Bridges to sustainable tropical health

Burton H. Singer* and Marcia Caldas de Castro†‡

*Office of Population Research, Princeton University, Wallace Hall, Second Floor, Princeton, NJ 08544; and †Department of Population and International Health, Harvard School of Public Health, 665 Huntington Avenue, Building I, Room 1113, Boston, MA 02115

Edited by Barry R. Bloom, Harvard School of Public Health, Boston, MA, and accepted by the Editorial Board July 8, 2007 (received for review January 31, 2007)

Ensuring sustainable health in the tropics will require bridge building between communities that currently have a limited track record of interaction. It will also require new organizational innovation if much of the negative health consequences of large-scale economic development projects are to be equitably mitigated, if not prevented. We focus attention on three specific contexts: (*i*) forging linkages between the engineering and health communities to implement clean water and sanitation on a broad scale to prevent reworming, after the current deworming-only programs, of people by diverse intestinal parasites; (*ii*) building integrated human and animal disease surveillance infrastructure and technical capacity in tropical countries on the reporting and scientific evidence requirements of the sanitary and phytosanitary agreement under the World Trade Organization; and (*iii*) developing an independent and equitable organizational structure for health impact assessments as well as monitoring and mitigation of health consequences of economic development projects. Effective global disease surveillance and timely early warning of new outbreaks will require a far closer integration of veterinary and human medicine than heretofore. Many of the necessary surveillance components exist within separate animal- and human-oriented organizations. The challenge is to build the necessary bridges between them.

global surveillance | health impact assessment | sustainable health | water and sanitation

> Health: Soundness of body; that condition in which its functions are duly and efficiently discharged. Spiritual, moral, or mental soundness or well-being
> Sustainable: Supportable, bearable. Capable of being maintained at a certain rate or level

Pairing together these definitions of ''sustainable'' and ''health'' (1), we consider three contexts where health is, and has been, prominently featured, but where a process of sustainability is either not clearly specified or where current practices and discourse serve to inhibit its coming to fruition. In each instance, a bridge between two or more communities is needed to bring sustainability and health together. Placing particular emphasis on tropical regions of the world, the purpose of this paper is to specify bridges in concrete terms, as three among a myriad of such connecting links that need to be forged if sustainable health is to become a widespread reality.

The first context for consideration is the phenomenon of polyparasitism, in which a single individual is infected with multiple parasites simultaneously (e.g., schistosomiasis, hookworm, and ascariasis). In many tropical localities, polyparasitism is the norm rather than the exception (2–7). Today, interventions for these diseases focus almost entirely on pharmacological treatments (2, 8–12). This amounts to an intensive concentration on the process of deworming infected individuals and doing nothing to prevent reworming, a decidedly nonsustainable set of programs whose objectives are, nevertheless, the promotion of improved health. It is curious that well documented evidence from the past [e.g., hookworm elimination in the southern United States nearly 100 years ago (13)] that indicates the critical importance of both deworming and prevention of reworming in a common program to ensure sustainability is largely ignored in the contemporary initiatives. A recent editorial (8) focused on the disease burden of what are referred to as ''neglected tropical diseases,'' precisely the intestinal parasites and geohelminths mentioned above, is a useful case in point.

A common denominator of many of the neglected tropical diseases (schistosomiasis, hookworm, and a wide range of geohelminths) is that clean water and sanitation at the household and community level could eliminate the process of reworming. Some of the public health discourse (14–16) mentions this category of interventions, but the unfortunate separation, in thinking and action, of what is regarded as the health sector from the engineering sector has led to the critical need to build a sturdy bridge between these communities. The section *Engineering and Health: Two Islands In Need of a Ferry Service* contains a discussion of this topic and presents concrete proposals for building sustainability into programs for the reduction, or even elimination, of diverse forms of polyparasitism.

The second context for a consideration of sustainable health is global surveillance and timely reporting of infectious disease outbreaks, with particular emphasis on tropical areas of the world. This issue had particular salience in the severe acute respiratory syndrome outbreak of several years ago (17), the bovine spongiform encephalopathy outbreak in the United Kingdom (18), and the current concern about avian influenza (19). A National Research Council Study (20) in the late 1980s, focused on emerging infectious diseases, placed a premium on the need for a global surveillance system. This is also a key ingredient in the new International Health Regulations adopted by the World Health Assembly in 2005 (21), which represents a fresh attempt to: (*i*) bring broad coverage to considerations of health threats, (*ii*) establish global surveillance via networks of official and unofficial data sources, (*iii*) set performance criteria and accountability for national public health systems, (*iv*) foster human rights protection, and (*v*) promote fair and transparent global health governance (22, 23). Linked to these objectives is the Foresight Project (24), whose basic objective is to provide a vision for governments and international agencies of how threats such as infectious diseases are likely to evolve in the future and, thereby, put forth strategies to help meet the challenges.

A common theme of these health-sector-based initiatives is that they lack a basis for enforcing protective public health action plans and providing the sustained financial support for an effective global monitoring and surveillance network. We find it disconcerting to read: ''The recent statement from the G8 summit in Russia, which calls for 'tangible progress' on international disease surveillance, will, *we hope*, encourage the

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This paper is part of a special series on Sustainable Health. See the related editorial on page 15969 and accompanying articles on pages 16044, 16194, and 16263.

Author contributions: B.H.S. and M.C.d.C. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

Abbreviations: HIA, health impact assessment; NGO, nongovernmental organization; SPS, sanitary and phytosanitary.

‡To whom correspondence should be addressed. E-mail: mcastro@hsph.harvard.edu.

www.pnas.org/cgi/doi/10.1073/pnas.0700900104

interational community to make that investment" (ref. 24, p. 1393). This expression of hope becomes particularly problematic in tropical countries because they decidedly lack the resources, personnel, and even global priorities that are put forth by the G8 countries. At the same time, surveillance systems and accompanying capacity building in the tropics are relevant for all countries as a result of the increasing interconnectedness of the entire world by trade, migration, and travel.

Rather than trying to acquire a revenue stream and a long-term capacity building program in the tropics in one large step, it would seem to be more practical to build the necessary infrastructure on the surveillance and scientific evidence requirements of an international trade agreement: the Sanitary and Phytosanitary (SPS) Measures Agreement negotiated in the Uruguay Round of the General Agreement on Tariffs and Trade from 1986 to 1992 (25). As discussed below in the section *Surveillance, Tropical Health, and Trade Agreements*, the SPS surveillance requirements are particularly burdensome for tropical countries, but this agreement has been adopted by all World Trade Organization (WTO) member states, which has served as an important catalyst for tropical countries to partner with wealthier countries to facilitate their capacity to comply with the surveillance terms. The longer-term goal is to build an infrastructure on top of the SPS-driven data systems that can lead to a full-scale surveillance system in the tropics and, obviously, in the rest of the world.

An especially positive feature of the SPS surveillance requirements is that they force a focus on integration of animal and human health, a bridge that has proven difficult to build on the basis of scientific desirability alone. Thus, the challenge and the opportunity posed by the SPS agreement is to identify strategies that can yield maximal payoff for public health from a set of measures designed to delicately balance health and safety without unduly restricting international trade.

The third context that we consider is health impacts of development projects and their mitigation. Although health impact assessments (HIAs) for government and private sector development have become increasingly institutionalized in the U.S. and Western Europe (26), a very different process, which is often obstructive to sustainable health, is operative in tropical regions of the world. Large dams for hydroelectric development and irrigation (27–29) and oil and gas pipelines (30), to name two prominent types of projects, are usually planned over 25- to 30-year time horizons with environmental, social, and HIAs taking place very late in the planning process. Such assessments are rooted in environmental and human rights activist movements. The environmental component has been institutionalized via the financial community in "Equator Principles" (www.equator-principles.com/principles.shtml), where there is a requirement for securing bank loans to the effect that "the borrower shall carry out an environmental impact assessment."

The central problematic feature of most large-scale development projects from our perspective is that they are formulated and carried by a coalition of corporations, banks, and governments with no independent body responsible for impact assessments mitigation strategies, and monitoring and follow-up of agreements put forth that should be health enhancing, but are, in fact, frequently deleterious. This is a place where a new and independent organizational structure is required and where a sturdy bridge between it and the corporation–bank–government triangle is essential if any notion of sustainable health is to accompany economic development in many parts of the tropics. We take up this topic below in the section *Economic Development Projects and Health*.

Engineering and Health: Two Islands In Need of a Ferry Service

A useful place to start a discussion of prevention programs focused on intestinal parasites is the mission and vision statement of Engineers Without Borders (EWB). They indicate that their outward vision "is of a world where ALL people have access to the knowledge and resources with which to meet their basic human needs and promote sustainable development in such areas as water supply and sanitation, food production and processing, housing and construction, energy, transportation and communication, income generation, and employment creation." (www.ewb-international.org-about.htm). Sponsored by EWB–Australia (http://www.ewb.org.au/program/?pid=27) is an ongoing project in Papua New Guinea with four objectives: (*i*) planning and faciliation of water supply and sanitation at the village level, (*ii*) construction of water supply and sanitation facilities, (*iii*) training of two water and sanitation engineers, and (*iv*) training of a local community member in maintaining infrastructures. Similarly, EWB–United States has analogous projects in Paraná, Brazil (http://ewb-usa.org/project_search.php?op=phase&ID=395) and Frontirezo, Guatemala. These are but three examples within EWB, which is only one of a vast international array of nongovernmental organizations (NGOs)[§] that are, village-by-village, installing fresh water and sanitation facilities, training local personnel in the technology, and providing for maintenance, and hence sustainability, of these community interventions. The positive health impact of the above programs, however, is not registered in international health statistics because there is no systematic connection between EWB, the many other NGOs engaged in sanitary engineering, and the health community as it is broadly conceived.

It is useful to juxtapose the ongoing work of engineering NGOs with a recent overview of recommendations from the United Nations Millennium Project Task Force on Water and Sanitation, which has the promising title, "Focusing on improved water and sanitation for health" (13). Although the author admirably emphasizes the advantages of management of water resources for the improvement of health and even indicates the need for a health management plan linked to water resource development, the specifics on "actions required from the health community" are devoid of any mention of fostering linkages with the engineering community that is already engaged in the provision of clean water and sanitation.

An immediate benefit that could accrue from a bridge between the engineering and health communities would be the use of the growing number of spatially explicit risk maps for coinfection [e.g., schistosomiasis and hookworm (4, 5)] to prioritize villages for clean water and sanitation interventions where polyparasitism is pervasive.

As one among many concrete instances of this phenomenon, we consider an area in the region of Man in Western Cote d'Ivoire bounded by latitude N07°07′ and latitude N07°36′ and stretching from longitude E07°24′ to longitude E07°50′, an area of ≈2,500 km^2. Fig. 1 shows the distribution of single infections and coinfections with *Schistosoma mansoni* and hookworm among 3,578 schoolchildren in 56 rural community schools within this area. This risk map is based on integration of data from ground-based demographic and parasitological surveys, satellite imagery, and digitized ground maps, as documented in ref. 4.

Coinfection frequencies >35% are particularly prominent in the communities in the southwestern part of the region. This information can serve to prioritize communities for deworming accompanied by installation of sanitary facilities and sources of clean water that would provide for prevention of reworming. The benefits would go well beyond just prevention of schistosomiasis and hookworm because as more extensive assessments of polyparasitism in two of the villages in the region revealed that

[§]Examples include: Acumen Fund, www.acumenfund.org; Water Aid, www.wateraid.org.uk; and The Water Page, www.africanwater.org/ecoscan_links.htm.

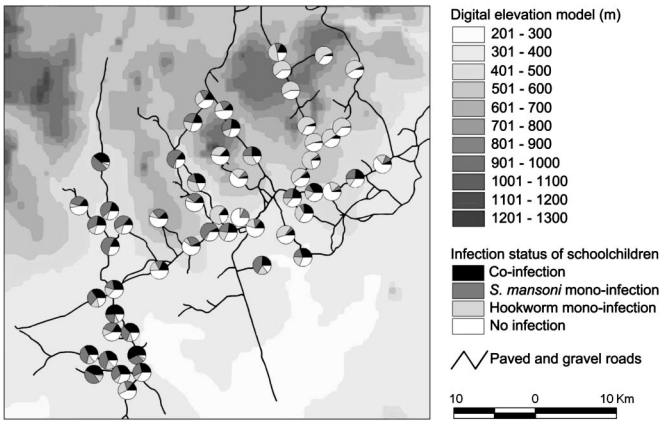

Fig. 1. Distribution of single infections and coinfections with *S. mansoni* and hookworm among 3,578 schoolchildren in 56 community schools in the region of Man, Cote d'Ivoire.

the range of parasite loads was from 0 to 10 distinct parasites, intestinal protozoa and soil-transmitted helminthes, in a single individual. The modal count was 4 and 5 parasites, respectively, in the villages of Gueupleu and Zouatta II (31). Clean water and sanitation has the potential to eliminate this parasite load.

The central message of this example is that coordination on pharmacological interventions for deworming, simultaneous with introduction of technology to prevent reworming and training of local personnel in sanitary engineering and maintenance, could introduce a facet of sustainable health where it currently does not exist. The substantial methodology for identification of high-risk villages for schistosomiasis (32, 33), coupled with the unsustainable Schistosomiasis Control Initiative, focused only on deworming by distribution of praziquantal (10–12), could potentially be transformed into a sustainable enterprise with linkages to engineering NGOs targeting the same communities as the Schistosomiasis Control Initiative. A major schistosomiasis control initiative in China, sponsored by the World Bank and operating over a span of 10 years by a deworming program of praziquantal distribution, supplemented by health education and some snail control (34), is now revealing its lack of sustainability with the end of the drug-distribution program and the rising incidence of schistosomiasis (35, 36). To change this kind of situation, the use of updated spatially explicit risk maps could be a first step in a process of establishing ongoing health system data collection that could be linked to both deworming by drugs and reworming prevention. It can provide a key part of the information base that would support adjustment and tuning of the engineering interventions to maximize health benefits and to provide a much more extensive database about reduction in parasitic diseases over time than is currently operable.

Our discussion has focused on a restricted set of parasitic infections without even considering malaria or coinfection between malaria and schistosomiasis and/or hookworm, malaria, and HIV/AIDS (37) or a diverse range of other diseases and illnesses. This omission is readily reparable via another aspect of promoting and ensuring sustainable health; namely, repairing and maintaining health systems at the district level. A role model for this is the Tanzania Essential Health Interventions Project (38). This program began with the introduction of demographic surveillance systems (http://indepth-network.net) that provided the information base from which to (*i*) identify the primary health problems for an entire district, (*ii*) reallocate existing budgets and personnel to respond to the priority problems of the district, and (*iii*) identify the additional financial and local capacity needs and provide the necessary catalyst for their fulfillment. This systemic intervention resulted in drastic reductions in infant and child mortality in the Rufiji and Morogoro districts of Tanzania, essentially meeting the Millennium Development Goals on this target nearly 10 years ahead of schedule (38). The relevance of this program to the present focus on clean water and sanitation is that the addition of a local engineer and hydrologist to the health system staff would immediately provide the missing bridge, at the district level, between engineering and health. Programs analogous to Tanzania Essential Health Interventions Project, adapted to local conditions and augmented by only a few people from the engineering sector, can be the basis for a vast expansion in sustainable health.

Surveillance, Tropical Health, and Trade Agreements

Although plans and much technical detail for a global surveillance system have been and continue to be developed by initiatives such as the Foresight Project (24), there is no organizational structure or revenue stream(s) in place to support implementation. The World Health Organization (WHO) could, in principle, be viewed as a natural home for this activity, but long historical experience clearly indicates that this is not a reasonable expectation. Financing of a global surveillance system could be activated with dominant support from the G8 countries. The political will to do this has yet to be demonstrated, but any serious attempt at implementation would require effective surveillance components in the tropical regions of the world, where local capacity and financial resources are inadequate and health-system priorities do not have the global focus that is promulgated by people from the wealthy G8 countries. One route forward in the tropical zones is to capitalize and build on extant trade agreements. We delineate a basis for this claim and identify potential mechanisms that could be developed into new bridges between currently separated communities.

One Health. Most human infectious diseases have animal origins, and many newly emerging diseases have links to either domestic or wild animals (39). This implies that there should be a tight integration of human and veterinary medicine and public health. The idea of having veterinary and human medicine in a common framework of "one health" has a long history, with systematic formulation dating at least to the German pathologist and architect of social medicine, Rudolph Virchow, in the 19th century (40). The separate pathways taken in the development of human and veterinary medicine in the 20th century have unfortunate implications for prevention, treatment, surveillance, and regulatory policies that require consideration in the context of pandemics. The practice of one health in recent decades has focused on nomadic and pastoralist populations in relatively remote areas of countries such as Chad and Mongolia. However, important lessons from this experience can help focus future initiatives. The integration of human and veterinary medicine is, from our perspective, a global issue. However, our focus is more on tropical regions of the world, where the building of necessary bridges is rather more difficult.

As one illustration of a tight connection between human and veterinary medicine, consider the options among control strategies to prevent human infection with brucellosis. These strategies are pasteurization of milk, livestock vaccination, and elimination of infected animals. A recent analysis (41) of mass vaccination of livestock in Mongolia over a span of 10 years revealed the cost-effective nature of this strategy for prevention of infection in humans and maintenance of livestock herds for economic benefit. The particular zoonotic nature of brucellosis leads directly to specification of multisectoral data collection for monitoring and surveillance, including human health, the socioeconomic condition of the concerned groups, and livestock production. Because of the economic connection to livestock production, this example provides a direct link between human health and trade agreements. Once the livestock market becomes transnational, the human health risks also have this

character. A more extensive review of the human health benefits of animal interventions for zoonosis control has recently been published by Zinsstag *et al.* (42).

WTO Agreement on SPS Measures. Article 5 of the SPS agreement (www.wto.org/English/tratop_e/sps_e/spsagr_e.htm) contains three provisions that are central to the objective of improving surveillance systems in the tropics:

1. Members shall ensure that their sanitary or phytosanitary measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organizations.
2. In the assessment of risks, Members shall take into account available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods; prevalence of specific diseases or pests; existence of pest- or disease-free areas; relevant ecological and environmental conditions; and quarantine or other treatment.
3. In assessing the risk to animal or plant life or health and determining the measure to be applied for achieving the appropriate level of sanitary or phytosanitary protection from such risk, Members shall take into account as relevant economic factors: the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease; the costs of control or eradication in the territory of the importing Member; and the relative cost-effectiveness of alternative approaches to limiting risks.

These points represent a substantial burden on tropical countries, which lack the data systems with adequate coverage to carry out the needed risk assessments. The question from our perspective is whether there are extant data systems linked to district-level health systems or data systems that could be established over time, adaptable to provide the scientific response needed to support provisions 1–3 above. An immediate by-product would be improvement of public health, albeit along dimensions specific to WTO requirements, and improvements in health surveillance across the spectrum of district-level problems. Demographic surveillance systems (43–45), with modules tuned to animal and plant health, as reflected on the human population, have the potential to bring this vision to reality.

Requirement of "Scientific Evidence." An important stimulus for building up not only a surveillance system *per se* but also the scientific capacity of health personnel in the tropics is the components of articles 2 and 5 of the SPS agreement listed below (www.wto.org/English/tratop_e/sps_e/spsagr_e.htm).

Article 2: Basic Rights and Obligations. (2) Members shall ensure that any sanitary or phytosanitary measure is applied only to the extent necessary to protect human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence, except as provided for in paragraph 7 of Article 5.

Article 5: Assessment of Risk and Determination of their Appropriate Level of Sanitary and Phytosanitary Protection. (7) In cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures on the basis of available pertinent information, including that from the relevant international organizations as well as from sanitary or phytosanitary measures applied by other Members. In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time.

The substantial international response to these SPS requirements is exemplified by the diversity and scope of the papers presented at the 2006 International Symposium on Veterinary Epidemiology and Economics at Cairns, Australia. Although most of the innovations on surveillance bridging animal and human health were from developed countries, there were new projects presented from African countries, based on collaborations with European and North American partners, that represented a good start on capacity building that was directly driven by the SPS agreement.

The U.S. Centers for Disease Control (CDC) has also started to systematically build bridges to veterinary medicine, as documented in a recent report on converging issues in veterinary and human health. An obvious next step would be an intensive integration between the CDC databases on human health and the world animal health information system, managed by the World Organization for Animal Health (46). The CDC has long-established links to tropical countries and could be a major contributor to the much needed capacity building in the tropics on the interface between human and animal health. This would be a highly positive spillover effect of the SPS agreement. Finally, the WHO has formed study groups focused on veterinary public health and its linkage to human public health (47). The extensive discussion of this topic in WHO forums is a useful development. Systematic links to the Advanced Veterinary Information System, established by the Food and Agriculture Organization of the United Nations in 1992 (http://aviscollege.com/pdfs/PH_factsheet.pdf), can be an important source of input to the human public health community. However, without the force of trade agreement requirements, it seems implausible that major steps toward implementation of new surveillance systems and accompanying capacity building in the tropics would be in process.

Economic Development Projects and Health

A common feature of large-scale development projects, of which dams and oil and gas pipelines are prime examples, is that the elapsed time from initial conception to construction and implementation is on the order of 25–30 years (30). See for example, the Three Gorges Dam (www.american.edu/ted/threedam.htm), and the Nam Theun 2 Hydropower Project (www.namtheun2.com/0601%20Project%20Introduction.pdf). The current Chad–Cameroon oil pipeline, running 1,070 km from the Doba basin in southern Chad to the Kribi marine export terminal on the Atlantic coast of Cameroon, is the result of the discovery of significant oil reserves in Chad in 1975 and ultimately the initiation of oil exporting in October 2003 (30). The Nam Theun 2 hydroelectric project in Laos was first conceived under the auspices of the Mekong Secretary in the 1970s with dam construction actually initiated in 2005. A central objective was to produce electricity for sale to Thailand while also assisting in electrification in Laos. Gold reserves at Ahafo, Ghana were identified >30 years ago, but extensive mining activity was initiated by the Newmont Mining Corporation (Denver, CO) in 2002 (www.newmont.com/en/operations/ghana/ahafo/index.asp). Not surprisingly, economic projects of this scope are focused on profit maximization with varying allocations among corporations, governments, and development banks involved in their formulation and implementation.

A second common denominator of such projects is that they have substantial environmental, social, and health impacts on local communities, many of which are quite deleterious (48–50). Whole communities are forcibly resettled to areas where, for example, agricultural potential is inadequate relative to what was feasible in the community of origin (50). Soil erosion, loss of biodiversity, inadequate fresh water, disrupted fishing, and inadequate compensation for housing and land are consequences of project implementation (50). There is great potential for increases in transmission of malaria, HIV/AIDS, tuberculo-

sis, and respiratory infections among a much longer list of infectious diseases, to say nothing of the mental health consequences of forced community relocations. Rigorous impact assessments and mitigation plans for such diverse negative consequences have not been part of the early stages of project planning. Indeed, they have occurred long after major decisions about project structures have been made (30). From a combined economic and human rights perspective, the projects should be planned as constrained optimization problems, where profit maximization is an objective but subject to the constraints that potential deleterious environmental, social, and health impacts are either prevented or adequately compensated. If effective mitigation was factored into the original plans of development projects (i.e., early in the 25- to 30-year time interval between project conception and implementation), it is quite conceivable that some extant projects would never have come to fruition or would have been substantially modified before financial agreements and construction activities had gotten under way.

Primarily as the result of environmental and human rights activist groups seeking equity for the populations impacted by the projects (ECA Watch, www.eca-watch.org), first environmental and then social impact assessments became a contractual requirement for loans from many development banks to corporations promoting dams, oil and natural gas pipelines, mineral extraction, and large-scale agricultural production (Equator Principles mentioned earlier). This process did not begin until the late 1990s, with strengthening in the Equator Principles of July 2006. However, a major weakness in the basic structure is that the borrower, i.e., the corporation(s), is responsible for doing an environmental and social impact assessments of its own operations. Admittedly, the banks, particularly the World Bank and the Asia Development Bank, have signed on to do regular inspections at project sites to ensure that mitigation of impacts is appropriate. This seemingly positive step has been accompanied by a situation where independent inspections by human rights groups, e.g., Catholic Relief Services (49), International Rivers Network (50), and Amnesty International (48), have found extensive violations of initial compensation and mitigation agreements. All projects have revenue streams flowing among one or more governments, one or more corporations, and usually several financial institutions, including the essentially unregulated export credit agencies (ECA Watch). There is basically no independent means of enforcing original mitigation agreements or even the carrying out of impact assessments by an independent international body.

Before getting into a discussion of sustainable health in the present context, it is important to note that HIAs are not mentioned in the current Equator Principles, where the borrower, in effect, does a self-assessment. They are, nevertheless, increasingly carried out by the corporate borrowers in response to rising pressure from human rights groups and some fresh visibility provided by the WHO (51). Indeed, the International Petroleum Industry Environmental Conservation Association, an international consortium of major oil companies, has an HIA guide posted on its web site (www.ipieca.org/activities/health/downloads/publications/hia.pdf) and now regularly discusses industry-wide health issues. We surmise that the very late appearance of HIAs is a consequence of the fact that there has never been a Greenpeace equivalent for health. The environmental activist community has been far ahead of the health community on this issue. However, there is nothing other than lack of activism from the health community standing in the way of bringing environmental and social impact assessments and HIAs under a common umbrella: IAs in the next revision of the Equator Principles. With this point in hand, we are still left with the structurally unsound situation (*i*) that no independent body is responsible for the conduct of such assessments and (*ii*) there are no effective means of negotiating constrained optimization, as discussed above, into the early stages of planning development projects and monitoring mitigation with enforcement responsibilities once they are implemented.

Sustainable health in communities impacted by development projects depends on our ability to solve the structural problem outlined above. One possible route, which is not entirely satisfactory, would be for the banks themselves to be responsible for the conduct of impact assessments and for enforcing, to the extent possible, ongoing mitigation of negative impacts. A major change in financial arrangements between banks and corporations and governments would have to require that impact assessments be carried out in the early planning stage of any project for which a loan is sought and the costs of mitigation factored into the project specification. An independent organization, supported by the banks and using some of the revenue derived from corporate borrowers, would have to be responsible for contracting the impact assessments. No reorganization along these lines would seem possible without persistent lobbying from substantial networks of NGOs and human rights activist groups. Transparency of the impact assessments and the results of periodic project inspections focused on mitigation would be essential.

The above proposal is designed to stimulate further thought on solutions for the structural problem before us. To the best of our knowledge, this issue, despite its profound implications for people in many parts of the tropics, is simply not part of the development or health discourse. To the extent that diverse communities of activist groups, banks, governments, and corporations get seriously involved with our question, we would feel that some progress toward sustainable health in the context of economic development might be on the horizon.

Discussion

The routes to sustainability in the contexts discussed in this paper are all based on establishing strong connections/bridges between communities that have limited interaction (e.g., engineering and health, veterinary and human medicine, health and international trade) or where a new organizational structure is needed along with a sturdy bridge to current actors (i.e., the corporation–bank–government triangle) in economic development projects, and an independent organization(s) responsible for HIAs, monitoring of mitigation, and enforcement of agreements to the extent possible.

The issue of forced community relocation as part of development projects has been an integral part of the loan approval process of the International Finance Corporation for >15 years (52). The guidelines regarding resettlement are increasingly designed to be equitable for the communities involved (53). However, aside from the obvious problems of modified living standards, this phenomenon can have major mental health consequences that have not only been largely absent from tropical region HIAs to date, but mitigation plans deriving from such assessments hardly mention this long-term problem. The literature on mental health consequences of forced relocations after natural disasters (hurricanes, floods, earthquakes, tsunamis) is quite substantial and needs to be brought into the planning stages of development projects in the future. A good place to start would be incorporation of mental health as an integral part of HIA guidelines in the International Finance Corporation approval process for corporate loans.

We have emphasized the use of surveillance requirements and the provision of solid scientific evidence pertaining to animal, plant, and human diseases in the SPS agreement of the WTO as a route to facilitating new health surveillance systems and positive public health consequences in the tropics. The central importance of trade for government policy in countries where allocation of fresh resources to the health sector would otherwise be difficult for ministers of health to defend can hopefully serve

as a catalyst to give new emphasis to this activity and engage international partners toward provision of technical assistance and the fostering of long-term capacity building ventures. Establishing new bridges between human and animal health should be a critical part of this activity because it would be difficult to meet the SPS requirements without this linkage. Recent outbreaks of severe acute respiratory syndrome and avian influenza have promoted discussions that could ultimately link veterinary and human medicine in the U.S. (54) and among the wealthier countries of the world. Partnerships with tropical countries, some of which are already underway, are a current indicator of the potential public health benefits of the SPS agreement. It is difficult to imagine another entrée to this kind of development without having the force of a WTO agreement behind it.

Finally, building bridges between the engineering and health communities with a focus on clean water and sanitation will require a concerted effort from the health community to break out of the present overemphasis on treatment and vaccine research, as well as the building in of systematic outreach to the community, i.e., engineering, with the ongoing track record of successful preventive interventions. Success on the engineering side both promotes sustainable health and leads to a reduction in the demand for pharmacological interventions for deworming. Despite the strong track record of many extant vaccines [e.g., measles, pertussis (whooping cough), smallpox, and polio], it seems that in the realm of intestinal parasites, the overall benefits of clean water and sanitation far outweigh the long-term dependence of communities on biomedical technology that would be consequential to continued overemphasis on this category of interventions.

We thank Juerg Utzinger, Robert Keohane, and Gary Krieger for helpful discussions on many aspects of this paper. This work was supported by the Center for Health and Well-Being at Princeton University (B.H.S.) and the Department of Population and International Health, Harvard School of Public Health (M.C.d.C.).

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