



Public Meeting of the
President's Council of Advisors on Science and Technology (PCAST)

December 1, 2023

Meeting Minutes

MEETING PARTICIPANTS

PCAST MEMBERS

- | | | |
|------------------------------|--------------------------|-----------------------|
| 1. Frances Arnold, Co-Chair | 11. Sue Desmond-Hellmann | 21. William Press |
| 2. Arati Prabhakar, Co-Chair | 12. Inez Fung | 22. Jennifer Richeson |
| 3. Maria T. Zuber, Co-Chair | 13. Andrea Goldsmith | 23. Vicki Sato |
| 4. Dan E. Arvizu | 14. Laura H. Greene | 24. Lisa Su |
| 5. Dennis Assanis | 15. Paula Hammond | 25. Kathryn Sullivan |
| 6. John Banovetz | 16. Eric Horvitz | 26. Terence Tao |
| 7. Frances Colón | 17. Joe Kiani | 27. Phil Venables |
| 8. Lisa A. Cooper | 18. Jon Levin | 28. Catherine Woteki |
| 9. John O. Dabiri | 19. Steve Pacala | |
| 10. William Dally | 20. Saul Perlmutter | |

PCAST STAFF

1. Lara Campbell, Executive Director
2. Reba Bandyopadhyay, Deputy Executive Director
3. Bich-Thuy (Twee) Sim, Assistant Director for Transformative Medicine and Health Innovation
4. Kimberly Lawrence, Administrative Assistant

INVITED SPEAKERS (IN ORDER OF PRESENTATION)

1. Upmanu Lall, the Alan and Carol Silberstein Professor of Engineering at Columbia University and Director of the Columbia Water Center
2. Jay Famiglietti, Global Futures Professor at Arizona State University and Executive Director Emeritus of the Global Institute for Water Security at the University of Saskatchewan

3. Bridget Scanlon, Research Professor at the University of Texas at Austin Bureau of Economic Geology

START DATE AND TIME: FRIDAY, DECEMBER 1, 2023, 9:10 A.M. Eastern Time

LOCATION: Virtual Meeting via Zoom.gov

WELCOME

PCAST Co-chairs: Frances Arnold, Arati Prabhakar, Maria Zuber

The PCAST co-chairs—Frances Arnold, California Institute of Technology; Arati Prabhakar, Assistant to the President for Science and Technology; and Maria Zuber, Massachusetts Institute of Technology—called the meeting to order. Prabhakar stated that most of the day's session would focus on groundwater. The goal of the three presentations to follow was to provide PCAST with a better understanding of the status of this critically important resource including how it is being used, the scope of the problem of groundwater depletion, and potential remedies.

Arnold noted that following the presentations and discussion about groundwater, Catherine Woteki, the PCAST Nutrition working group co-lead, would summarize that working group's November 3, 2023 workshop on Advancing Nutrition Science.

SESSION: UNDERSTANDING GROUNDWATER

UPMANU LALL, COLUMBIA UNIVERSITY

Lall started by framing the landscape and stated that groundwater is part of the water system and not an individual thing by itself. Groundwater is the stock of water in any given place, while rainfall or streamflow are fluxes that go through the water system and are renewable. This distinction is important because much of the groundwater used in human activities comes from deep sources with relatively slow recharge rates. The age of deep groundwater can be 100 to 10,000 years, and drawing upon deep groundwater is effectively mining water, which creates a sustainability problem. He explained that the renewable portion of the water system – what is visible to us (such as rainfall and streamflow) – has high variability and needs to be buffered by an underlying stock of water. That buffering stock is groundwater.

Groundwater depletion, said Lall, is a challenge similar in some ways to dealing with climate change. Both have intergenerational equity issues, and both are global challenges. Depleting groundwater and climate change both limit future development opportunities, perhaps irreversibly, and limit resilience to climate variability. Both involve multiple actors with political power, creating challenges for addressing these issues. For both groundwater depletion and climate change, government policies and subsidies favor current use trajectories that lead to negative effects.

One difference between groundwater depletion and climate change is that the former is a global challenge that is happening everywhere, but which manifests itself as a local issue (where local activity drives local futures), while the latter is a global challenge resulting from local activities but which can manifest far

away (in time and distance) from specific local activities. Another difference is that substitutes are available for carbon-based energy sources, but there are no substitutes for water. In addition, while energy conservation is not enough to address climate change, water use efficiency can produce significant benefits for reducing groundwater depletion. Increasing water use efficiency requires a national strategy because if the locations where specific crops are grown must change, for example, there are implications for food security, local and national economics, and land use characteristics.

Lall explained that groundwater depletion is a public sector issue, making the role of federal and state governments clear and relevant to any potential solutions. One possibility is for policy makers to establish markets that could change the trajectory of water depletion. He noted that regions with the biggest groundwater depletion challenges include areas with intensive agriculture, arid areas in which rainfall is variable, and large urban areas reliant on groundwater.

In framing possible federal roles in potential solutions to groundwater depletion, Lall said there is resistance to bringing regulatory pressure and ideas from outside, i.e., from the federal government. In the current system, local actors and interests control potential solutions, making it difficult to enact change even when recognizing that change is necessary. At the same time, groundwater depletion affects all economic sectors in affected regions, which by proxy affects the national economy. There are additional national impacts as well – for example, when persistent drought affects a particular region, such as the western United States, states call on the federal government to help by declaring a disaster and providing compensation to farmers.

Lall proposed creating a strategic water reserve similar to the national strategic petroleum reserve. Because water is expensive to move, water reserves would have to be local and preserved in a way that regions of the country can meet needs without a disaster declaration. He added that work in India, which has significant groundwater depletion issues, showed that central government action, using levers such as crop insurance programs and other subsidies, can significantly influence the trajectory of water use characteristics, both positively and negatively.

JAY FAMIGLIETTI, ARIZONA STATE UNIVERSITY

Famiglietti said his comments would be based on 25 years of working with, analyzing, writing, and communicating about the results his team has generated using measurements from space to estimate changes in groundwater storage. His key takeaways were that groundwater is disappearing rapidly from the world's major aquifers, including those in the United States, because of little or no oversight of these resources. Groundwater depletion in California's Central Valley and the southern part of the Ogallala aquifer, driven primarily by over-pumping for irrigation, threatens the western U.S. water supply and the nation's food security. Groundwater depletion also threatens the resilience and capacity to adapt to climate change of desert cities such as Phoenix, where cuts to Colorado River water access will place increasing stress on the city's dwindling water resources.

Another takeaway, said Famiglietti, is that the rapid pace and extensive scale of the groundwater crisis will far outstrip the pace and scale of the U.S. response, as well as that of the rest of the world. Far greater awareness of the importance of groundwater, extensive exploration, and new management paradigms and policies, including at the national scale, are key to preserving groundwater for generations to come. The bottom line, he said, is that this is an all-hands-on-deck moment for groundwater sustainability.

Famiglietti said one of the greatest contributions of NASA's Gravity Recovery and Climate Experiment (GRACE) mission, which was designed to estimate changes in groundwater storage from space, and the subsequent follow-up missions, is the ability to map trends in total water storage. When combined with a map of the world's major aquifers, the result shows that over half of the world's major aquifers are being depleted, with the Central Valley aquifer among the three fastest in terms of depletion rate. The United States and the rest of the world have a full-on groundwater crisis, he said.

Though the GRACE mission and the follow-on missions measure change in water storage, they do not provide information on the absolute amount of groundwater, making it difficult to know when an aquifer will be depleted, said Famiglietti. He called for the United States and the rest of the world to conduct a major exploration effort to characterize Earth's shallow crustal water environment. The goal of this effort would be to determine how much groundwater is available and accessible and how the quantity of groundwater varies with depth.

Famiglietti explained that estimating changes in groundwater requires removing snow, surface water, and soil moisture from the GRACE signal using observations, modeling, and data from other satellites. The resulting analysis shows that groundwater decline in the Central Valley has been accelerating over the past 20 years and as of June 2023 has reached a couple million acre-feet per year. There have been three short periods of recharge during rainy winters, but these were followed by longer periods of groundwater depletion when farmers have had to rely on irrigation to sustain their crops. A large increase in groundwater storage did not occur following the wet winter of 2022-2023, though he acknowledged there may be more recharge going forward. In 2014, California passed the Sustainable Groundwater Management Act to target sustainability by 2042. So far the Act has had no impact on groundwater sustainability, which Famiglietti said should be a concern.

Famiglietti said Arizona State University secured a large grant for the Arizona Water Innovation Initiative. This initiative will catalyze deep engagement, co-developed research, public awareness, and changes in water use. It will also enable research to identify pathways for economic growth and water sustainability in Arizona that may help the rest of the United States and the world.

Groundwater in Arizona, said Famiglietti, is the state's most precious resource, but as with the Central Valley, groundwater storage has been declining over the past 20 years and has accelerated over the past three years. Groundwater management occurs in less than 25 percent of the state, and after 45 years, most active management areas are not on track to meet 2025 sustainability targets. Given that Arizona now has a water-forward governor; many willing participants across state agencies, universities, and industries; and urgency driven by future cuts in allocations from the Colorado River, the time to seize the moment and act is now, he said.

Famiglietti said transdisciplinary engagement with the private sector, government, civil society, researchers, and academia will be critical to charting pathways to groundwater sustainability. Awareness, education, and science communication are of paramount importance at all levels, but more is needed to achieve groundwater sustainability. Water, he said, is the new carbon, and the nation needs to take a page out of the carbon dioxide playbook to foment change in groundwater management policies and convince the highest levels of government, the nation's water managers, its elected officials, and policymakers that groundwater is a real issue. Going forward, he said, there is a desperate need to understand how disappearing groundwater will affect food production and food systems in the United

States. He noted that the National Academy of Sciences, Engineering, and Medicine's Board on Agriculture and Natural Resources is considering conducting a study on groundwater security's role in food security, though sponsors are needed to make such a study happen.

BRIDGET SCANLON, UNIVERSITY OF TEXAS AT AUSTIN

Scanlon said declines in water storage in the U.S. Southwest, its central and southern High Plains, and California's Central Valley in the 15-year period from 2002-2017 totaled approximately 90 cubic kilometers, or about three times the capacity of Lake Mead. Groundwater storage has stayed relatively stable in Idaho, the upper Colorado River basin, and the lower Mississippi River basins, and has increased in Nebraska, the northern High Plains, Columbia River basins, and the eastern United States. Climate extremes, particularly droughts, are linked to water storage variability, with a high degree of correlation between changes in total water storage and the U.S. drought monitor. She noted that the recharge rate in the southern High Plains is roughly one-tenth the rate of water withdrawal there.

The elephant in the room regarding groundwater, said Scanlon, is irrigated agriculture, particularly in the Central Valley, southern High Plains, and the lower Mississippi River basin. During wet periods, California uses surface water to meet 70 percent of its irrigation needs, with groundwater filling the remaining 30 percent. During a dry year, the numbers switch, with groundwater providing 70 percent of the Central Valley's irrigation needs, amplifying the effect of climate extremes on groundwater depletion. The lower Mississippi basin pumps more groundwater than the Central Valley but without depleting the aquifer because most of the pumping from irrigation captures surface water or reduced evapotranspiration.

Scanlon said that between 2018-2020, 1 in 10 people in the United States lived in areas where the community water system had a health-based violation, with about 70 percent of community water systems with health-based violations affecting high social vulnerability groups. Many of these community water systems are rural and serve small communities of less than 500 people. The U.S. Geological Survey has shown that most of the contamination in these systems results from treatment, disinfection, non-point source agricultural nitrate, and naturally occurring contaminants such as arsenic and radionuclides. While the White House and Environmental Protection Agency have environmental justice tools focusing on proximity to point sources of contamination, most of the contamination in areas served by small community water systems are not from point sources.

The path forward to resolving the water quantity issue, said Scanlon, is conjunctive management of groundwater and surface water where surface water is used during wet periods and groundwater during droughts. In areas of the Central Valley using this management approach, groundwater levels have stabilized. This, she said, needs to be expanded over a larger area. At the same time, the nation needs to enact water-smart agricultural policies. For example, with airlines racing toward a future of using corn-based fuels to power their jets, it will be important to consider the implications of increasing irrigation to meet the demands for corn across the nation's corn belt.

Scanlon said the path forward regarding water quality requires stopping the pollution of water sources. Small rural water systems, she noted, do not have alternative water sources. Therefore, they need to rely on treatment or connecting to a different water system in the region. Workforce development also plays a role in terms of increasing enforcement and the managerial capacity of these small systems. Understanding the challenges of and developing solutions for workforce development will require strong

integration of efforts across academia, industry, and government. She also noted that remote sensing, modeling, and monitoring will play a role, and tools like artificial intelligence and machine learning can help synthesize data and accelerate the development of solutions.

Funding, said Scanlon, is a huge issue. The Inflation Reduction Act allocated \$50 billion to implement potential solutions, but the Act contains no funds for academic research. Communication will also be key going forward.

PRABHAKAR MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND LALL, FAMIGLIETTI, AND SCANLON.

SESSION: NUTRITION WORKSHOP SUMMARY

CATHERINE WOTEKI

Woteki said PCAST created the Nutrition working group in response to a September 2022 White House conference on hunger, nutrition, and health and the release of the Biden Administration's National Strategy on Hunger, Nutrition, and Health. The national strategy called for PCAST to work with the Interagency Committee on Human Nutrition Research (ICHNR) and the Office of Science and Technology Policy to identify scientific opportunities, gaps, and priorities to advance nutrition science, with a particular emphasis on ensuring equitable access to the benefits of this research.

The working group's first actions, said Woteki, were to post a blog on the PCAST website requesting public input, review the scientific literature, and interview federal agencies that either sponsor nutrition research or rely on that research to inform their programs and policy decisions. The thrust of these interviews was to get the agencies' views on the biggest evidence gaps and impediments to the ability of their programs to deliver equitable access to new research findings. From the information gained through these activities, the working group began drafting findings, conclusions, and recommendations for actions the administration can take to strengthen the evidence base and ensure the public is obtaining benefits from federal investments in nutrition research.

Woteki said the goal of the November 3, 2023 nutrition workshop was to gather additional insights and vet the working group's findings and conclusions by seeking opinions from a broad range of stakeholders across both public and private sectors. Workshop participants came from 12 agencies; organizations involved in food production, processing, and dietary supplements; insurance companies; private foundations; health care providers; academia; and nongovernmental organizations.

Woteki said there was general agreement among the workshop participants that the biggest problem facing Americans is the immense health, economic, and social impact that diet-related chronic diseases are having. Diet-related chronic diseases, including diabetes, cardiovascular disease, stroke, most cancers, and obesity, are the leading causes of morbidity and mortality in the United States. Obesity also contributes to physical disabilities, social isolation, and stigma. She noted that the appearance of these diseases at younger ages can be prevented through proper diet and exercise. Proper diet and exercise can delay the emergence of diet-related risk factors such as hypertension, metabolic syndrome, and prediabetes by 20 to 40 years, providing decades of healthy life.

The workshop participants also agreed that the burden of these diseases fall inequitably across the U.S. population, disproportionately affecting people of color, those with limited resources, and rural residents. Woteki noted that recent data from the Economic Research Service shows that adults living in food-insecure households are more likely to have a chronic illness than adults living in high food-security households. While the emergence of new pharmacologic treatments for obesity is a promising development to help people achieve a healthier weight and reduce their risk of developing chronic diseases at an early age, the cost of these drugs could exacerbate the inequitable distribution of these diseases without a national prevention effort.

Woteki said the working group is reviewing the comments it received in response to the blog post and from the workshop, and it is preparing a report to the President. The major findings are:

- The greatest return on research investment will be primary and secondary prevention of diet-related chronic diseases and conditions, especially when translated into federal food and health programs and as the basis for private-sector initiatives.
- There is poor alignment between the magnitude of the diet-related disease epidemic and U.S. government programs, with an emphasis on treatment and little on primary and secondary prevention. The federal government spends approximately \$1 trillion on Medicare, Medicaid, and other health programs to treat diet-related diseases and \$122 billion annually on food programs such as the Supplemental Nutrition Assistance Program and the Special Supplemental Nutrition Program for Women, Infants, and Children. However, the food programs do not have health as a primary outcome, focusing instead on food insecurity.
- The current evidence on reducing the risk of diet-related disease is not translated effectively into programs even though there are ongoing promising experiments, such as the Food is Medicine initiative.
- Agencies and the private sector rely on foundational science from the National Institutes of Health and U.S. Department of Agriculture.
- The National Health and Nutrition Examination Survey (NHANES) is an underfunded and vital resource that forms the basis for public health and clinical decisions and for monitoring the nutritional status of Americans. Without up-to-date NHANES data, it is not possible to measure the extent of diet-related problems and how they change over time.
- The nutrition workforce lacks diversity, which influences the equity of the evidence base.
- ICHNR provides a valuable forum for federal agencies to share information about their research efforts, but it lacks authority to initiate multi-agency projects requiring resource commitments.

Woteki said the working group also reached three major conclusions around three needs that will inform its forthcoming recommendations.

1. The federal government needs a long-term strategy to strengthen federal nutrition efforts from research to practice. This will include strengthening surveillance efforts to enable monitoring changes in diet and diet-related health conditions over time, and leading change to provide healthier food environments for all, starting with its own massive food catering facilities. By removing barriers to cross-agency work, diet-related chronic disease prevention efforts could be

the outcomes of the more than 200 federal nutrition programs. The federal government should also implement and resource a new 5-year nutrition research plan.

2. Rapid action on implementation research is needed to fill the biggest gaps hindering equitable access to the benefits of research. This will require more quickly incorporating research-based nutrition into public and private programs, diversifying equity in food and nutrition programs, diversifying the nutrition and dietetics workforce, and prioritizing creating an implementation research program.
3. ICHNR will require additional authorities, dedicated staff, and resources to enact these recommendations.

ARNOLD MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND WOTEKI.

Andrea Goldsmith asked Woteki to explain what implementation research is. Woteki said implementation research is based on transdisciplinary behavioral research that can provide effective strategies that people can use when making choices about the food they choose within their environment. Implementation research involves developing an understanding of the determinants of why people make their food choices and then provide them with the skills they can use to prepare health-promoting meals with the food they can purchase.

Vicki Sato asked Woteki if grocery stores, drug stores, and other purveyors of foods are part of the working group's community of analysis and participation. She pointed out that stores in different communities stock different levels of healthy foods, which affects the ability to access these foods depending on what the food retailers in a community choose to stock. Woteki replied that food retailers are part of the working group's stakeholders. She acknowledged that food retailers were not as well represented at the workshop as desired, but there will be opportunities to have conversations with less represented sectors in the working group's future consultations.

PUBLIC COMMENT

No public comments were presented.

CLOSING COMMENTS

Zuber, Prabhakar, and Arnold expressed appreciation to the speakers in the groundwater session for their presentations. The presentations, said Zuber, made it clear that selecting and reporting data will go a long way toward understanding groundwater-related challenges. Commenting on the summary of the nutrition workshop, she said positive practices in nutrition research need to be highlighted and adopted broadly. Both sessions pointed out how collecting and disseminating scientific information are crucial to solving problems and improving the lives of Americans. Arnold added that yes, it is important to understand the challenges regarding the nation's groundwater resources, but the time for action is now.

PUBLIC MEETING ADJOURNED: FRIDAY, DECEMBER 1, 2023, 12:48 P.M. Eastern Time

I hereby certify that, to the best of my knowledge, the foregoing minutes are accurate and complete.

Frances Arnold, Ph.D.
Co-Chair
President's Council of Advisors on Science and Technology

Arati Prabhakar, Ph.D.
Co-Chair
President's Council of Advisors on Science and Technology

Maria Zuber, Ph.D.
Co-Chair
President's Council of Advisors on Science and Technology