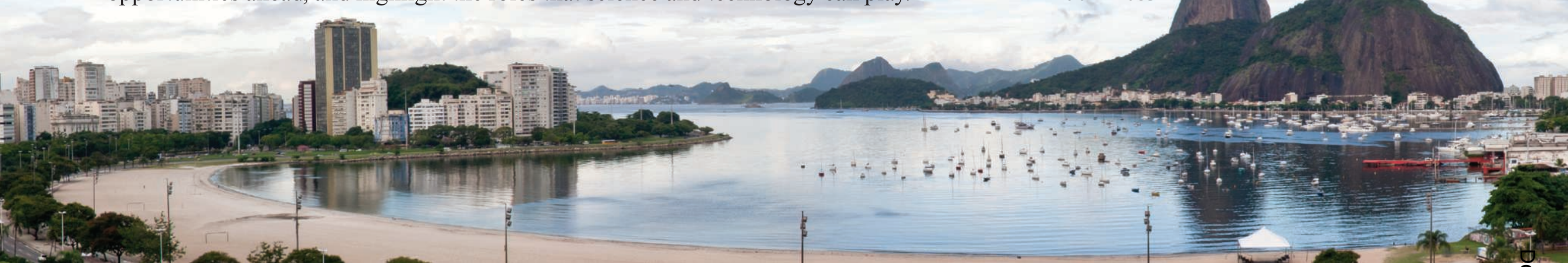
ESSAY

RIO+20

Science for Sustainable Development

The United Nations Conference on Sustainable Development takes place in Rio de Janeiro, Brazil, on 20 to 22 June. Dubbed "Rio+20," the conference comes 20 years after the 1992 UN Conference on Environment and Development, also held in Rio. That '92 "Earth Summit" produced 27 guiding principles and the adoption of Agenda 21, all focused on sustainable development. *Science* invited experts from different countries, institutions, and fields to reflect on progress thus far, anticipate challenges and opportunities ahead, and highlight the roles that science and technology can play. **–Brad Wible**



Analyzing Sustainable Development Goals

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The Rio+20 agenda has grown from two uninspiring, but essential, foci, the green economy and institutional framework for sustainable development, into a chaotic catchall for the world's woes. Neither approach offers much hope of attracting the attention of world leaders needed to make the conference a success. In recent months, though, one promising idea has emerged:

... [sustainable development goals] deserve deeper analysis of interconnections and synergies ...

universal sustainable development goals (SDGs). Proposed by Colombia and Guatemala, SDGs have gained momentum and could provide a much-needed "big idea." Much work, including early engagement from science, needs to be done to ensure success.

The new goals would likely expand on the United Nations Millennium Development Goals (MDGs) due to end in 2015. But several key differences must mark SDGs. First, MDGs centered around seven social goals and just one environmental goal. Long-term social and economic improvement will need closer attention to be paid to the environment. Second, whereas MDGs focused on developing countries, SDGs need buy-in from all nations. Third, MDGs were hastily assembled without thorough analysis. In spite of this, there have been successes, particularly those with quantitative targets such as universal primary education (MDG 2) and access to safe drinking water (MDG 7). SDGs deserve deeper analysis of interconnections and synergies between goals, trade-offs, and indicators and targets.

The March conference, Planet Under Pressure, held the first major science-policy dialogue on SDGs, jointly organized with the team set up to direct the post-2015 MDGs. The resulting State of the Planet Declaration endorsed the SDG proposal, but the conference concluded that rushing to identify goals without in-depth dialogue with all stakeholders would be a grave mistake. Given that we have 3 years left to run on MDGs, there is no excuse to sidestep such a deep analysis. The global scientific community is ready to participate in the codesign of the SDGs and related measures. The launching of the 10-year Future Earth initiative focusing on global sustainability solutions is an example of their commitment and that of their funders.

The Urban Challenge

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"The Urban Challenge" was a chapter in the 1987 Brundtland report, *Our Common Future*. The issues remain depressingly familiar for Rio+20. Urbanization has continued around the world, sometimes diminishing rather than enhancing social and environmental capital. Urban populations then 2 billion are estimated to have reached 3.5 billion. But three unforeseen new factors have changed the world's urban landscape since the 1980s: globalization of transportation, information technology, and clean energy. Globalization could only have taken place with adaption of cities (and their ports) on a scale without precedence. Driving that change have been leaps in logistics and transport technology. Modern cities have become inseparable from the means with which they link to each other. The scale of production and consumption in modern cities is awesome, not least for the problems created in waste and pollution. At the heart of these issues is continued availability of clean energy that is affordable for all and less dependent on fossil fuel. The race is on to reconfigure urban processes and land-use patterns to extract the most from waste streams of matter and energy and to minimize the resource overhead of transport.

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Finding optimal solutions for the complexity of the growing modern city is beyond the reach of conventional pencil-and-paper city master planning. Cities are turning to increasingly sophisticated software decision-support tools both to minimize internal transportation needs and to optimize the locational opportunity to recover high-grade waste energy and material flows to lower-grade uses. At the moment, even the powerful optimizers used in process industries are hard pressed to tackle the formidable "integer programming" problem presented by the myriad of possible networks of resource flows of a modern city.

Nevertheless, the prospect is a possible halving of primary resource use, and it will have to be achieved. One study of global data for cities sounds the warning; as urban population grows, major innovation cycles have had to be generated at a continually accelerating rate to sustain growth and so avoid stagnation or collapse. The urban citizen is running with no time to take breath.

Harnessing New Scientific Capacity

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There is worldwide recognition that progress on Agenda 21, the result of the 1992 Earth summit, has been woefully insufficient. Rio+20 must start a process where all countries, North and South, commit to sustainable development and the "greening" of their economic systems. But there will be no green economy without clean technology, innovation, and sound science. For the proposed Sustainable Development Goals to be effective, they should include a call for a mechanism for international scientific cooperation and coordinated research on major sustainable development challenges—building on, and working with, existing programs. Recent decades saw the development of a robust research community in many developing countries. They should be part from the start of an effort that would gather existing knowledge and coordinate research on key sustainable development and green economy issues—working with the private, public, and nonprofit sectors—and would enhance collaboration with policy-makers, funders, and other stakeholders in designing, implementing, and communicating research. Another important aspect of this mechanism would be promoting and coordinating capacity-building in science and technology where needed. To promote progress toward these goals, ICSU and its partners will launch, during Rio+20, a new, 10-year global initiative, Future Earth: Research for global sustainability—a voluntary commitment from the scientific and technological community. Such initiatives should allow a more effective transition to the sustainable development we want.

From Industrial Toward Ecological in China

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Since the 1992 Rio summit, China has been on the fast track to industrialize and urbanize, having transitioned from a low-income developing country into the second-largest economy in the world. But many, including President Hu Jintao, have admitted that the current conventional path to industrialization and urbanization is unsustainable. Although China has met the millennium goals for poverty reduction, there have been increasing disparities between rich and poor, rural and urban, and coastal and inland regions. Concerns are growing over water availability and pollution, land degradation, depletion of exhaustible resources, and so on.

China has no choice but to lead the way for a new paradigm of sustainable development. In 2007, China called for shifting from traditional models of production and consumption to more environmentally friendly and resource-saving models. Among 17 mandatory targets in the 12th 5-year (2011–2015) plan, 12 are related to the protection of natural resources and the environment, with the rest for social welfare improvement and with none for economic growth. Although progress has been slow, actions are being taken: progressive pricing for electricity consumption introduced; energy consumption quota and emission targets disaggregated for implementation and monitored; emissions trading schemes experimented; initiatives for eco-cities and low-carbon cities developed and implemented; and building codes upgraded and enforced. Moreover, the rate of GDP growth is no longer considered the primary indicator for evaluating the performance of local government officials. The official target is set at 7% per year as compared with two-digit figures in the past decades. In many aspects, China is accelerating the transition from industrial to ecological civilization. Looking beyond Rio+20, although the road will be difficult and will require intensified international cooperation, there is reason to believe that sustainable development is not simply a slogan or vision but a real ongoing process in China.

Creating the New Development Ecosystem

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Twenty years after the Earth summit, we continue to face tremendous challenges to ecological, human, and national security. Development is the frontline defense, but traditional approaches are no longer sufficient. Development interventions have been dominated by a handful of bilateral and multilateral institutions that defined the problems and implemented a narrow set of solutions. Although there have been tremendous successes, this has not been enough to reverse the continued degradation of our environment or to overcome entrenched problems. To turn grand chal-

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lenges into grander opportunities, we must harness the entire planet's creativity to contribute novel solutions.

The USAID and its partners have crowd-sourced the world to apply science, technology, and innovation against seemingly intractable barriers to solving the Grand Challenges for Development (GCDs) and to catalyze global action to achieve scale, sustainability, and impact. Between 25 and 50% of the proposed solutions to the first two GCDs (Saving Lives at Birth and All Children Reading) have come from developing countries. A new partnership between USAID and the U.S. National Science Foundation (NSF), Partnerships for Enhanced Engagement in Research, generated 488 proposals from 63 of the 79 eligible countries with a USAID presence to partner developing-country scientists with NSF-funded American scientists on shared global development problems. These programs, and others like Open-Source Drug Discovery, recognize that developing countries are sources of solutions and ideas as much as developed countries. Constraints of low-resource settings allow for creation of efficacious world-class products that can cost less and have a smaller environmental impact.

Democratization of science and technology, increases in global connectivity, and greater availability of data will facilitate a movement from a handful of traditional global development agencies toward 7 billion development agents. Cell phones, for example, have been tools of transformation that moved societies beyond traditional infrastructure barriers, serving as platforms for services and learning, providing remote diagnostics for medical treatment, identifying centers of corruption, and serving as distributed sensors of communities and their ecosystems. Our planet's future, driven largely by developing countries, will depend on whether we can work collaboratively to leapfrog 200 years of industrialization and to harness the power of science and technology to create a new revolution based on knowledge.

Systems Science for Policy Evaluation

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Narrowly focused, single-disciplinary science alone cannot adequately underpin policies and solutions to resolve major sustainability challenges. For science to play a pivotal role in addressing the green growth and sustainability challenges of Rio+20, or the UN MDGs, we must rapidly refocus intellectual and economic investments toward multiscale, integrated, interdisciplinary approaches that consider social, economic, and environmental aspects, that look across and between borders and sectors, and that identify feedbacks or the cobenefits of a policy or management decision, before it is made.

... academic merit should value and reward integrated, multidisciplinary "systems science," ...

One example of this "systems" approach is the Global Energy Assessment (GEA), a multiyear, multidisciplinary study (coordinated by IIASA), whose findings will be released during Rio+20. The GEA links energy to climate, air quality, human health and mortality, economic growth, urbanization, water, land use, and other factors. The GEA scenarios find that energy access for all (by 2050) is possible with cobenefits of limiting warming to 2°C, improving air quality and human health, and stimulating economic growth within a green economy framework. A similar analysis on water resources will be undertaken by IIASA, UN Water, and the World Water Council.

On the basis of our experience with the GEA, realizing the sustainability goals of Rio+20 will require investment in integrated analyses to fully understand the Earth system (human and natural). This must be enabled by substantial growth in public-private partnerships that stimulate and fund activities that encourage collaboration between social and natural scientists and that engage key stakeholders in the user community at all stages of the research cycle—from inception to implementation. In addition, academic merit should value and reward integrated, multidisciplinary "systems science," with scholarships and tenure no longer dominated by single disciplines. Above all else, success requires clear leadership and defined objectives.

Rigorous Evaluation of Human Behavior

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Scientific and technological advances, combined with an internationally coordinated effort to help the diffusion of those technologies to poor countries, have had important impacts on the quality of life for millions of poor people. For example, antibiotics and vaccinations have dramatically increased life expectancy. New seeds have promoted a "green revolution," making several Asian countries self-sufficient for their food needs. Some current development challenges undoubtedly would benefit from new technologies. The world still needs vaccines for malaria and HIV, as well as crops better suited to Africa.

The contribution of science to development and poverty alleviation, however, should not be limited to facilitating the development of new products. For there are numerous technologies that are known to be effective but have not been widely adopted, from bed nets to chlorine to iron pills. And others

have yet to prove their effectiveness in the real world, despite their promise in the lab, such as cheap laptop computers in schools. The missing part is often recognizing human behaviors that are barriers to adoption or correct use and designing appropriate policies to address them. A recent experiment on improved cookstoves, for example, showed that the stoves were not properly used or maintained. This was sufficient to override the encouraging effects of stoves on health that were found in more controlled conditions.

In the last 15 years, social scientists have adopted the method of randomized controlled trials (RCTs), one of the key tools of scientific practice, to evaluate development policy. RCTs allow researchers and policy-makers to rigorously evaluate the impact of an intervention. Once very rare in social science, they are now widely used: Hundreds of RCTs are currently being run to evaluate the impact of policies ranging from police reform to the health impacts of fortified foods. Beyond the obvious value of finding out what works and what does not, RCTs can also shed light on the reasons for individuals' behavior, by incorporating insights from economics, psychology, and sociology into the design and analysis of experiments. This makes for good science; these experiments make it possible to test scientific hypotheses with a degree of rigor that was not available before. It is also essential to the design of policies that take our human nature into account. This is the new frontier for the collaboration between science and development policy.

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Science

The Urban Challenge

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