Systems Analysis to Inform and Support Global Transformations

By Stephen M. Robinson, Elena Rovenskaya, and Ulf Dieckmann

Governments and private decision-makers worldwide now confront problems of unprecedented difficulty. The challenges include the increasing scale and coupling of complex systems, the acceleration of technological advances, economic interactions, and information flows.

New Kinds of Global Challenges

Four relatively new trends heighten the difficulty of the aforementioned problems. First, the *increasing scale* of the world's population and people's activities—and hence their impact on the natural environment—runs the risk of exceeding planetary boundaries. Secondly, *interdependencies* among people, companies, and countries have grown to the extent that local failures in public services can create mass emergencies; the systemic risk underlying the latest global financial crisis is a prominent example. Thirdly, the high speed of *technological advances* presents challenges to long-term planning, such as the planning of investments in large infrastructures subject to high uncertainties. And lastly, the advent of new social media facilitates mass agitation over contentious issues, often leading to *irrational politicization*.

Traditional technical education in operations research (OR) does not provide sufficient tools for assisting decision-makers in handling these problems. It is still common to analyze systems via a quantitative model for predicting their future—either deterministically or stochastically—and then examine the ways in which a single, known criterion for the goodness of a solution varies with decisions. Students in traditional university programs learn effective technical methods to make such analyses, producing what are often called "technocratic" solutions. These solutions are important and useful, but insufficient to serve as guidelines for handling problems of the kinds described above.

For one thing, decentralized decision-making under bounded rationality is a characteristic of many of these problems. One must account for this, as well as for the aforesaid interdependencies, to produce feasible solutions. For instance, enhancing transportation to improve an area's economic condition will not work if those influential in the local government block the new arrangement to preserve their monopoly on transportation. Likewise—an actual, recent example—a program that builds wells to provide clean drinking water in rural areas will fail if villagers are not both able and motivated to keep the pumps in good repair.

A typical OR graduate is unlikely to see the real problem in such situations, because the key dimensions in these examples are not primarily technical, and often not even economic, but rather social and/or political. Moreover, even if the graduate is able to clearly recognize the additional dimensions, he/she will not typically possess a toolkit of skills for tackling them. In addition, the graduate will often not know how to carry on a constructive conversation with stakeholders in terms they can understand.

Systems Analysis: A Multidimensional Tool

Over the past decades, the field of systems analysis has matured into a broadly applicable tool for the development of integrated multidisciplinary solutions and policy advice for some of the world's most pressing problems. From its inception in military analyses during World War II to its extension to civic applications pioneered by the RAND Corporation, modern systems analysis employs concepts, models, and methods that help account—simultaneously and as seamlessly as possible—for a problem's interwoven technical, economic, social, political, and communication dimensions.

Systems analysis looks across borders and sectors to identify feedbacks, trade-offs, and synergies. For this purpose, it builds on and interlinks sectoral and disciplinary approaches to enable holistic and global outlooks. In doing so, it strives to recognize uncertainties, nonlinearities, adaptive capacities, tipping points, bounded rationality, and normative pluralism. Systems analysis helps identify smart pathways through the complex nexus of interdependent processes to reach a world that accommodates the needs and aspirations of different groups and respects the limits imposed by the planet itself.

CAREERS IN MATHEMATICAL SCIENCES

For the last 45 years, the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, has led developments in systems analysis, continually enhancing the field's methodologies and strengthening its applications. Problems of global and universal relevance lie at the heart of IIASA's research agenda, including sustainable development, climate change, energy strategies, environmental protection, resource utilization, land-use change, ecosystem management, risk and resilience, and population growth. Recent impacts of IIASA's research range from shaping European Union air pollution policy to providing results central to the Paris climate summit negotiations.

New Challenges Require New Preparation

Dealing with the aforementioned global and universal problems requires access to skills in multiple dimensions covered by systems analysis:

- **Technical skills:** Our current educational sector does this quite well.
- **Economic skills:** How to assess costs and benefits, both direct and indirect?
- **Sociological skills:** What solutions are acceptable in a given situation? Why and how can such acceptability be changed?
- **Political skills:** Who will stand in the way of certain solutions? Why and how can such obstacles be overcome?
- **Communication skills:** How can we talk with stakeholders to promote mutual understanding?

Focus-group discussion with local farmers who are non-beneficiaries from the considered irrigation site in Ethiopia. © Christoph Perger (IIASA).

Training graduates across this skill profile may seem hopelessly unrealistic. OR students already spend much time learning about the technical dimension in their study area, which is why they become good at it. There is no way to formally teach them—at a similar depth and breadth—economics, sociology, politics, and communication.

The key is to recognize that "access to" does not necessarily mean "mastery of." What we should be able to do is teach the students both how to work with experts in these other dimensions, and why such collaboration is necessary to develop solutions to problems arising in complex systems. As yet, few OR programs do this effectively. Some do not even realize that the problem exists.

A Practical Way Ahead

How might we change this situation? A helpful role model might be the "capstone" courses taken shortly before graduation by students in many engineering programs. In these courses, students work in teams to solve real-world problems in their respective disciplines, often in cooperation with industries or government agencies. This helps prepare them for the kind of situations they will face after graduation.

If we want to build competence in teamwork when not all team members are from technical disciplines, it makes sense to do so by having students work to solve a complex, multidimensional real-world problem under the guidance of experts skilled in multidisciplinary research. In fact, this is quite feasible; the Young Scientists Summer Program (YSSP) at IIASA has utilized this approach for nearly 40 years, bringing together about 50 young scientists for three months each summer to work in this format as a multidisciplinary group.

The YSSP has been very successful, but it is small and cannot possibly provide as many skilled systems analysts as will be required for dealing with current global and universal problems. However, a revision and expansion of capstone courses in strong OR departments all over the world, to train students for work in multidisciplinary teams on complex problems, could significantly enlarge that pool of analysts. There is surely no lack of such problems for them to solve.

Where can we find the students graduating in other disciplines to complete the needed teams? Here it is helpful to think about the career challenges graduates in sociology, political science, communication, or other disciplines currently face. The job markets in those areas are often much less promising than those in the science, technology, engineering, and mathematics (STEM) fields. Would not some of those graduates find interest and appeal in contributing to solutions for some of the most difficult problems facing humanity? And would not an effort like this help build bridges among very different disciplines, leading to new perspectives on those problems – perspectives that we would never see if we do not leave our silos?

Universities and their schools are very unlikely to take the initiative for a change of this magnitude, but professional societies are in a good position to lead. Through meetings and publications they set the standard for what is currently important, thereby putting pressure on academic programs that otherwise might not recognize the need to change. By thus transforming the conversation, professional societies could play a critical role in advancing competence in techniques that humanity already needs now, and will need even more in the future.

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In cooperation with the International Fund for Agricultural Development (IFAD), the International Institute for Applied Systems Analysis (IIASA) supports the impact evaluation of IFAD-funded projects by collecting data from farmers in the field, to be fed into models supporting the development of future policy scenarios. The image shows an IFAD-funded irrigation site in Ethiopia. © Christoph Perger (IIASA).