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Global environmental change research: empowering developing countries

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ABSTRACT

This paper discusses ways to reconcile the United Nations Millennium Development Goals with environmental sustainability at the national and international levels. The authors argue that development and better use of sustainability relevant knowledge is key, and that this requires capacity building globally, and especially in the less developed regions of the world. Also essential is stronger integration of high-quality knowledge creation and technology- and policy-development, including, importantly, the creation of centers of excellence in developing regions which effectively use and produce applications-directed high quality research and bring it to bear on decision making and practices related to environmental change and sustainable management of natural resources. The authors argue that Southern centers of excellence are a necessary first step for bottom-up societal transformation towards sustainability, and that such centers must help design innovative ways to assess and place value on ecosystem services.

Key words: sustainability, Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), knowledge, development, ecosystem services.

INTRODUCTION

The United Nations Millennium Development Goals (MDGs) are ambitious targets. They aim to lift over 500 million people out of poverty while simultaneously promoting sustainable development at the national and international levels, reversing the loss of environmental resources. Are these two objectives compatible? Historically, most developed countries have moved out of poverty by progressing from subsistence agriculture to an industrial economy. If this process is repeated in pursuit of the MDGs, will this not inevitably add pressure on the natural resources of an already strained global environment? Concluding in the affirmative, many already see the objective of global environmental sustainability as one more unrealistic burden at odds with the development needs of poorer countries of the world.

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This impasse needs to be overcome, urgently. The development and better use of sustainability relevant knowledge is key. For this, capacity building is needed across the board. It requires stronger links between knowledge creation and technology- and policy-development, including the creation of applications-directed high quality research institutions focused on environmental change and sustainable management of natural resources. Establishing such centers of excellence in developing regions is a necessary first step for bottom-up societal transformation towards sustainability based on sound scientific knowledge.

Global, regional and local environmental change has long been a concern of a number of global environmental change (GEC) research programs, such as IGBP, IHDP, WCRP and DIVERSITAS. A growing number of scientists from developing countries have participated in GEC research projects and capacity building activities. More recently, under the Earth System Science Partnership (ESSP), joint projects on food, water and health were initiated to address questions of direct relevance to developing regions. ESSP also promotes and facilitates Integrated Regional Studies (IRS) focused on a few regional hotspots of environmental change.

New research needs to further specify what kinds of knowledge can make a difference to actual sustainability-related decision making. Such research needs to identify and target root problems and it must strive to ensure that the resulting knowledge is both usable and actually used. What are the sustainability-inhibiting factors at the levels of the funding and production of science and its use in governmental decision making and "on the ground" in local settings?

This paper will identify some central challenges involved in bringing about applications-oriented research and institutions bearing on sustainability. To add specificity, it will focus on the achievements and challenges of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA).

EVALUATING THE LBA

The LBA is an example of an integrated regional study carried out by an international science program – indeed, the largest program in international scientific cooperation ever focused on the Amazon region. It involves collaboration between predominantly Brazilian, American and European environmental scientists and institutions and had an annual total budget of around US$ 12-15 million for the years of its first, more international phase (1998 to 2004), the period of intensive field campaigns and especially strong international involvement. [The program's first phase ran from 1998 through 2006. NASA continues its support of collaborative synthesis activities through 2008. During its second phase, the LBA is a more national program, with continued, but more limited, participation of foreign scientists]. These costs were shared mainly by Brazil and the U.S. National Aeronautics Space Administration (NASA), with Europe contributing a smaller part. (Although NASA has contributed the largest share of direct funds, Brazil is estimated to have contributed at least half of the funding for the LBA indirectly through facilities made available to the LBA, as well as salaries of LBA-involved Brazilian scientists and student scholarships). The LBA has carried out over 120 studies over the past decade, advancing quantitative and qualitative understanding of the functioning of tropical ecosystems and their linkages to the Earth System. It has produced over 700 peer-reviewed publications, the vast majority in international science journals.

The LBA has self-consciously sought to improve past models of "scientific colonialism" in which Northern-funded science experiments in less developed countries did little, and usually nothing at all, to improve the knowledge and infrastructure in the latter (note: henceforth, "North" and "South" refer to the *global* North and South unless otherwise specified). Brazilian law requires that Brazilian scientists serve as principal co-investigators in international scientific projects on Brazilian soil, and Brazilian scientists in the LBA worked insistently to make their full, scientific collaboration in all projects under the LBA a reality in practice. Diverging from past examples where Northern scientists leave the country with the data such that it fails to benefit the region and its scientists, the LBA left an extensive material infrastructure in place for environmental research in various sites in the Amazon (e.g., vehicles, measurement towers and other equipment), and emphasized and institutionalized free-of-charge data sharing and mutually beneficial scientific collaboration between Southern and Northern researchers. Finally, and importantly, the LBA has trained hundreds of young scientists, most of them from Amazonia. Some of the above stretched NASA to support development, something beyond its official mandate.

The LBA fell short in other respects, however, in particular in its explicit goal to produce sound scientific understanding in support of sustainable development. Lahsen and Nobre (2007) tie these shortcomings to a variety of cultural, institutional and political factors, including the professional, normative and experiential backgrounds of LBA's planners, all of whom were natural scientists, relatively unfamiliar with how to apply their "cutting-edge" science to real, on-the-ground practices bearing on sustainability, and locked in institutions whose incentive structures encourage new knowledge over its application. In these respects, the LBA reflected more general tendencies. Sustainability needs as a whole challenge long-standing, institutionalized practices and normative frameworks that structure the organization of science in the North as in the South, from how scientists select, plan, execute and communicate their own research to how they evaluate the work of others and think about the relationship between science and societal problems. The LBA overcame some hurdles (described above), but a single science program does not change such deeper structures.

Deforestation of the tropical forests of Amazonia has increased to clearly unsustainable levels and at great social and environmental cost. Sustainable management of ecosystems requires appropriate public policies and regulatory frameworks. Yet translating the scientific knowledge created in LBA into public policies has proven difficult. Knowledge and capacity to develop and disseminate appropriate technologies and methodologies for sustainable management of the environment are key to overcoming this difficulty. Few developing countries are making substantial investment to develop this capacity. This is of huge consequence as the funding-structures, interests and incentive structures – and even the knowledge base – of developed-country-dominated international scientific efforts are inadequate to meet present challenges. The LBA serves to illustrate this inadequacy (Lahsen and Nobre 2007).

Aside from merely identifying humans' environmental impact, the LBA's mission, as stated in its planning document, was to help safeguard the Amazon's basic ecological processes. In addition to scientific capacity building, the sustainability dimension is the most obvious point where LBA research could bring benefits at the local level. It is also the least developed dimension of the LBA. An independent mid-term review concluded that the program had performed weakly in the area of identifying and developing social, political and economic implications of the findings, especially as concerns sustainable development in the Amazon region (Philippi Junior et al. 2003).

DISCUSSION

One may look for part of the root trouble in resource disparities between the global North and South. Resource limitations and weak institutions weaken the science-policy interface in less developed countries (Kandlikar and Sagar 1999, Lahsen 2007), and as such also weaken efforts to assess and combat human-induced climate change and associated effects. It also limits the level of participation and input of less developed countries in international scientific programs and policy efforts, allowing Northern nations, and especially the United States, to overwhelmingly dominate the production and framing of science underpinning international environmental negotiations. Studies suggest that this dominance can translate into political gain and that it at times weakens less developed country representatives' trust and regard for international environmental assessment and negotiation processes (Biermann 2001, Fogel 2002, Kandlikar and Sagar 1999, Lahsen 2001, 2004, 2007, Lahsen and Öberg 2006, Miller 1998).

Simply modeling science agendas in the South on those in the North would be a mistake, to the extent that this would perpetuate the evaluation criteria and incentive structures that prevail in the North. The latter results in high quality research, yes, but does not necessarily maximize knowledge applications at the regional, national and local levels. What is considered most interesting, scientifically or politically, by Northern country actors may not integrate the same priorities that best serve less developed countries, especially at the local level in the Amazon. Thus, for instance, the dominant scientific question within the LBA focused on the role of the Amazon in the global carbon cycle. While this question connected strongly with international political negotiations and scientists' intellectual interests, more applications-oriented research could have done more to advance sustainability in the Amazon region. For instance, in the case of Brazil, the country needs a science and technology agenda integrating a development model for the Amazon on the basis of sustainable, economically viable use of its rich biodiversity. At present, no other country can serve as a model for this, as no tropical, developed country exists with a sophisticated economy based on use of diversified, primarily forest-based natural resources, facilitated by the use of science and technology. Less developed countries thus benefit from shaping their own national science agendas to their particular needs. Their ability to develop and shape their own, independent analytical bases is also fundamental to engagement on an equal basis in the technical international negotiations related to climate (Sagar and Kandlikar 1997). In the case of the LBA, having it led by an Amazon-based federal scientific institution was a way of strengthening science and technology capacity in the region and maximizing local involvement.

The creation of independent national and local capacity is not necessarily a panacea either, and has its own minefields. Independence is not necessarily easy nor total in a context of globalization in science and society (Lahsen 2001, 2004). It takes critical and thorough thinking and institution building to identify and advance national scientific and political interests at odds with those being served by international or foreign science agendas. Brazilian scientists – especially those in the richer regions in the South of the country but also some in the Amazon – are increasingly hooked into international science and subject to the same incentive structures as their Northern peers. For this reason, had an Amazon-based institution led the LBA from the planning stages on, there is no guarantee that sustainability concerns would have been more central. Inversely, it would be overly essentializing to think that no Northern analysts are able to identify and advance the scientific and political needs of less developed countries.

Ways must be found to link excellence in research more tightly to urgent environmental and societal problems, and there are indeed changes underway, as captured in calls for "sustainability science" (Clark 2003, Clark and Dickson 2003, National Research Council 1999). Idealized models of sustainability science describe precisely the kind of research of which more was needed for the LBA to fulfill its sustainability goal. Such research challenges the long-standing tradition in science to separate knowledge production from action; it spans spatial scales and diverse phenomena such as economic globalization and local farming practices; it accounts for the temporal inertia, complexity and urgency of processes involved (e.g., multiple stresses in the present causing long-term environmental degradation); it recognizes the expertise and important input that can be provided by practitioners without formal degrees and scientific credentials; and it focuses centrally on the character of nature-society interactions and seeks to guide these interactions towards sustainable patterns, promoting the social learning necessary to facilitate institutional and behavioral transformation (Cash et al. 2003, Cash and Moser 2000, Clark 2003, Clark and Dickson 2003, Guldin 2003, Kates et al. 2001, National Research Council 1999).

Evaluation processes are slow to reflect and encourage transformation in the direction of such action-focused science (Franklin 1997, Jacob 2001). As a result, even a supposedly application-oriented program such as the LBA awkwardly straddles old and possibly emergent paradigms in science, integrating central elements of the curiosity-driven model with *aspirations* of sustainability science more than actual *achievement* of the latter. It reflects the general state of sustainability science as an unfinished project. To date, few institutions, if any, have successfully combined the features that characterize sustainability science (Clark 2003); the LBA is the rule rather than the exception. For support of this point in the case of environmental sciences, see Baskerville (1997), Franklin (1997), Guldin (2003) and Peterson et al. (1997).

The LBA has produced some sustainability science-type research, but it is a small fraction of the overall pool of LBA projects. Specifically, to achieve its sustainability agenda, the LBA should have sponsored and integrated more social science research focused on crucial human dimensions of Amazonian sustainability problems at both the macro- and micro-levels, from the effects of global economic and political structures to local-level technology choices affecting land-use practices. By contrast, social science research under the LBA has focused almost exclusively on micro-level processes (see, for instance, Moran and Krug 2001, Moran et al. 2000). To better achieve its sustainability mission, the LBA should also have designed its research agendas on the basis of identified user needs, and integrated technology development and validation, in part by analyzing technology options and choices at the local level as well as social, ethical and environmental consequences of the various options and choices. This would have required more leading scientists in the LBA to have active interest and knowledge of local-level socio-economic practices and problems in the Amazon region, and that local institutions in the Amazon had led the program from the early planning stages and forward.

It becomes clear, then, that the obstacles to sustainability science are not exclusively financial. A central challenge is to transform long-standing, institutionalized practices and normative/cultural frameworks that structure the organization of science in the North as in the South, from how scientists select, plan, execute and communicate their own research to how they evaluate the work of others and think about the relationship between science and societal problems. Incentive structures encouraging high-level scientific publications and sophistication independent of criteria of usefulness largely explain the LBA's shortcomings with regards to its sustainability mission (Lahsen and Nobre 2007). Increasing the relevance of scientific research for sustainability in the Amazon thus depends on changes at these levels, as well as in curriculum content. The sustainability science literature is limited when it comes to identifying exactly how to effect changes at these levels, however.

Some might argue in favor of a *status quo* arrangement in which scientists working in the Amazon chose whether they want to let their work be driven by applications or curiosity. However, this presumes unlimited funds and time. Institutions and scientists that combine natural science with a sustainability agenda are insufficient in number, and their financial resources too limited, to solve the daunting challenge of nurturing ecosystem sustainability in the Amazon. The Amazon is being deforested and its natural resources degraded very rapidly, to the detriment of the global environment and the present and future quality of the lives of many people living in the Amazon and elsewhere. Human-induced global environmental change weakens ecological systems in the Amazon and thereby also further undermines invaluable ecosystem services that it provides and, thereby, also the livelihood of many who live in the region.

An important conceptual and structural feedback from developing countries in favor of environmental sustainability stresses the importance of defining adequate mechanisms for valuing environmental services. Using a framework from the Kyoto protocol, Christoph Häuser (Stuttgart Natural History Museum) recently proposed a global system to pay for environmental services provided by ecosystems. Quantifying physical systems such as the balance between the carbon dioxide released into the atmosphere and absorbed by oceans and terrestrial biosphere is already difficult. Quantifying intangibles such as indigenous knowledge is exceptionally challenging and bound to be incomplete, as no metric is sufficiently holistic to take all the important value dimensions into account. As scholars have noted, the value of a system refers to "intrapsychic constellations of norms and precepts" (Farber et al. 2002). That is to say, the moral framework people use to assign rights to things and activities hinges on subjective, cultural and historical conceptions, challenging efforts to establish uniform systems for translating ecosystem services into financial terms.

Using the best means available, mechanisms have to be created to compensate primary users of ecosystems for their efforts to use the latter in sustainable ways. Local Amazonian individuals and communities depending on a particular ecosystem for survival should receive greater compensation for such efforts, on a lifetime basis, compared to those using the natural resources for financial gain, e.g., by means of cattle raising, timber extraction or agriculture. For guidance, we might look to Costa Rica, where the Government has successfully devised a system which pays land owners to preserve both the functional and aesthetic attributes of ecosystems, including water quality (http://www.fonafifo.com/). We might also look to projects in Africa which link ecosystem service valuation to poverty and hunger reduction. In 2005, for instance, the USAID developed a strategy in partnership with the government of Mozambique to simultaneously generate economic profits to communities learning sustainable agricultural techniques and water-use patterns. The *Southern African Millennium Ecosystem Assessment (SAfMA)* provided innovative ways to assess ecosystem services, including the use of supply-demand surfaces, service sources and sink areas, priority areas for service provision, service hotspots and trade-off assessments (for a valuable evaluation, see Jaarsveldi et al. 2005).

An important part of the solution to the sustainability challenge is to create high quality research institutions throughout developing regions which integrate understanding of the interaction between social and ecological processes. Grounded on high-quality, robust scientific knowledge, regional centers of excellence with this approach in developing regions can nurture bottom-up societal transformations favoring more sustainable use of planetary resources. These centers must study environmental change and ways of nurturing sustainable management of natural resources, in part by devising better ways of identifying the actual value of well-functioning ecosystems. They should also be adequately linked to development of appropriate technologies. Putting this framework into practice is a way to ensure greater societal and environmental benefits from high quality research.

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RESUMO

Este artigo discute caminhos para conciliar os objetivos do desenvolvimento das Nações Unidas para o milênio (United Nations Millennium Development Goals) com sustentabilidade ambiental em níveis regionais e globais. Os autores argumentam que o desenvolvimento e melhor uso do conhecimento, com relevantes aspectos que facilitam a sustentabilidade, é crucial e que isto demanda investimentos na capacitação científica/tecnológica, fundamentalmente nas regiões menos desenvolvidas do mundo. É essencial também uma forte integração da tecnologia com a criação do conhecimento de alto nível e a estruturação de uma política pró-desenvolvimento que incluiria a criação de centros de excelência nas regiões em desenvolvimento do mundo, as quais efetivamente produziriam pesquisas de alta qualidade com foco e aplicabilidade direta para questões regionais, com potencial efetivo de influenciar diretamente nas decisões políticas e práticas com relação às mudanças ambientais e ao manejo sustentável dos recursos naturais. Os autores argumentam também que estes centros de excelência são um primeiro passo necessário para uma transformação a partir da sociedade em direção à sustentabilidade ambiental, e que estes centros devem contribuir ao desenho de caminhos inovadores na compreensão, utilização e valorização de serviços ambientais prestados pelos ecossistemas.

Palavras-chave: sustentabilidade, Experimentos de Grande Escala da Biosfera-Atmosfera na Amazônia, conhecimento, desenvolvimento, serviços ambientais.

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