River: ~ 5% inflow, good quality
- East Side Rivers: ~ 5% inflow, good quality
- Tidal Flows: High salinity
Land Subsidence
Due to farming, erosion & peat soil oxidation

Feet Below Sea Level
-25 ft
-20 ft
-15 ft
-5 ft
Delta Levees

Prone to failures due to

Earthquakes
Seepage
Flood
Wave overtopping
Burrowing animals
6.5 Magnitude Earthquake
causing 20-Island Failure

Simulations courtesy of Dr. John DeGeorge

RMA Salinity Modeling

0 – 6 hours: Islands flood with fresh water
12 – 24 hours: Salt water intruding into Delta

Simulations courtesy of Dr. John DeGeorge
6.5 Magnitude Earthquake
causing 20-Island Failure

Simulations courtesy of Dr. John DeGeorge

1 – 7 days: Salt water throughout Delta
6.5 Magnitude Earthquake
causing 20-Island Failure

Simulations courtesy of Dr. John DeGeorge

RMA Salinity Modeling

30 days: A saline estuary
Extreme Precipitation and Variability in Precipitation

Ralph & Dettinger, BAMS, 2012
A Collapse in Delta Smelt

There are many other endangered species – many have conflicting needs (seasonally and spatially). Who decides?
• Drought of 2012-16
• Snowpack: one third of the historic lowest ever recorded
• 2015 allocation to urban users – 25%
• 2014 and 2015 allocation to agriculture through Central Valley Project - 0%
• Groundwater deficit in past decade: 45+ km$^3$
2012-16 Drought: Groundwater storage depletion and subsidence in the California Central Valley

Source: USGS, 2016
"Coequal goals' means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place." (California Water Code §85054).
Delta Science Program
[Established by the Delta Reform Act]

Mission: To provide the best possible, unbiased scientific information for water and environmental decision-making in the Bay-Delta system

- Support and facilitate research
- Synthesize scientific information
- Facilitate independent peer review
- Coordinate science
- Communicate science
Even the simple questions are complex!

What do we mean by natural flows in such a complex and irreversibly altered system?

Restoration to Managing for Novel Ecosystems

We need to understand "novel ecosystems" that sustain critical functions under conditions that are now irreversibly different from how species evolved.

Resilient or sustainable ecosystems are not necessarily desirable ecosystems.

Peter B. Moyle, 2016
A Restoration Success Story – the Napa River Basin

California

www.freeworldworldmaps.net
27 major floods in past 120 years
County Courthouse, Napa - 1896
The Napa Living River Strategy

- 55 Miles from San Francisco Bay to Calistoga
- 450 square mile watershed
- A navigable estuary to the City of Napa
- 6.9 mile Project
COMMUNITY COALITION FORMED

27 local stakeholder groups and 24 agencies
Creation of 659 acres of wetland, mudflat and open water
NAPA RIVER BYPASS

- Railroad relocation including two bridges
- Flood walls and trails
- Bypass channel
- Terracing
- Flood wall & promenade
NAPA RIVER BYPASS

Railroad relocation including two bridges

Flood walls and trails

Bypass channel

Flood wall & promenade

Terracing
NAPA RIVER BANK BEFORE PROJECT

NAPA RIVER BANK AFTER

Napa Floodplain Restored
California Drought 2012-16

2017 Wettest Winter in Recorded History with no flooding in Napa

Very dry summer

Fundamental Question:  Will the ecosystem recover or was the fire a tipping point?

Photo Source: Atlantic Monthly, Getty Images
Sea Level Rise in Chesapeake Bay

Projections in this 2018 report.

2008: 1.5’ – 4.2’

2013: 2100: 4.2’ – 7.9’

Projections with more rapid ice loss.
High Tide in Dorchester County
Source: Hightidedorchester.org
Health Consequences in Maryland

Projected change in negative health outcomes by 2040 during extreme heat events in Maryland during summer months:

<table>
<thead>
<tr>
<th>Health Outcome</th>
<th>% Increase 2010-2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella* infection</td>
<td>28%</td>
</tr>
<tr>
<td>Hospitalization for heart attack</td>
<td>68%</td>
</tr>
<tr>
<td>Hospitalization for asthma</td>
<td>136%</td>
</tr>
</tbody>
</table>
Ecological engineering is defined as the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both.  

*Mitsch, 2012*  
(www.ecoeng.org)

Engineering with Nature  
(https://ewn.erdc.dren.mil)

Nature-Based Solutions  
(https://www.iahr.org/index/detail/414)
Carbon Sequestration and Tidal Wetlands

Stephen Crooks PhD
Silvestrum Climate Associates
Principal: Wetland Science & Coastal Management
Blue Carbon

Blue Carbon is defined as the carbon accumulating in vegetated, tidally influenced ecosystems such as tidal forests, tidal marshes and intertidal to subtidal seagrass meadows (International Blue Carbon Working Group, 2015).

Blue Carbon Ecosystems (BCEs) are defined as coastal wetland ecosystems with manageable and atmospherically significant carbon stocks and fluxes (Windham-Myers et al., 2019).
Building Blue Carbon Experience
Blue Carbon: Multiple Benefits

Benefits include:
  Carbon sequestration
  Coastal resilience
    - risk reduction to homes and infrastructure
    - wetland and ecosystem function
    - adaptation [time]
  Water quality
  Recreation
  Aesthetics – living shorelines
  Agriculture

Multiple benefits = multiple funding sources
Developing the Learning Curve

1. Recognize value of wetland management
2. Establish examples of good practice
3. Achieve multi-use functional landscape
4. Adaptation to climate change
5. Incorporate GHG fluxes and storage

Blue Carbon Interventions:
- Policy adjustment
- Management actions
- Carbon finance projects
Poplar Island and Mid-Bay Islands
Maryland Dredge Material Management Program
Poplar Island Expansion
Coastal Wetlands and Sea-level Rise

Depends on:
- relative sea-level rise
- tidal hydrology
- sediment supply

Practical limits?
The Baylands and Climate Change: WHAT WE CAN DO

LETITIA GRENIER
SAN FRANCISCO ESTUARY INSTITUTE

Email: letitia@sfei.org
Tel: +1-510-875-5723
BAYLANDS GOALS 2015

• Science synthesis

• Effect of future change, especially climate and sediment supply, on the Baylands

• Goal is healthy ecosystem, providing a resilient shore for people and wildlife

• Recommendations and landscape visions for the next century
WHAT WE CAN DO

- Restore complete systems, including processes
- Restore soon, in areas marshes are likely to persist
- Plan for the Baylands to migrate
Build up of sediment and vegetation takes time

Higher starting elevation means marshes survive sea-level rise for longer
PLAN FOR THE BAYLANDS TO migrate
PLAN FOR THE BAYLANDS TO migrate
PLAN FOR THE BAYLANDS TO migrate
Novato Creek Baylands Long-term Vision

- Convert Hwy and RR into an elevated causeway
- Remove levees and re-establish tidal marsh
- Create a depositional marsh plain
- Re-establish upland transition zones
- Re-establish marsh ponds
- Coordinate with existing projects
WE HAVE choices to make
Adaptive Management

Example from Delta Stewardship Council, California
We are drowning in information, but starving for wisdom. The world will henceforth be run by synthesizers, people able to put the right information at the right time, think critically and make important decisions wisely.

E. O Wilson, 1978
This is the decade for action

• Opportunity to transition from a predicament to a crisis
• No magic bullet to solve the challenge
• No single entity will solve the challenge
• Innovation partnerships that are built on principles of economic outcomes, a just and equitable transition and engagement with marginalized social and business sectors
• Opportunities for win-win-win actions
• International Collaboration – professional communities such as IAHR

Thank you for your attention.