Systems, Complexity, Wicked Problems, and BSEC – An Explainer

June 2024. Miriam Avins and the BSEC Team

The Baltimore Social-Environmental Collaborative (BSEC) aims to generate climate science that can power good local outcomes. It aims to help policymakers address climate change while also meeting other priorities that neighborhoods value, and it aims to make science relevant and useful – right now and in the long run – to communities that have suffered the long-term effects of disinvestment, exclusion, and racism.

Complexity and systems are concepts that are helpful for understanding what makes problems like climate change and racial inequity hard to resolve. This explainer provides some basics of systems and complexity, and then relates these to the design and aspirations of BSEC.

Systems, Complexity, and the Physical World

Wikipedia defines a system as "a group of related things that work together as a whole." Anything we want to study in the natural or social worlds is a part of a system or a system itself, and often both. For example, there's plenty to study about what happens in a plant cell – genetics, cell division, photosynthesis. To fully understand any of these phenomena, however, we need to also study the environment the cell functions in – perhaps how materials are transported within a plant, or how sunlight interacts with cells. The system could be defined as the plant cell's parts; the whole plant; or the plant and its environment.

All of these systems are real. We can only understand and study them, however, by creating our own mental models of them. When we do this, we make decisions about the boundaries of the system. The boundaries chosen can strongly affect how hard a problem seems.

For example, in the case of climate change, we know that when there is more carbon dioxide in the atmosphere, more heat is trapped. The physical processes that bring this result are easy to trace. To understand the phenomenon, we only need to consider these elements as part of the system: the atmosphere as a whole, variation in the amount of carbon dioxide, and energy from the sun that's absorbed by the planet. In simple systems everything is knowable and relatively easy to understand. The simple causation path is that an input (more carbon dioxide) causes the atmosphere to increase in temperature, due to absorption of energy.

But will temperature actually increase the same amount everywhere? That's a more complicated question, and to answer it we would need to add more elements to the system under study: perhaps established weather patterns and how they dampen or magnify the heating effect. The answer is possible to trace by studying how individual components interact, but it's much harder to do so. Complicated systems are like simple systems, except that there is far more to keep track of.

But in fact, climate change is a complex problem. In a complex system, the elements of the system actually generate their own behavior in ways that are unpredictable. For example, when the atmosphere heats up, forest fires occur more frequently and are more severe. This removes more trees (which would cool the air if they were still alive and standing), and releases more carbon into the air (which traps yet more heat). This can lead to even more forest fires. So far, this is a fairly simple explanation. What makes this *complex* rather than complicated is that once the process starts, the system may start to act in unexpected ways. For example, there may be thresholds of change beyond which there is a catastrophic collapse. Or the system may generate feedback loops that balance the trend toward more heat. And all of this might affect how *people* manage forests, leading to further unanticipated change. Delays between causes and their effects also make the system harder to understand.[1]

Climate change in cities has its own complexities. In cities, multiple human systems interact with (and disrupt) natural systems like topography, streams, and tree cover. These human systems include roads, buildings, geographic distribution of wealth, and more. The interaction of these systems brings unwanted results. For example, in neighborhoods where people are least likely to be able to afford air conditioning, heat can be worse. The people who live in poverty are more likely to suffer from many health conditions that make them more vulnerable to the effects of heat; they are also exposed more to high heat (for example, because they must wait outdoors for public transportation). The hottest neighborhoods are already among those with the lowest life expectancy. Efforts to reduce heat are also complex. Trees that thrive in cooler, more suburb-like neighborhoods might not survive in the densely urban areas where they are needed most, so tailored solutions are required. Even our knowledge of heat is affected by social systems: there are far more sensors for heat in whiter, richer parts of Baltimore city and county than in the neighborhoods most affected.

Notice that to understand the actual behavior of a system, we need to add more elements to our model of it. The more we add, the more closely the model will resemble the real world – and the more trouble we will have understanding it. This is a basic tradeoff that researchers, organizers, policy makers, teachers, and writers all grapple with. Is it better to "keep it simple, stupid" to generate actionable advice? Or is it better to try to build a more realistic model that is harder to understand and use? Simple models and solutions are attractive but are generally fallible. When we admit that a problem is complex, we are forced to recognize that solutions will generally be partial and temporary. This is uncomfortable and can also make it hard to rally support. On the other hand, we can recognize that we will need to adapt as we go. And we can recognize others' concerns as valid, and think about how to build solutions that meet multiple needs.

For centuries, science has focused on methods that are very successful at studying simple and complicated problems. In essence, one analyzes smaller and smaller pieces of a complicated problem to understand how the bits of it work – and then build up an understanding of the whole from these bits. It's great when it works, as in many problems in physics, chemistry, and

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[1] The discipline of systems analysis focuses on creating models of complex systems and trying to understand their likely behavior. For an introduction, see Donella H. Meadows, *Thinking in Systems: A Primer,* ed. Diana Wright, White River Junction, VT: Chelsea Green Publishing, 2008.

engineering. To study complex problems, however, one must study the functioning of the system as a whole. This is frequently necessary in biology, and when approaching a subject that involves interactions within or between living things.[2] Unfortunately, we often fall into the trap of thinking that we can understand things by understanding their components rather than looking at them holistically.

Complexity and Policy: When People's Needs are Part of the Picture

To talk about problems that involve people, it's useful to add an additional category: "wicked problems." These are complex problems that look different to different people or groups (because each draw different mental models based on their perspective). Important social problems tend to be wicked.

In general, the description or framing of a wicked problem is dominated by the perspectives of more privileged groups. A strong focus of struggle by less privileged groups is to reframe problems in ways that match their experience. Privileged groups will expect to see their needs met by the process of finding a solution. Less privileged groups will have to fight harder for their needs and may seek recompense for many ills. With wicked problems, it's very hard to work toward a common understanding that allows for creative problem solving.

For example, cities and other municipalities must ensure that residents receive many services, including trash removal. Trash can be placed in a landfill, which has a limited capacity, or it can be burned, with the advantage of generating electricity. From one perspective, this is great: two goals served with one machine. But those who live near a trash incinerator may be forced to breathe more polluted air, leading to various health problems and causing more people to die younger. As a society, we often disregard the needs of those who are most vulnerable to such costs, especially when they are poor or non-white. In Baltimore, the WIN incinerator in Baltimore has been a focus of struggle for the South Baltimore communities for many years. Advocates have tried many paths to shut down the incinerator, framing the issue in different ways. They have worked with City government to consider approaches that drastically reduce the amount of trash that Baltimore produces. They successfully pushed for Baltimore City legislation that would hold the incinerator to tighter rules on pollution (this gain was lost in a lawsuit). Most recently, advocates have filed a federal civil rights complaint.[3] WIN incinerator pushes against these efforts, and Baltimore City government remains risk-averse about losing any current capacity for trash. The different stakeholder groups have different objectives, and at least some of them have more than one objective. It can be very hard for diverse stakeholders to think creatively about how to move toward a future that they would all be glad to live in when so many things are at stake and when people feel vulnerable. (Note that the vulnerability of those who run the incinerator is about work, while for those who live near the incinerator it is about health.)

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[2] See, for example, https://medium.com/@hsabnis/organic-and-inorganic-systems-6200e4c90ca4, for an explanation of "organic systems."

[3] https://www.thebaltimorebanner.com/politics-power/local-government/baltimore-trash-incinerator-complaint-WPG2TBTVGVA2TBF74SKL4RSM7E/

The world of policymaking often treats complex and wicked problems as if they are merely complicated. A small number of causes and goals become the focus. Solutions are identified that provide the best chance of meeting the focal outcome – without enough work to see what other important goals should be included, or how the proposed solution may play out over time for various goals. In addition, many of the outcomes that stakeholders value may be hard to measure.

For example, there is a proposal to add sulfur dioxide to the upper atmosphere, which would deflect some solar radiation, providing relief or reversal of warming. In sufficient quantities, sulfur dioxide also causes acid rain, which greatly harms ecosystems. To model the long-term effects of this intervention for, say, aquatic life, would require creating an expansive model.

Policy is a complex and unpredictable environment. As policymakers and the entire political environment struggle to understand issues, they may favor simplicity and explanatory power over the complexity of human life and politics. We need to embrace complexity if we are to identify solutions that best support the ability of human, animal, and plant communities to thrive.

Complexity and BSEC

How does BSEC work with complexity?

First, both climate action and racial equity – the two problems at the center of BSEC – are complex and wicked. This is hard material. Much of the physical research is based on models that view the phenomena they study as complicated. At the same time, both BSEC's interdisciplinary approach and its community engagement seek to add multiple relevant perspectives and insights.

The Equitable Pathways decision support tool at the heart of the BSEC process is a way to cope with complexity in policymaking. The Equitable Pathways tool incorporates many goals, causes, and interventions. It's a computational tool that seeks to optimize for many goals at once, and it can also identify pathways that will fail in important ways. This material is meant to inform conversations among stakeholders about tradeoffs and new information to gather.[4] (See BSEC's explainer for more information.)

The structure of BSEC itself appears to be complex – multidisciplinary teams made up of researchers and practitioners at multiple institutions, and the Equitable Pathways Steering Committee – and so outcomes are unpredictable. This is actually a strength. A simpler research design would be more predictable, but would also fail to address the concerns and complexity of neighborhoods and to take full advantage of the opportunities for neighborhood-based research that require close collaboration.

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[4] Note that the Equitable Pathways model is not the same as a formal systems analysis. It is a different way to deal with complexity.

BSEC is nested within a larger and complex system: Baltimore City as it faces climate change. The ultimate goal goes beyond BSEC's research goal: it is to implement strategies that will improve equity as Baltimore adjusts to climate change and that can also address decades-old inequities. To be most effective, BSEC must think about how to foster the ability to get to implementation. BSEC can do this in at least two ways. First, by including knowledgeable community partners and building communities' knowledge and engagement around climate change, it aims to co-generate scientific understanding and identify potential policy directions. Second, it can draw in organizations that focus on issues that BSEC is also studying, creating avenues for effective advocacy fueled by pertinent research.

The complex problems that BSEC seeks to address are daunting, inherently difficult, and often enraging. They also can't be ignored. A just and resilient future depends on our ability to come together to understand, to design, to argue, and to implement a way forward. BSEC seeks to be a platform for that journey.