AAAS Annual Meeting 2019 – Science Transcending Boundaries

Hackathon for Science Policy

Theme: Living with Environmental Change

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Introduction

The team observed nine meeting sessions addressing the theme *Living with Environmental Change*. From these sessions, they pulled together results and ideas that have the potential to enhance or impact policy.

The presentations covered multiple perspectives of *Living with Environmental Change*. In this summary, the sessions are identified by their titles in the AAAS conference program and grouped into three focus areas.

- *Climate Change Impacts* applies current natural and social scientific knowledge of the Earth system to the study of climate change impacts.
- *Climate Change Technology and Policy* builds on a scientific framework of the Earth system to suggest actions to address climate change.
- *Stakeholder Engagement* highlights the importance of working with affected populations for sustainable development.

Climate Change Impacts

Climate Impacts Analysis: Integrating Scientific Disciplines

Speakers:

Katja Frieler, Potsdam Institute for Climate Impact Research, Germany
Juan-Carlos Ciscar, Joint Research Center for the European Commission, Spain
Jim McFarland, US Environmental Protection Agency

This session's theme is the improvement in the economic analysis of the impacts of climate change on major sectors. The studies connect biophysical and social impacts across Europe and the United States. The methodology shows the effects of different scenarios of greenhouse gas emissions to reveal the consequences of reducing global greenhouse gas emissions in this century.

The 2015 Paris Agreement on climate change provides international policy context. In the United States, a key report is 2015 Climate Impacts and Risk Analysis (CIRA) that led to work in the Fourth National Climate Assessment (NCA4).

In general, the goals are to understand the most important economic impacts and their regional patterns and to understand the effect of reducing greenhouse gas emissions with a focus on limiting the global rise in temperature to 2 degrees Celsius. In addition, climate impacts outside the region of primary interest can have economic effects (estimated possible 20% in losses in Europe from global transboundary effects). Large impacts bring attention to climate change mitigation and adaptation policies. Improved economic analyses of climate change can better support policy development.

Several policy priorities were raised in the presentations and the discussion.

1. Improve communication strategies to convey the importance to policymakers, including better attribution of events to climate change, analysis of impacts at a local scale (county-level in the United States), and more community engagement.
2. Enhance adaptation and resilience strategies without delay.
3. Examine how attribution of climate change might lead to the possibility of legal liability for damages in insurance markets.
4. Examine the role of businesses in managing climate risk.
5. Examine the role of individual actions in addressing climate risk.
6. Examine losses that are not reflected in economic impacts (such as enjoyment of recreational fishing, significant cultural locations on tribal lands).

Climate Change: Understanding Feedback from Nature, Culture and Society

Speakers:

Thomas Crowther, ETH Zürich
Laura Duncanson, University of Maryland, NASA Goddard
Matto Mildenberger, University of California, Santa Barbara

The influence of Earth's changing climate by and on human behavior is a growing field of study. Moreover, modeling and data visualization techniques to elucidate such feedback mechanisms have become increasingly important in understanding the complex impacts of human behavior on climate change and climate change on human behavior. In this symposium hosted by the ETH University in Zurich, Switzerland, scientists shared how mapping of ecological, technological, and political data is beginning to illuminate gaps in knowledge on climate change impacts.

Dr. Thomas Crowther from ETH Zurich began the discussion by presenting his research using fundamental ecological approaches to develop large scale models of how climate change affects atmospheric carbon composition. Much of his work focuses on the ecology below the Earth's soil, such as carbon load and microorganism density. He combines these studies with analysis of an international soil biodiversity database to create a global map of how below-ground species determine soil fertility and contribute to the feedbacks determining atmospheric carbon composition. Ecology, he argues, is the best mechanism by which to address uncertainty in many climate models because understanding the organisms on the planet helps us understand the impacts of an altered carbon cycle.

Dr. Laura Duncanson next discussed her work imaging forest canopies from space to better understand how above-ground ecology contributes to climate feedbacks. Because forests account for a large portion of the global carbon budget, and forest management is an easily controllable human-mitigated intervention strategy, her work at NASA utilizes data collected from two satellites, the GEDI docked on the International Space Station and the ICESat-2 orbiting the poles, to create 3D images of the world's forests in real-time. In this way, Duncanson and her team can begin to understand how deforestation and forest management contribute to carbon release into the atmosphere.

Dr. Matto Mildenberger concluded with a discussion around the human element in climate change feedbacks in terms of beliefs, risk perceptions, and policy preferences. He and his research team have used data collected about people's perceptions related to climate science and policies and mapped these to their corresponding congressional district. Through a series of maps, his team has visualized where the majority of constituents stand on a particular issue in either predominantly Democratic or Republican districts. Despite the polarized partisan rhetoric of the national news cycle, he found that there was a majority belief that climate change is happening even in very Republican districts. These same Republican districts also saw a majority of people willing to prioritize the environment over the economy. When asked if climate change had impacted their lives personally, however, these districts overwhelming did *not* believe this to be true. Mildenberger pointed out that voting patterns have remained the same in these districts, indicating a disconnect between belief and policy preference for Republican voters. His analyses offer nuance to the nationally reported data and have implications for a more targeted approach for political action networks aiming to influence these districts.

Health Beyond Humanity: A Planetary Perspective On Our Past and Future

Speaker:

Sabrina Sholts, National Museum of Natural History, Smithsonian Institution

Dr. Sabrina Sholts works at the intersection of human, animal, and environmental health. An anthropologist by training, she has contributed to an array of studies investigating issues such as the microbiome health of animals in captivity, the effect of environmental contaminants on neurological function in humans, and the persistence of endocrine disrupters in marine ecosystems.

Disease and stress are indicators of environmental health. For example, Dr. Sholts's early research on animals in captivity showed that primates in zoos often develop bone diseases such as rickets as well as dental anomalies. Additionally, captivity alters the primate microbiome in such a way that experts have paralleled it to humans living in highly industrialized areas. In other words, captivity "humanizes" the primate microbiome.

Dr. Sholts continued investigating the connections between environment and health through a series of studies on microplastics and environmental toxins. Despite being banned in the 1970's, the endocrine disrupter PCB continues to bioaccumulate in the fatty tissues of marine animals. Because this compound does not degrade naturally, its persistence has far-reaching, adverse effects from ecosystem loss to human health consequences.

At the root of Dr. Sholts's extremely interdisciplinary work is the "Total Environment" concept coined by bacteriologist and environmentalist, Rene Dubos. This approach emphasizes the connection between human caused environmental impacts and subsequent global health impacts. Through this lens, she views climate change as an issue of planetary health and disease. For example, elevated carbon dioxide levels due to climate change can alter the nutritional profile of wheat, barley, and other crops, decreasing their endogenous levels of zinc and iron. In countries in which these crops are the primary source of such minerals, the potential effect of climate change on food safety will be particularly damaging.

Dr. Sholts is also the curator of the Smithsonian's current *Outbreak* exhibit, an interactive exhibit emphasizing global disease epidemics and a "One Health" approach to address environmental, animal, and human health. This exhibit also highlights the range of scientists including anthropologists, biologists, computer scientists, environmentalists, and many others currently working to address these complicated issues. In this way, museum patrons not only learn about the complex ways that humans, animals, and environment influence one another, but also about the interdisciplinary nature of solving global issues.

Climate Change Technology and Policy

Climate Change 2019: Finding the Accelerator Pedal

Speaker:

Christopher B. Field, Stanford Woods Institute for the Environment

Dr. Christopher Field began this topical lecture with a warning: without seriously addressing the growing impact of the Earth's changing climate, we risk crossing a threshold beyond which human mitigation actions will have no effect. As a working group co-chair on the Intergovernmental Panel on Climate Change, he and others have urged the global community to limit warming of the Earth to 1.5 degrees Celsius by restricting total carbon emissions between now and the end of the century. If for example, the permafrost of the Arctic melted due to an increase beyond this 1.5 degrees C, the subsequent massive release of carbon into the biosphere would drive the system into a state in which human intervention no longer matters.

To address this pressing climate challenge, Dr. Field presented five key areas in which the global community can find the "accelerator pedal" to prevent the breach of such a threshold:

1. Make climate change a global priority.

Dr. Field presented evidence that climate change affects aspects of human well-being from economic stability and national security to violence and rising ocean acidity. In particular, these effects will endanger regions of the world that are already vulnerable to such aspects, such as Sub-Saharan Africa and Southeast Asia. It is therefore critical that leaders in the developed world utilize their economic and technological tools to support the developing world in addressing this crisis.

2. Unleash creativity.

Solving the climate challenge will require a multi-actor approach. No single technology will hold the answer, but rather, a broad portfolio of approaches focused on behavioral technologies is needed. Some examples include decreasing agricultural emissions by producing meat replacements like the "impossible burger," nuclear energy options, and solar radiation management strategies.

3. Pursue multiple policy options.

A carbon tax is often proposed as a policy measure that could reduce emissions. Field advocates for an active marketplace of ideas, which could include such a policy, but could also include alternative initiatives or combinations of initiatives. He also emphasized the promising role of non-government actors. Increasingly, green initiatives are being launched by major corporations like Walmart, state governments who pledge to meet the commitments outlined in the 2015 Paris agreement, and individuals from universities and community organizations dedicated to doing what they can to decrease their own carbon footprint.

4. Manage adaptively and redesign solutions.

Importantly, Field highlights the importance of adapting human behavior to this new climate reality. Changing infrastructure, developing common-sense insurance policies, creating faster and more accurate warning systems, building protective structures in some areas, and relocation of communities in direct danger are all examples of "activity switching" that Field proposed as simple forms of human adaptation.

5. Recognize opportunity.

Finally, Field argues that we need to change the issue of climate change from being viewed as a burden to that of an opportunity. By developing solutions that are consumer-driven, companies have the capability of transforming energy technologies that are not only good for the environment, but good for their pocketbooks. For example, when electric vehicles are cheaper and more efficient than less sustainable options, consumer demand will drive the market into creating even more green solutions.

Carbon Dioxide Utilization (CCU): An Opportunity to Tackle Climate Change

Speakers:

Katy Armstrong, CO2Chem Network
André Bardow, Aachen University
Shelie Miller, University of Michigan

In the context of climate change, most people think of CO_2 as a waste product. A growing body of research, however, is demonstrating that CO_2 emitted by fossil fuel burning and other industrial processes could be a useful ingredient in other manufacturing processes. Waste CO_2 could provide a feedstock for liquid fuels, fertilizers, carbon fibers, cement, and potentially many other products. The process, known as carbon capture and utilization (CCU), could contribute to efforts to stem the rise in the atmospheric CO_2 concentration, although for most CCU applications, significant cost and feasibility obstacles need to be addressed.

The fundamental challenge of CCU is the stability of the CO_2 molecule; converting CO_2 into most other carbon-based molecules requires large inputs of energy. If that energy does not come from renewable

sources, the climate impact of a CCU product will be no better, or possibly even worse, than the equivalent non-CCU product. Additionally, because the product created with captured waste CO_2 may itself be combusted within a few years (or less) of its production, a full product life cycle analysis is required. For example, Dr. André Bardow presented research on polymer production using captured CO_2, which can save 3 kilograms of CO_2 emissions for every 1 kilogram of CO_2 used.

Dr. Shelie Miller presented contrasting case studies representing strong and weak potential for CCU applications. Methanol production with CCU, involving the hydrolysis of water to produce hydrogen gas, would require so much energy that scaling up with renewable energy sources would be very challenging. In contrast, utilizing CCU to produce cement is quite feasible at industrial scales, and engineered cement composite with CCU is already cost-competitive with traditional cement products. Katy Armstrong noted that certain industries will be extremely difficult to transition to renewable energy sources in the near future. In particular, for aviation and shipping fuels and cement production, CCU could play an important role in reducing CO_2 emissions.

The keys to effectively implementing CCU for climate mitigation are (1) identifying the most appropriate applications for a particular product and CO_2 source, and (2) developing standard methodologies for CCU product lifecycle analysis. Life cycle analysis methodologies will be especially important for climate policies addressing CCU, so that the CO_2 emissions impact of any given CCU product can be quantified reliably and transparently.

Extreme Event Attribution in the Context of Climate Change

Speakers:

Claudia Tebaldi, National Center for Atmospheric Research
Alexis Hannart, Ouranos
Richard Smith, University of North Carolina

In recent years, media coverage of extreme weather events—hurricanes, heat waves, floods, and the like which cause significant physical and societal damages—often includes a debate over whether the event was "caused by" climate change. The answer, of course, is never so simple. But the field of attribution science has advanced to the point that, in 2016, the National Academies of Sciences, Engineering, and Medicine found that the notion that particular extreme events cannot be attributed to climate change "is no longer true as an unqualified blanket statement." In many cases, scientists can make rigorous quantitative analyses to determine how much more or less likely a particular storm or type of storm would be with and without anthropogenic climate change, and how this likelihood is expected to change under future climate scenarios. Climate attribution studies have demonstrated value both for communicating climate change impacts to the public and for identifying gaps in key climate data collection and modeling capabilities.

Dr. Alexis Hannart presented attribution findings for winter storms, such as the especially cold, snowy Nor'easter that affected southern Quebec, Canada, in January 2019. Dr. Hannart's analysis found that climate change may be causing an increased probability of colder, snowier storms like this one; however, regional variability and inconsistencies between models mean that additional research is needed for more conclusive answers. In contrast, Hurricane Harvey, which brought devastating flooding to the Texas Gulf

Coast in August 2017, has a much clearer link to climate change. Dr. Richard Smith presented a statistical analysis demonstrating how anomalous the rainfall associated with Hurricane Harvey was for the Gulf of Mexico region. Dr. Smith's studies found that Hurricane Harvey was about twice as likely to occur under present atmospheric CO_2 and sea surface temperature conditions as under pre-industrial conditions, and that the chances of such a storm increase significantly under future warming scenarios. Without significant changes to current fossil fuel emission trajectories, Smith found that a storm like Hurricane Harvey would be about sixteen times more likely by 2080.

Scientific studies such as these typically move too slowly to respond to the media attention surrounding a single extreme weather event. Dr. Claudia Tebaldi described how the World Weather Attribution Group is bridging this gap by developing a framework for rapidly assessing whether a particular weather event was more or less likely given anthropogenic climate change. If adequate data and models are available, the group can make a determination in a matter of days. This allows researchers to provide quantitative information to the public and policymakers while the event is still prominent in the public consciousness.

The rapid response and traditional research approaches are parallel efforts for understanding the impact of climate change on extreme weather events. Rapid analyses are especially critical for increasing public awareness of the impacts of climate change that are already underway. The speakers in this session also noted that attribution studies may eventually be used in climate change lawsuits by linking CO_2 emissions to the climate contribution attributed to damages caused by a particular weather event.

Stakeholder Engagement

Sustainability Science and Public Engagement: Involving Land Owners in Research

Speakers:

Sally Koerner, University of North Carolina
Kate Tully, University of Maryland
Amy Johnson, Virginia Working Landscapes

Farms, rangelands, and other human-managed landscapes provide ecosystem services in unique ways compared to wild landscapes, and constitute a large swath of habitable land on Earth. However, since much of this land is under private ownership, it is not easily accessible to ecological researchers. Scientists who study such ecosystems must engage with a variety of stakeholders, including the land owner and many other local community groups such as farmer cooperatives, agricultural extension specialists, citizen scientists, and environmental organizations. This session presented numerous case studies of researchers designing studies around stakeholder engagement in order to study managed ecosystems around the world.

The presenters in this session offered different lenses on the challenges and opportunities of working with a broad range of stakeholders. Successful partnerships depend on shared goals, which need to be identified at the outset of a study. After surveying their stakeholders, Dr. Sally Koerner's research team discovered that the questions they had intended to address with their study of drought resilience on grazed grasslands in Montana and Wyoming were not quite the same as the questions that the local ranching

community was most interested in. Adjusting the study design early on was an important step in making the research relevant for the stakeholders they were intending to support.

Conducting research on private lands also requires researchers to share results with stakeholders in ways that are more timely and relevant than a journal article. Dr. Amy Johnson described how Virginia Working Landscapes regularly provides land owners with farm-specific bird species survey reports, which inspires some land owners to engage in friendly competition over who has the most biodiverse property. Dr. Kate Tully's research on fertilizer practices in Kenya and Tanzania demonstrated the importance of providing tangible benefits to stakeholders. The team worked to build capacity among local researchers to support education and skills development in the local community.

Working with so many different non-researchers has challenges, but it's also an opportunity to advance ecosystem science while engaging with a broad range of local community members. While these studies focused on terrestrial ecosystems, the lessons learned also apply to managed water systems such as aquaculture operations. This session highlighted key recommendations for effectively engaging with land owners:

- Listen to stakeholders and respect their expertise of their lands.
- Involve stakeholders in research decision-making, for example through an advisory board.
- Carefully select study sites to maximize the likelihood of producing scientifically robust data.
- Engage with relevant stakeholders early so they can provide input on study design.
- Be culturally aware of the community: frame issues in terms accessible to them, understand the history of the community's interaction with researchers, speak the local language, etc.
- Be creative and timely in providing research results to stakeholders (don't wait until the study is finished and send only a journal article).

Community Responses to Climate Change

Speakers:

Emily Therese Cloyd, AAAS Center for Public Engagement with Science and Technology
Elana Kimbrell, AAAS Center for Public Engagement with Science and Technology
Dan Barry, AAAS State and Local Advocacy
Vicki Arroyo, Georgetown Climate Center
David Reidmiller, US Global Change Research Program

This session presented a new AAAS program to communicate about community responses to climate change. A central feature is a Spotlight series of multimedia stories that may include photos, videos, links to live data, maps of climate impacts, and visualizations of the effects of actions taken. Stories of community responses to climate change are intended to encourage other communities to take action.

A Spotlight story featured in the session describes the work of Dr. Burke Hales, an ocean chemistry expert at Oregon State University who developed a method of monitoring ocean acidification that is now used to protect oyster larvae in hatcheries. The project began when a hatchery production manager in Oregon reached out to the scientist after noticing a connection between oyster mortality and summertime ocean upwelling. The use of Hales's technique, dubbed the Burke-o-Lator by hatchery operators, has expanded to other locations on the West Coast and the East Coast.

The aim of the AAAS program is to work with local opinion leaders to disseminate materials through community groups. Possible ways of reaching out are policy and community forums or conferences of local decision-makers. AAAS is completing a short report with written guidance for community responses to climate change. The AAAS program activities will launch later in 2019.

The presentations and discussion identified issues for communication based on experience with community engagement.

1. Listen to what people care about as the first step in local forums.
2. Use brief reports written in accessible language instead of long technical reports.
3. Use multimedia stories of actions taken by communities.
4. Anticipate that solutions to local problems may be hampered by uncertainties.

The Digital Agenda: Supporting the Sustainable Development Goals

Speakers:

Molapo Qhobela, South African National Research Foundation
Daan du Toit, South African National Research Foundation
Heidi Hackmann, International Council for Science, France
Anna Scaife, Square Kilometer Array Headquarters, UK
Lidia Brito, UNESCO in Latin America and the Caribbean

This session's main message is that the digital agenda supports the United Nations sustainable development goals both as an analytical tool for identifying pathways for global sustainability and as a driving force in the economy. Digitization transforms lives and societies as it transcends boundaries. Building capacity in local populations is necessary for achieving broader societal benefits of digital technologies.

One illustration of local capacity-building for digital technologies is the Square Kilometer Array (SKA), the world's largest radio telescope that is planned for construction in Africa and Australia. World-class astronomy is not typically viewed as a priority for sustainable development in Africa. Yet scientific infrastructure leads to social infrastructure. The building of SKA requires big data on a zettabyte scale, which depends on an infrastructure of technology and people. Capacity-building is part of planning for the African component, which includes South Africa and eight partner countries.

The presenters highlighted several policy priorities that incorporate engagement with stakeholders in the local populations where new technologies are introduced.

1. Develop regional African infrastructure of technology and people.
2. Develop strategic international partnerships in Africa, such as SKA.
3. Identify pathways to global sustainability and supporting policies.
4. Link data in multiple disciplines subject to different standards and ontologies.
5. Build federated (linked) data-intensive science systems throughout the world.
6. Build open and inclusive systems to avoid enabling inequality.
7. Build interoperability with open access to data and to processes.
8. Foster knowledge societies with science and technology education.
9. Use technologies in positive ways (prevent violence, combat cyberbullying).

10. Use data to monitor progress on the sustainable development goals.

Key Takeaways

Climate change impacts are serious and far-reaching in sectors as diverse as public health, agriculture, transportation, and power generation. The effects are already apparent and are projected to become more costly throughout the 21st century. In regions of the developing world, the effects on economic stability, food security, public health, and personal safety will be even more devastating. Improving economic analyses of climate change could provide a stronger basis when considering policies for mitigation, adaptation, and protection of the most vulnerable.

New technology and policy approaches are creating opportunities in reducing these and other impacts of climate change in a variety of ways. The use of waste CO_2 in production with carbon capture and utilization, for example, has the potential to result in avoided CO_2 emissions from areas such as chemical manufacturing, aviation and shipping fuels, and cement production. Advances in the precision and speed of the attribution of extreme events to climate change continue to increase public awareness of climate change impacts when national attention is focused on extreme events such as the Hurricane Harvey flooding across Texas. It will not be a single technology or solution that successfully addresses the challenges and impacts of the changing climate, but rather an "open market" of ideas from multiple stakeholders across a range of sectors.

Engaging this wide range of stakeholders is perhaps the most essential element in addressing climate change and the broader context of sustainable development across the globe. In Washington, DC, the Smithsonian's *Outbreak* exhibit informs the public on the relationship between environmental and human health through the lens of global health epidemics. Another program involves sharing stories of community action to encourage communities across the United States to engage with climate change responses. From Montana, Wyoming, and Virginia to Kenya and Tanzania, scientists across the globe are collaborating on sustainability projects with private land managers. Digital technologies make a greater contribution to the achievement of the United Nations sustainable development goals worldwide when local populations have the capacity to be part of open and inclusive systems. The common theme of all these initiatives is to listen to people affected by climate change and build their capacity and agency to work on solutions.