MIT Environmental Solutions Initiative (ESI)

An Agenda for Education, Research, and Convening

John E. Fernández, Professor and Director
Amanda Graham, Ph.D., Executive Director

MAY 2016

A Defining Moment

Day by day, year after year, the urgency grows: Humanity's past actions and current behaviors have already resulted in dramatic damage to people and to nature, and pose huge risks for our planet's future. From declining fisheries to acute urban pollution to record-breaking global temperatures, the evidence of human impact on the environment continues to mount.

Across the MIT community, our scholars and students are working to understand, address, and reverse the negative effects of humanity's footprint on the Earth. History has shown that effective solutions to challenging environmental problems nearly always depend on not just one discipline.

At MIT, the boundaries between disciplines are porous. Advancing our understanding of the drivers of and remedies to environmental issues requires contributions not only from science, engineering, and technology, but from the full range of fields represented at MIT: the humanities, arts, economics, history, architecture, urban planning, management, policy, and more. It is only through a broad perspective that truly effective improvements in our relationship with the environment may be achieved. MIT's exceptional strength in all of these areas is matched by our proficiency, born of long experience, in bridging them.

For these reasons, MIT launched the Environmental Solutions Initiative (ESI) in 2014, a major campus-wide effort to coordinate and develop interdisciplinary solutions to urgent challenges in environment and sustainability. ESI aims to harness the MIT community's ingenuity and altruism, and the Institute's unique culture of collaboration through diverse activities in ***education***, ***research***, and ***convening***.

I. Education

As emerging leaders, change agents, and innovators, MIT students have a profound interest in, and capacity to shape a more sustainable environment. ESI seeks to fulfill MIT's commitment to develop this extraordinary capacity through a growing number of opportunities—within the classroom and beyond—that equip students to steward a healthy planet in every career path.

Emphasizing integration and complexity

Ecological and social systems are fundamentally intertwined, and solving environmental challenges is not just the domain of scientists. Addressing complex environmental problems requires professionals, leaders, and scholars in all sectors of society who understand biological, geological, chemical, and physical processes; behavioral, organizational, governmental, and cultural dynamics; and how they interact. ESI is developing opportunities for faculty and students across MIT to incorporate environmental content and activities into their research, teaching, and learning.

Leveraging multiple ways of learning

ESI is leveraging traditional, digital, and hands-on approaches to learning. The residential learning experience in higher education is a powerful model. There is no substitute for the alchemy that brings passionate, smart people together in the same room. At the same time, it is particularly critical within the environmental context to incorporate learning through immersive experiences in the field, preferably in a range of ecosystem and climate types. These field experiences provide opportunities for students to practice complex problem solving. Finally, diverse digital learning tools are emerging that can and should enhance our educational strategies.

Highlights of ESI's current and planned educational activities include:

- A new undergraduate minor in environment and sustainability open to students in any major.
- Infusing introductory freshman classes with diverse environmental content.
- A student Environmental Solutions Action Corps to respond to emergent environmental concerns.
- Expanding the Martin Family Society of Fellows for Sustainability for advanced doctoral students.
- New and reconfigured classes, as well as mini-lectures, problem sets, and other content that can be incorporated into undergraduate and graduate classes, new student orientation, and student leadership activities.
- Domestic and international internships in business/industry, government, and non-profit organizations.
- “Living laboratory” projects in dorms and campus buildings in partnership with MIT’s Office of Sustainability.

II. Research

Earth is a supremely complex system, and our understanding of the underlying forces that support human life is incomplete in many key respects. Human behavior and social systems are similarly complex and not fully understood. Investments in environmental and social sciences are required to improve both our baseline knowledge of how these systems function and interact, and our understanding of how humans are affecting and disrupting the intricately interconnected systems and cycles of life on earth. Insightful characterization of the problems we face and novel analyses are critical steps on the path toward solutions.

In 2015, ESI launched a Seed Grant Program with a set of nine funded, multi-investigator projects. Moving forward, ESI will expand this program to provide full grants that engage MIT researchers for three- to five-year periods. We are also building an undergraduate research opportunity program (UROP) to involve students from all majors in the full spectrum of ESI research. Through these activities, ESI aims to expand and accelerate research toward environmental solutions in three vital domains: Climate Science and Earth Systems, Cities and Infrastructure, and Sustainable Economy and Society.

These research domains are multidisciplinary and promote collaboration across MIT's five schools. Current and future projects may easily span two and even all three of these domains as important research topics are defined, and effective engagement and influence in the world beyond MIT is developed.

Climate science and Earth systems

The primary challenge to our species has become the rapidly progressing changes to our climate systems and associated geophysical dynamics. These changes threaten entire regions and societies partly because we have become exquisitely attuned to the stability of the climate. Disturbances to that stability have already begun to result in great human suffering, ecosystem damage, and biodiversity threats through increased severity and frequency of extreme weather events (such as flooding and droughts), water and food disruptions, ocean acidification, and more.

The science of the climate has dramatically improved in recent decades, but we are now at a critical point that requires a redoubling of our efforts to improve our understanding of the physics of the climate and its interplay with Earth's other systems. A better understanding of the complexities of climate change and associated geophysical consequences should inform actions to mitigate carbon emissions and adapt to Earth system changes already underway. This research domain seeks to

improve our understanding of global climate and earth systems generally, and the application of this knowledge to allocate resources, mitigate carbon emissions, and adapt to climate change. Critical areas for further investigation include:

- Advancing the fundamental physics of climate science for robust predictive modeling.
- High-resolution modeling of continental, regional, and local consequences of climate change, including implications for water, food, and population disruption.
- Increasing precision of environmental sensing.
- Better understanding of ocean warming, acidification, and sea level rise and associated effects on ecological and marine systems.
- Extreme weather modeling and prediction.
- Political and economic dynamics and their impact on local, national, and international climate and environmental policy formulation.

Cities and infrastructure

Humans have irreversibly altered the face of the earth—through land clearing, settlements, cities, and infrastructure; power, water, and food systems; and, air, and sea transportation networks; and information systems.

Today, more than half of our species lives in cities, where 75% of energy is consumed and 75% of carbon emissions are produced. Urban populations are expected to double in the coming decades, and urban energy use and land areas will triple by 2050. Carbon emissions and other significant forms of pollution will inevitably accompany these expansions. The degree to which these waste streams increase will be greatly determined by the technologies and engineering solutions deployed to serve urban needs and the production, consumption, and planning policies implemented to influence our environmental footprint.

These questions are directly addressed by the emerging field of urban metabolism. The study of the resource requirements and environmental consequences of cities, urban metabolism is a powerful framework to reveal the resource intensity of cities as their demographics and economies grow and change. Novel approaches to urban systems and infrastructure, transportation technologies, and incentives for individual and collective behavior change are needed.

This research domain seeks to engage directly with cities, their decision-makers, and citizens to generate knowledge and partnerships to shift urban consumption patterns

toward a low-carbon future. Research priorities in this area include:

- Urban metabolism and the resource intensity of contemporary cities.
- The "Future City" and its environmental opportunities and challenges.
- Urban air pollution and electrification of transportation.
- Environmentally calibrated urban planning and design.
- Resource, waste, and demographic flows between urban and rural environments.
- Environmentally advanced aviation technologies and systems.

Sustainable society and economy

Our industrial world mobilizes enormous material and energy resources in the making and distribution of all manner of products, services, and systems. Adverse environmental consequences on humans and many other species are associated with energy and material extraction/generation and refinement, processing and production, transportation and consumption, and recovery and waste management. Transitioning these processes toward a more sustainable society and economy will require building in new capacities to anticipate and minimize environmental and cultural harm.

This research domain aims to reorient the relationship of individuals, organizations, and civil society to the environment; improve understanding of the interaction of technical, political, and cultural dynamics in energy and materials management; and apply creative engineering and design solutions for more positive environmental and social outcomes. Close engagement with a wide range of industrial partners will be critical to developing alternative modes for supplying society's energy and material needs. Research priorities in this area include:

- Environmentally positive resource extraction and processing, supply chains, and logistics.
- Design for reuse, disassembly, material recovery, and other extensions of material and product lifetimes.
- Regional and sub-national impacts of resource extraction on communities and cultures.
- Environmental toxicity: better understanding of diffusion, exposure, and health effects.
- Carbon pricing and/or tax.
- Cultural, behavioral, and ethical dimensions of forging a more sustainable economy.

III. Convening

Direct and sustained engagement with the world beyond MIT is critical to generating solutions that can be developed and deployed effectively where they are needed. Now more than ever, the world needs sustained support for decision-making based in rigorous analysis. ESI will foster effective communication and engagement with the greater world through various forms of convening that connect the MIT community with diverse experts and stakeholders, including business leaders, policy makers in government and leading nongovernmental organizations, and others.

ESI's convening activities ensure that our solutions are relevant to communities and constituencies experiencing environmental difficulty. They are also the key vector by which those solutions are brought into the world. Through our education and research activities, ESI brings MIT students, faculty, staff, and alumni together to work on human- environment challenges; through our convening activities, we connect the MIT community to the world.

We seek to achieve three goals with our convening agenda: to generate new cross-disciplinary, cross-sector insights that inspire action; to build societal capacity and resilience in responding to environmental problems; and to spark new collaborations that continually expand and energize the community of environmental problem solvers.

Current and planned convening strategies include:

- Environmental "war games" workshop to engage business and government leaders in developing response scenarios for societal disruptions resulting from serious environmental crises.
- Research-focused workshops and symposia that bring thought leaders and stakeholders together with researchers to identify and refine research questions and programs.
- Curated digital/online platforms where researchers and educators can share information and collaborate.
- Major reviews of research, policy, and technology aimed at developing pathways to better human and environment futures in key sectors of society, such as cities, aviation, and manufacturing.

The Time Is Now

The world is at a technological and societal crossroads in its relationship with the environment. Though we face significant known and unknown challenges, possibilities for regional and global solutions are emerging. Industry, government, and civil society must work together to have any real prospect of forging a promising future.

ESI is dedicated to leveraging MIT's unique culture and enormous capacity toward this end.

For More Information

Environmental Solutions Initiative
One Broadway, 12th Floor
Cambridge, MA 02139

esi@mit.edu

John E. Fernández '85, Director ESI
Founder and Director, Urban Metabolism Group Professor of Architecture

Amanda C. Graham, PhD Executive Director

Hannah Loomis
Senior Program Assistant