NOAA technical memorandum NOAA Science Council-007

The Emerging Climate Economy and Role of the NOAA Climate Enterprise

The NOAA Science Council

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Introduction

The scope and pace of climate change have introduced significant challenges and opportunities for the global economy. As the economy continues to shift towards mitigating and adapting to the effects of climate change, many industries and entire sectors of the economy will transform. Understanding the current state of the Climate Economy and the role that the National Oceanic and Atmospheric Administration (NOAA) is playing and will play within it as it evolves is critical to scaling climate solutions, developing new technologies, efficiently allocating and attracting investment, building new businesses and industries, maintaining American competitiveness, and supporting our trading partners. This memorandum outlines the current and rapidly evolving state of the Climate Economy and how the NOAA Climate Enterprise relates to it.

What is included in a Climate Economy (Figure 1)?

The "Climate Economy" refers to climate change's economic aspects and implications, including the costs and benefits of mitigating and adapting to climate impacts.[1] It encompasses the evaluation of economic damages caused by climate change, the expenses involved in reducing greenhouse gas emissions, and the economic opportunities that emerge from shifting towards a low-carbon economy. Responding to the dual challenges of mitigating and adapting to climate change will alter many industries. These responses will take two forms that are **not** mutually exclusive: climate mitigation and climate adaptation.

- *Climate mitigation* involves reducing activities that cause climate change (e.g., greenhouse gas emissions, deforestation, land and marine ecosystem degradation) and increasing activities that reverse it (e.g., renewable energy, carbon dioxide removal, carbon capture and storage, ecosystem restoration).
- *Climate adaptation* involves increasing activities that reduce the financial, social, and ecological costs and risks of climate change events (e.g., building community resilience, developing climate-smart infrastructure, and developing early warning systems).

[1] Saha Devashree, and Joel Jaeger. America's New Climate Economy: A Comprehensive Guide to the Economic Benefits of Climate Policy in the United States. Working Paper. World Resources Institute, July 2020. Available at: https://www.wri.org/research/americas-new-climate-economy-comprehensive-guide-economic-benefits-climate-policy-united-states.

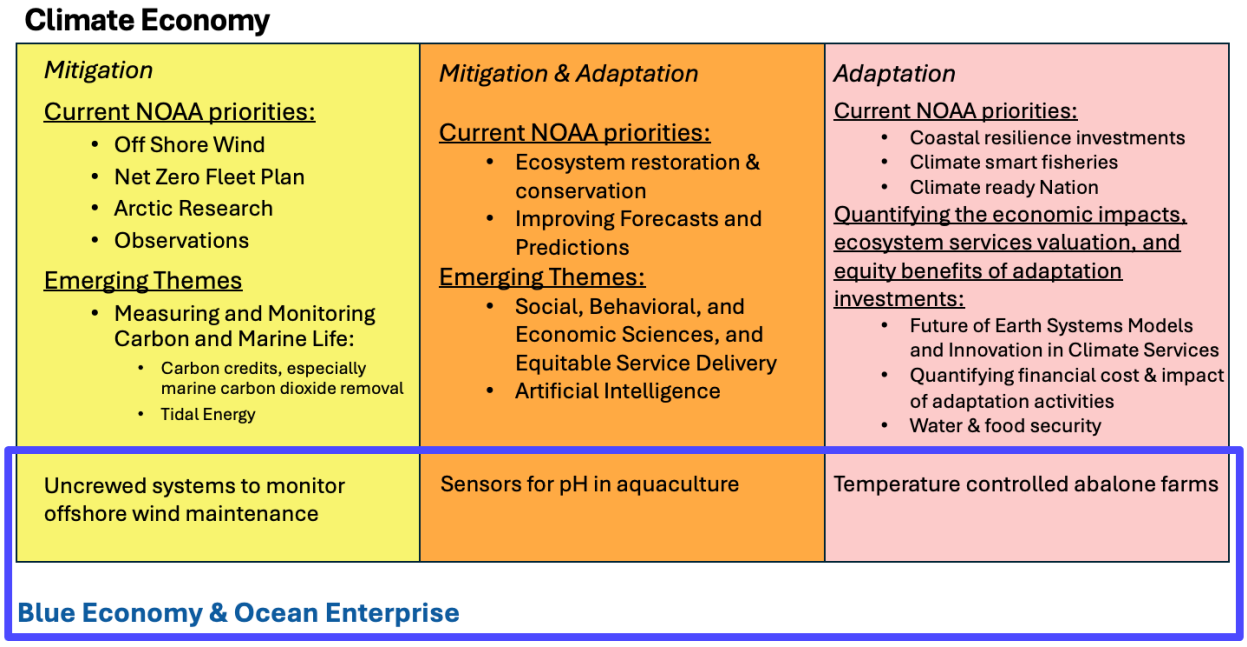

Figure 1: The Climate Economy. The Climate Economy includes climate mitigation and adaptation activities with measurable impacts in both areas. The Ocean Enterprise is included within the Climate Economy but can also be placed outside of it, using measurable impacts to determine placement.

In many ways, the growth of a Climate Economy is dictated by traditional investment drivers: regulation; technological innovation; and demographics. Government regulators, climate scientists, and financial investors have used predictions and forecasts about changing regulations, scientific innovations, and financial investments to drive research and funding for climate change solutions. These traditional investment factors have stimulated efforts to mitigate and adapt to the effects of climate change, shaping the future of the Climate Economy. However, the growth of the Climate Economy is also driven by the speed of climate change and the severity of its associated impacts, particularly in responding to chronic and slow onset climate change impacts such as sea level rise, ocean, coastal, and freshwater acidification, and the increasing frequency of extreme events, including wildfire, marine heatwaves, floods, and drought. Rapid economic growth related to climate change often follows events that spark increased efforts to rebuild communities or innovate on climate solutions to address rising risks. This part of the Climate Economy is more focused on climate adaptation and is currently underdeveloped but may rapidly expand due to new and growing impacts of climate change. There is an emerging need to understand climate adaptation measures and their effectiveness. The growth of the Climate Economy is also driven by the urgent need to rapidly mitigate climate change through monitoring and reduction of greenhouse gas concentrations and

emissions through activities such as the expansion of renewable energy, the removal of carbon dioxide from the atmosphere, and ecosystem restoration. Historically, there has been an emphasis by the public and private sectors on investment in mitigation, which accounts for 90% of global climate investment.[2] In comparison, less than 10% of global climate investment has gone into adaptation in any given year.[3]

Quantifying the growth of the Climate Economy will rely on well-defined impact metrics and climate data, products, and services to show progress. The emissions reductions we make today impact the need for adaptation and the opportunities available for adaptation in the future. Therefore, facilitating growth and innovation in mitigation and adaptation are necessary for understanding the future potential of the Climate Economy. Current federal government goals involve reaching Net Zero GHG emissions by 2050, which requires an estimated investment flow of around $27 trillion through 2050.[4] Even if the U.S. achieves Net Zero emissions tomorrow, unavoidable climate change impacts are projected to increase in the coming decades.[5] The U.S. is inherently exposed to extreme weather and climate disasters, with $93 billion in damages in 2023 reported by NOAA.[6] This underscores the immediate need for investment in adaptation and resilience to weather and climate disasters due to the inevitable impacts we are currently facing and those that are yet to come. Damage can be reduced when

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[2] Historic global climate finance information available from the Climate Policy Initiative. https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2023/

[3] Historic global climate finance information available from the Climate Policy Initiative. https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2023/

[4] There are various estimates of the cost to reach Net Zero by 2050. McKinsey's 2022 report is one of the most cited. <https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring>

[5] IPCC. "Climate Change: A Threat to Human Wellbeing and Health of the Planet. Taking Action Now Can Secure Our Future." Intergovernmental Panel on Climate Change, 28 February 2022. Available at: https://www.ipcc.ch/2022/02/28/pr-wgii-ar6/.

[6] Even without climate change, the U.S. has exposure to extreme weather and climate disasters. Records of financial costs are available since 1980: <https://www.ncei.noaa.gov/access/billions/>. NOAA data quantifies historic, current, and projected physical risks of such events.

lives are protected, the built and natural environment is able to withstand injury, and economic activity can resume immediately after adverse events occur.

How do major NOAA priorities of Climate-Ready Nation and the Ocean Enterprise fit within the Climate Economy?

NOAA's priorities respond directly to the growing demand for reliable and accessible climate information, products, and services in the Climate Economy. We should focus on areas where we can best leverage and enhance our capabilities and stimulate innovation to protect lives, livelihoods, property, and ecosystems in a changing climate.

Climate-Ready Nation will accelerate climate adaptation through better understanding, identifying opportunities for action, measuring impact, and developing products and services to build adaptation. NOAA also supports certain climate mitigation activities, including offshore wind energy production, providing observations of various variables critical for renewable energy and efficient fuel use in transportation, and providing science, monitoring, and modeling to inform greenhouse gas reductions and removal.

The *Ocean Enterprise*[7] is also part of the Climate Economy with its emphasis on increasing ocean information for decision-making, improving our understanding of the ocean's role in climate, and identifying, implementing, and evaluating opportunities for ocean-based climate action. For example, emerging science in marine carbon dioxide removal and further technological development for monitoring the current ocean conditions, as well as off-shore wind, will become growing areas of investment and activity in climate mitigation.[8] In this way, building a *Climate Ready Nation* and the *Ocean Enterprise* work together to provide significant benefits to the Climate Economy.

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[7] For definition of Blue Economy and Ocean Enterprise, please, see paper NOAA Terminology related to Ocean and Coastal Economic Activity

[8] https://www.noaa.gov/news-release/carbon-dioxide-removal-as-tool-to-mitigate-climate-change

How does the NOAA Climate Enterprise fit within the Climate Economy?

The NOAA Climate Enterprise is part of the broader suite of Earth System information that NOAA provides to deliver on its mission and is also central to NOAA's contributions to the Climate Economy. NOAA has historically and continues to provide authoritative information on the Earth System and supports rigorous national and international climate assessments. This has been a fundamental building block for informing and developing the Climate Economy and makes NOAA essential for catalyzing future growth. In order to illustrate this vital contribution, NOAA has created three categories to define the use of Earth System data within the climate enterprise:

1. **Acquisition**: defined as the creation of data, encompassing both observations (*in situ* and remotely sensed) and models to monitor, forecast, predict, and project the Earth System over time.

2. **Access**: defined as bringing climate data together for exploration, analysis, or translation into usable and accessible products for diverse users.

3. **Application**: products that derive new information from climate data, often combining it with non-climate information to develop new insights.

NOAA excels at delivering these three "A's" and provides additional value and expanded reach in the Climate Economy by making the information publicly available and creating partnerships to enhance or generate new products and services (Figure 2). NOAA develops unique predictive models and early warning systems based on sustained in situ and satellite observations, which can be integrated into products and services for various sectors of our economy.

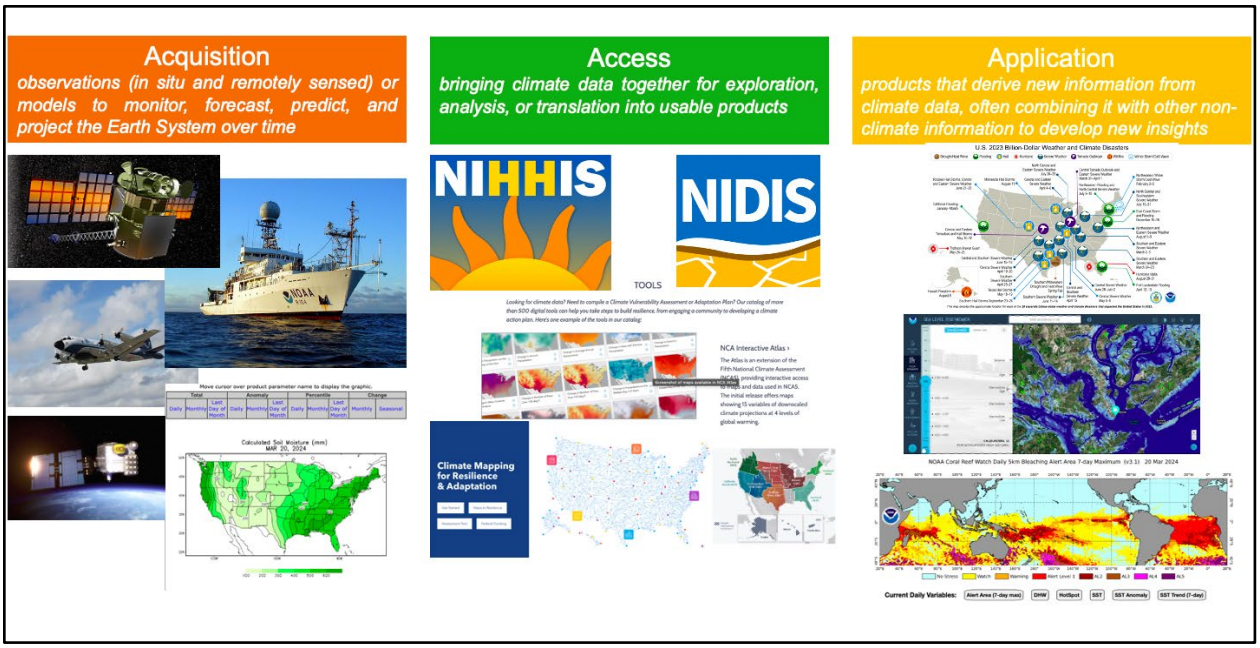

Figure 2: NOAA Climate Enterprise, Example For Earth System Data. Examples of NOAA's efforts of acquisition, access, and application. Our partners heavily rely upon direct NOAA data and products (Acquisition, left), but also need structures to use the data (Access, center), and or unlock new insights from the combination of climate and non-climate data developed by NOAA and our partners (Application, right). With the growth of data acquisition from our federal and private partners, NOAA may also purchase products from the left (Acquisition) column.

Both the private and public sectors are collaborating with NOAA to grow and thrive within the Climate Economy through NOAA's unique access to climate information. NOAA has scientific expertise and a reputation for quality, permitting it to expand beyond purely providing access to information and serving as an authoritative reference for new applications.

NOAA must evaluate opportunities to engage and strategically support the Climate Economy. The NOAA climate enterprise must continue to deliver and sustain weather and climate information while expanding and innovating the collection, use, and delivery to meet new and rapidly evolving innovation and user requirements. NOAA also wants to ensure that we can measure our impact on the growth of the Climate Economy and maintain NOAA's credibility through developing fundamental research and leveraging partnerships.

What is the current and rapidly evolving state of Climate Economy financial investments?

Financial investment flows in the Climate Economy have been centered around climate mitigation efforts, predominantly in the energy sector.[9] The recent focus on mitigation has delayed adaptation investments and resulted in an underdeveloped market for climate adaptation solutions. A shift in science and perceptions of risks has occurred with the help of the Sixth Intergovernmental Panel on Climate Change report and the Fifth National Climate Assessment report, which highlighted improvements in climate attribution science linking climate change to the changes in risks of extreme weather and climate events. These reports[10] have helped to draw attention to the need for greater investment in adaptation in addition to mitigation.

Partnerships accelerate the transfer of new technology to market.

Accelerating the transfer of new technology to market through public-private- partnerships is crucial because it combines the strengths, resources, and capabilities of different organizations, fostering innovation and speeding up the development process.[11] These collaborations often enable faster commercialization, reduce time-to-market, and enhance competitive advantage in a rapidly evolving technological landscape while allowing NOAA to fulfill its congressionally mandated requirement through the Small Business Innovation Research (SBIR) program to support private sector innovation and the growth of the Climate Economy. Vibrant private sector technology development is essential in supporting NOAA's mission while ensuring the

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[9] Of USD 653bn annualized flows in investment by public and private actors in activities that reduce emissions and improve adaptation and resilience to climate change in 2019-2020, 90% went towards climate mitigation. 51% of the total went towards energy systems. Climate Policy Initiative, Global Landscape of Climate Finance. October 2022. <https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-a-decade-of-data/>

[10] Intergovernmental Panel on Climate Change (IPCC). (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the IPCC. Cambridge University Press. Retrieved from https://www.ipcc.ch/report/ar6/wg1/

[11] Azarian, Mathew, Asmamaw Tadege Shiferaw, Tor Kristian Stevik, Ola Lædre, and Paulos Abebe Wondimu. "Public-Private Partnership: A Bibliometric Analysis and Historical Evolution." Buildings 13, no. 8 (2023): 2035. https://doi.org/10.3390/buildings13082035.

federal government increases U.S. competitiveness. Figure 3 shows how these programs support private sector technology development and commercialization at scale.

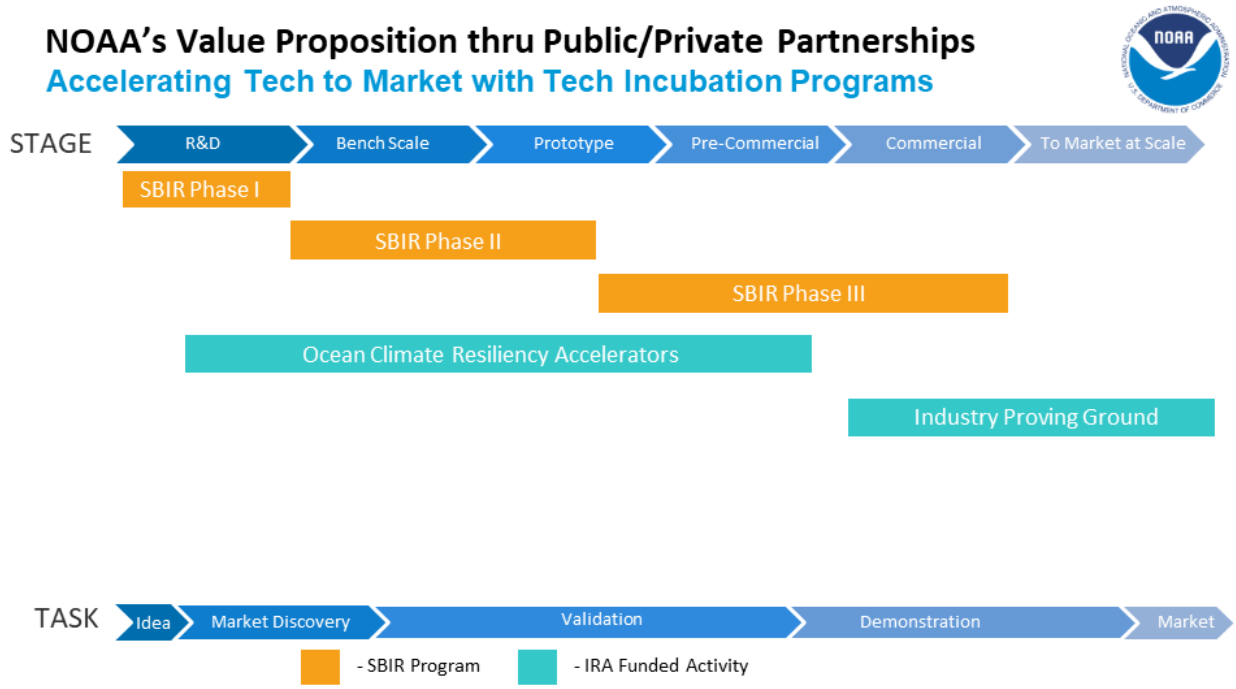

Figure 3: Accelerating Technology to Market through Public/Private Partnerships. This graphic highlights three NOAA programs: the NOAA Small Business Innovation Research (SBIR) Program, Ocean Climate Resiliency Accelerators, and activities funded by the Inflation Reduction Act that support technology development within the private sector. These programs highlight NOAA's efforts to accelerate technology transition to market.

In summary, supporting the Climate Economy puts NOAA at the cutting edge of research and development at a time when interest and investment in climate technology are growing worldwide.

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