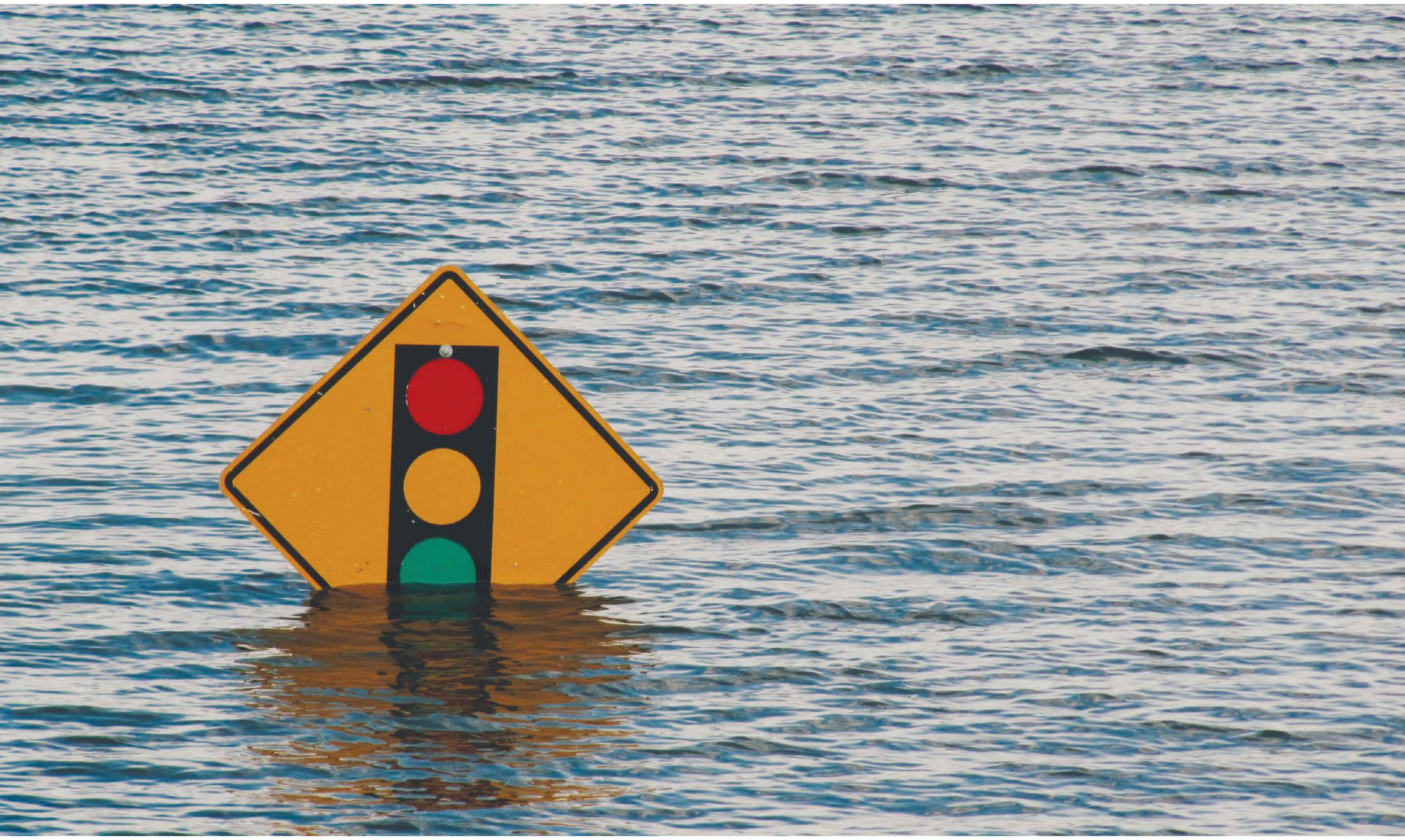

Building a Biotechnology Innovation Ecosystem to Mitigate Climate Change

A UIDP Academy Workshop
Oct. 12-13, 2021

Executive Summary

UIDP Strengthening University-Industry Partnerships

UIDP conducted this workshop on behalf of the NSF Biology Directorate to leverage top scientific minds to identify biotechnology research areas for strategic investments and acceleration.

Executive Summary

Anthropogenic greenhouse gas emissions continue to rise globally, driving urgency to mitigate climate impacts on our ecosystems, economy, public health, and future wellbeing. Food production accounts for 26% of global emissions, and within that segment, livestock, crop production and land use account for 82% of emissions.[1] Agriculture is both a contributor to climate change and directly affected by its impacts. While current policies strive to curb some emissions, broad implementation and adoption of further technological advancements is required to achieve emission targets to limit warming to 1.5°C to 2°C.[2]

More than 100 participants from the academic, corporate, government, and nonprofit sectors convened virtually for two days to discuss potential research and technology needs for biotechnology innovation ecosystems to mitigate climate change. The invited scientists and researchers were strategically selected to ensure that diverse perspectives and expertise were represented in the workshop deliberations. Participants explored themes related to systems analysis, managed systems, natural systems, and bioengineering/synthetic biology to identify the best opportunities. Topics discussed include regional considerations and risks, identified challenges to scaling up nascent solutions, implementation and adaptive management approaches, and supply chain and market considerations for new technology.

Purpose of the Workshop

Participants gathered to identify the primary levers by which climate change can be slowed or reversed using biotechnological or synthetic biology innovations that enhance the adaptation, resilience, preservation, and restoration of natural and managed ecosystems in response to climate change. The workshop provided a forum for interdisciplinary conversations around the promising, yet underdeveloped, potential of coupling nature-based practices with synthetic biology tools to guide the development and implementation of biotechnological solutions to climate change. Participants were challenged to address the following questions:

- What are the primary levers by which climate change can be slowed or reversed using biotechnological or synthetic biology innovations?
- How might biotechnology be used to enhance the adaptation, resilience, preservation, and restoration of natural and managed ecosystems in response to climate change?
- How can natural systems and nature-based solutions complement and guide the development and implementation of biotechnological solutions to climate change?

Workshop Findings in Brief

- **Mitigating the worst effects of climate change will require intensive research, development, and demonstration of biotechnological solutions.** These solutions must integrate into existing systems that are highly complex, including natural ecosystems, managed lands for agriculture and forestry, and centralized bio-industrial systems.

- **Monitoring the efficacy of biotechnological solutions that are implemented over large spatial domain.** Techniques used in natural ecosystems and managed lands will require standardized protocols and computational tools that enable streamlined data curation and distribution.

- **Carbon sequestration additionality and permanence** are two metrics that must be closely monitored, and at low cost and with high confidence.

- **Genetic engineering and adaptive evolution of microbes, crops, and synergistic systems.** The identified system has the potential to significantly reduce net greenhouse gas emissions through innovation in carbon dioxide (CO_2) and methane (CH_4) assimilation, nitrous oxide (N_2O) degradation, and lignocellulose valorization, to name a few.

- **The biotechnology workforce should be thoroughly informed of the beneficial impacts their skills and existing infrastructure can play in mitigating climate change.** This would justify the consideration of new outreach programs at pre-professional and professional levels.

- **Leveraging existing biotechnological knowledge and infrastructure will require strong partnerships.** This involves fluid communication between emerging innovators and existing operators, from both the public and private sectors.

- **Risks inherent to biotechnology scale up** are limited if such collaboration amongst various stakeholders between academia, industry, and government is not achieved and maintained over long time frames.

- **Caution is warranted in public-private scale ups.** This should be considered in relation to aggressive timelines and those that rely on unstable policy incentives.

- **The large-scale and rapid implementation of biotechnological solutions to mitigate climate change will be resource-intensive and potentially socio-economically biased.** Stakeholders at the community level must be engaged throughout the implementation timeline to ensure such bias is avoided and benefits are equitable.

- **Resiliencies in biotechnologies.** Particularly centralized industrial biosystems, will require resilient and sustainable supply chains to ensure long-lasting climate benefits.

- **Biotechnological solutions to climate change are immature** and will require coordinated efforts at global, national, and local scales across public and private sectors to achieve their exciting potential.

Critical Topics and Necessary Advancements

The critical topics and necessary advancements to achieving large-scale climate change mitigation via biotechnological solutions are summarized below.

SYSTEMS ANALYSIS

- Standardization
- Streamlined data acquisition
- Reliable and accurate monitoring
- Long-lasting benefits
- Regional to global impact translation

BIOENGINEERING

- Crop genetics for carbon sequestration
- Crop genetics for climate resilience
- Engineered microbes for carbon sequestration
- Adaptive evolution
- Transparency and public awareness

NATURAL SYSTEMS

- Ensuring additionality and permanence
- Long-term data acquisition
- Distinction of challenges across system types
- Emphasis of socio-enviro-economic co-benefitpolicy

MANAGED SYSTEMS

- Ensuring additionality and permanence
- Stakeholder engagement
- Appropriate prioritization
- Socio-economic impacts

INDUSTRIAL SYSTEMS

- Leverage existing infrastructure
- Early-stage, long-term partnerships
- Life cycle assessment
- Workforce training and education

RISK ASSESSMENT

- Open source data
- Regional, data-driven decision making
- Accounting for policy uncertainty

SCALE-UP

- Technology-readiness-level considerations
- Reasonable timelines
- Public-private partnerships

IMPLEMENTATION

- Local community engagement
- Simple, low-cost, standardized tools and protocols
- Long-term commitments

SUPPLY CHAIN AND MARKETS

- Carbon market maturation
- Resilience and sustainability
- Circular economy

Critical topics and advancements matrix (UIDP, 2022)

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