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DRINKING WATER AND SANITATION IN THE DEVELOPING WORLD: THE MISKITO COAST OF NICARAGUA AND HONDURAS AS A CASE STUDY

Peter J. Balint

Worldwide, one billion people are without access to safe drinking water, and three billion lack minimally acceptable sanitation facilities. Impediments to addressing these inadequacies in the public health infrastructure are complex, with institutional, political, economic, and cultural dimensions. This paper focuses on water and sanitation in rural areas of the developing world, using the Caribbean coast of Honduras and Nicaragua as a case study to provide context for discussion of the global problem. The analysis suggests that political and economic commitments required to mitigate shortcomings in water and sanitation services are 1) underestimated but 2) within reach nonetheless.

INTRODUCTION

Clean drinking water and adequate sanitation are fundamental components of effective public health regimes. Development of the germ theory of disease in the mid-19th century, coupled with contemporaneous improvements in public services, led to revolutionary improvements in life expectancy (World Bank 1992). Fecal-oral pathways for transmission of infectious agents in human communities are now well understood, and the combination of health education and a reliable sanitation infrastruc-

Peter J. Balint is pursuing a Ph.D. in Policy Studies at the Maryland School of Public Affairs, University of Maryland College Park.

ture has virtually eliminated widespread adverse health effects associated with contaminated water in developed countries (Moeller 1997).

In the developing world, however, a billion people remain without access to safe drinking water, and two to three times that number lack basic sanitation facilities (Nigam and Rasheed 1998; World Bank 1992). The resulting human toll is enormous. Hundreds of millions of people, many of them children, suffer from chronic diarrheal diseases and long-term parasitic infestations transmitted through impure water and contaminated food (WHO 1996). Other more acute waterborne diseases are constant threats in these populations.

Impediments to eradicating health risks associated with unsafe water and inadequate sanitation are complex, with institutional, political, economic, and cultural dimensions. Moreover, relevant circumstances vary significantly, both among regions of world and within countries. Residents of humid tropical areas, for example, face problems unlike those found in arid zones, and policies that may be appropriate in urban centers are likely to be ineffective or impractical in outlying regions.

This paper focuses on water and sanitation in rural areas of the developing world, using the Caribbean coast of Honduras and Nicaragua as a case study to provide context for discussion of the global problem. The first section briefly recapitulates the epidemiology of waterborne and excreta-related diseases, reviews global efforts to reduce associated morbidity and mortality, and summarizes the current debate over program design. The second section, focusing on the specific case of the Miskito Coast, describes water and sanitation facilities typically found in the region, enumerates political constraints to effective implementation of service improvements, and evaluates the outcome of a project to construct wells conducted in the area by an international aid agency. This section of the paper is based on personal impressions gathered by the author during two separate visits to the region, in 1993 and 1997. The third section considers practical and ethical difficulties that complicate attempts to institute project designs recommended by multilateral development institutions. The concluding section returns to global dimensions of the problem, arguing that political and economic commitments required to mitigate shortcomings in water and sanitation services are 1) underestimated but 2) within reach nonetheless.

The Global Problem of Waterborne and Excreta-Related Diseases

Epidemiology

According to the World Health Organization, half the world's human population suffers from illnesses associated with insufficient or contami-

nated water (WHO 1996). The Global Burden of Disease study, using standardized units of disability-adjusted life years to compare specific health risks, lists diarrheal disease as the second leading contributor to global ill-health, behind only lower respiratory infection (Murray and Lopez 1997). Gastrointestinal disorders stemming from waterborne pathogens are the primary cause of mortality among children under five worldwide (Franceys et al. 1992).

Inadequate sanitation promotes the spread of a variety of ailments. Pathogenic microorganisms commonly transferred among members of human communities through fecal-oral pathways include infectious bacteria, viruses, and protozoa. Among these disease agents are those responsible for cholera, hepatitis, poliomyelitis, typhoid and paratyphoid fevers, giardiasis, cryptosporidiosis, and various other forms of bacillary and amoebic dysentery and diarrhea. Helminths frequently found in human hosts where sanitation is inadequate include, among others, hookworms, tapeworms, roundworms, liver flukes, and schistosomes (Franceys et al. 1992).

Morbidity and mortality rates from these afflictions are high. Each year, for example, children in the developing world experience more than a billion episodes of diarrhea and dysentery, and three to four million children under five succumb to associated diseases (Huttly et al. 1997). More than 16 million cases of typhoid fever occur annually, leading to 600,000 deaths (WHO 1996). Two hundred million humans worldwide suffer from schistosomiasis, and more than 200,000 people die from the disease each year (Franceys et al. 1992).

In the absence of adequate sanitation and hygiene, infectious agents found in human waste follow a number of transmission routes to infect new human hosts. The cycle begins when improper disposal of infected excreta leads to contamination of soils, surface waters, and groundwater. Susceptible persons may then be infected in various ways. First, microorganisms may be passed to food by flies, unwashed hands, or wastewater used for irrigation. Second, parasites in the soil or in surface waters used for bathing, swimming, or washing clothes may penetrate the skin directly. Third, victims may ingest pathogens in drinking water. In many rural areas of the developing world, villagers take drinking water from streams or ponds and use it without treatment. Where wells are available, surface runoff or unsanitary water-retrieval practices may contaminate well reservoirs.

Patterns of disease resulting from inadequate sanitation are often pervasive and enduring. Opportunistic infectious agents that depend on external transmission to new hosts have been shaped by natural selection

to persist for extended periods in water or soil. For example, bacteria responsible for cholera (*Vibrio cholerae*) and protozoa that induce dysentery (*Entamoebae*) are viable for up to a month in wastewater. Enteroviruses, including polioviruses, and hookworms (*Ancylostoma* species) remain active for up to three months outside the body. Roundworms (*Ascaris* species) can survive outside the host for up to a year (Franceys et al. 1992).

Often, there are evolutionary tradeoffs between persistence outside the host and infectivity. That is, organisms with shorter lifespans in the external environment may be able to infect new hosts in smaller doses. For example, protozoal cysts only survive between hosts for a few days or weeks, but the number required to cause symptoms in 50 percent of exposed individuals (ID_{50}) can be as low as from 10 to 150 organisms (DuPont et al. 1995). In contrast, fecal coliform, such as *Escherichia coli*, may persist in the environment for several months, but these bacteria must be ingested in doses seven or eight orders of magnitude greater to produce clinical symptoms (Franceys et al. 1992).

The International Response

In the mid-1970s, the United Nations established the goal of "clean water and adequate sanitation for all by 1990" (Schiller 1982). At the time, 60 percent of the population in developing nations was without access to safe drinking water, and 75 percent lacked adequate sanitation facilities. Over the next five years, the situation continued to deteriorate. Between 1975 and 1980, the population of the developing world increased by approximately 300 million persons (UNDP 1997). During that period, the number without access to potable water grew by 100 million, and the number without sanitation grew by 400 million (Agerwal et al. 1981). The world's health infrastructure could not keep pace with population growth in the provision of potable water and, in the case of sanitation, was losing ground in absolute terms.

In late 1980, to maintain focus on the problem, the General Assembly declared the decade of the 1980s the International Drinking Water Supply and Sanitation Decade (Agerwal et al. 1981). Non-governmental organizations and multilateral development agencies—including various components of the United Nations, World Health Organization, and World Bank—supported numerous studies to clarify obstacles to successful provision of basic services, and established pilot projects in many parts of the world to evaluate new program designs in the field. National governments in affected countries also allocated substantial resources to the issue.

Total expenditures worldwide in the water and sanitation sector during the decade exceeded $130 billion in then-current dollars (Nigam and Rasheed 1998).

Results of this 10-year global effort were mixed. By the early 1990s, the proportion of people without access to safe drinking water had been halved, down to 30 percent; yet, more than 60 percent of the world's population still lacked adequate sanitation (UNDP 1997). In rural areas the latter figure remained near 80 percent, no lower than at the start of the initiative (Franceys et al. 1992). In summary, despite significant progress in the provision of potable water, serious deficiencies remain in the disposal of human wastes. The World Health Organization estimates that by the year 2000, over three billion people will be without access to environmental sanitation (Nigam and Rasheed 1998).

Lessons From the Decade

Researchers have investigated the effectiveness of various approaches to resolving public health problems associated with unsafe water, inadequate waste disposal, and unsanitary hygiene practices.

Water Versus Sanitation

First, several studies have examined the relative importance of safe drinking water and adequate sanitation in the reduction of morbidity. Esry (1996) analyzed data collected from eight countries in Africa and Latin America. He found that sanitation is more strongly correlated with health improvements than is potable water, and that there are increasing returns to upgrading further from adequate pit latrines to flush toilets. Reduced incidence of diarrhea was noted in communities where sanitation facilities were improved even if water supplies remained substandard; where the reverse was the case—i.e., improvements in water supply without improvements in sanitation—no benefits were observed.

In some cases, there actually were negative effects associated with intermediate improvements in water supply. One explanation is that residents no longer exposed to relatively benign organisms show increased susceptibility to more virulent pathogens. For example, the presence of *Plesiomonas shigelloides* in traditional water sources may immunize people against *Shigella sonnei* (the agent responsible for shigellosis). If intermediate improvements remove *P. shigelloides*, however, more severe health effects may occur when replacement water supplies become contaminated with *S. sonnei*, as commonly occurs when sanitation remains inadequate (Esry 1996).

VanDerslice and Briscoe (1995), who studied the effects of improved water supplies on infant health in the Philippines, support the finding that sanitation deserves priority over water where infrastructure improvement resources are limited. Purification of drinking water had no significant positive effects in areas with poor sanitation. In neighborhoods with good community sanitation, however, morbidity declined markedly when improvements in water supply were introduced.

Policy implications of these studies are a matter of debate. VanDerslice and Briscoe (1995) argue that disagreements over which technical interventions are most effective inappropriately overshadow a more fundamental concern—lack of efficient and accountable institutions to provide necessary services. Cairncross and Kolsky (1997) criticize Esry's (1996) emphasis on achieving high-level sanitation standards, arguing that his findings bias policymakers against modest, low-technology projects and may result in postponing interventions that have the potential for significant, though suboptimal, benefits. Cairncross and Kolsky (1997) further assert that because of valuable contributions to human dignity and the emancipation of women, investments in water and sanitation are justified regardless of the impact on health.

Hutley and colleagues (1997) interject a cautionary note. In their review of nonvaccine diarrheal interventions, they remark on the limitations of attempts to ascribe health effects to any particular component of multifaceted programs. Further, they observe that results of studies on the relative impact of water and sanitation improvements are often inconsistent and occasionally contradictory. They suggest that other interventions, including supplementing nutrition, improving prenatal care, and promoting domestic hygiene, may be more cost-effective than infrastructure improvements in reducing childhood gastrointestinal disorders.

Integrating Socio-Cultural Factors

Investigators have also assessed outcomes of projects with integrated technical and social components. Hoque and colleagues (1996) report on a follow-up survey conducted in 1992 of a community in Bangladesh that received a combination of hygiene education and infrastructure improvements from 1984 to 1987. The authors observe that five years after termination of outside support, the treatment community still demonstrated significant improvements over the comparison community, both in sanitary habits and in reduced diarrheal morbidity. Approximately two-thirds of latrines and tube wells installed in the village had been adequately maintained in the interim. Interestingly, knowledge about transmission of

waterborne infectious diseases had reverted to pre-intervention levels; residents of the treatment and comparison communities were no longer significantly different in their understanding of linkages among drinking water, waste disposal, and disease.

Almedom (1996) reports on recent advances in hygiene behavior research. Studies conducted in rural areas of East Africa using anthropological methods reinforce the idea that traditional sanitation practices are largely determined by social norms and taboos rather than by health concerns. These attitudes are amenable to change through education, but the likelihood of successfully modifying behavior is improved if project personnel are sensitive to local cultural mores. Almedom (1996) also emphasizes the important distinction between verbal and behavioral indicators of improved hygiene awareness. In studies conducted in Ghana, for example, Nyaku and Diamenu (1997) found that although villagers were able to demonstrate substantial understanding of good hygiene habits after an education program, they generally did not apply their new knowledge in practice.

The Demand-Driven Paradigm

There is growing recognition that recipient involvement contributes significantly to the success of water and sanitation interventions. Rao and colleagues (1997) contrast two latrine construction programs in India. In the first, latrines were built for each family in a village. Workers did not poll families to determine their preferences, however, nor were villagers asked to contribute materials or labor. In the second, the project commenced with an education program. Latrines were then installed only for interested families willing to help with construction and pay a portion of the costs. Ten years later, only 15 percent of latrines built in the first village remained serviceable while all of those built in the second village were still in use and in reasonably good condition.

Briscoe (1992) argues that the most effective water and sanitation projects are those that provide a choice of services at a fair price. Well-intentioned but paternalistic projects typically provide what donors think most appropriate, without addressing recipients' desires; consequently, donated facilities quickly fall into disrepair (Rao et al. 1997). A report by the World Bank Water Demand Research Team (1993), with which Briscoe was affiliated, spells out the argument in greater detail. Where possible, market forces should be allowed to operate. If a menu of services is offered, aggregate willingness-to-pay, even in poor communities, may be enough to cover the full cost of implementation, with the added benefit

of supporting public institutions with built-in incentives for efficiency. Where poverty is extreme and transfers or subsidies are required to cover cost shortfalls, utility will be maximized when projects remain demand-driven and beneficiaries' willingness-to-pay is tapped (Solo 1998).

Rights-Based Approach

Nigam and Rasheed (1998) of the United Nations Children's Fund (UNICEF) propose a modification of the economic efficiency model. Referring to the 1948 Universal Declaration of Human Rights, they assert that water belongs in the category of fundamental rights. National governments therefore face political, legal, and ethical imperatives to ensure that all citizens receive at least minimum levels of acceptable service. Market mechanisms can be employed to maximize allocative efficiency once this just initial distribution is achieved.

The authors cite several examples—in India, South Africa, and Honduras—where civil institutions and the market successfully combined to achieve health goals after governments, implicitly acknowledging rights to water and sanitation, acted to guarantee minimum services.

Discussion

There is a lack of consensus among international development experts as to the best way to attack public health problems associated with inadequate sanitation in poor countries. Both empirical and political disagreements fuel the debate. First, most water and sanitation interventions in developing nations are not conducted as rigorous experiments structured to produce convincing, generalizable findings. Project designs are not standardized. Traditions differ among recipient communities. Research objectives become entangled with social development goals. Integrated programs combine more variables than can be separated in post-intervention analysis. Long-term interventions are often abandoned before completion, and short-term projects are rarely subjected to systematic follow-up. In the absence of a firm body of knowledge to serve as a foundation for policymaking, ideology and politics intervene. Water, sanitation, and health become enmeshed in debates over rights, justice, class, ethics, economics, paternalism, gender politics, and cultural relativism. Those who espouse application of market incentives argue with rights advocates. Conflicts develop over prioritizing what should be complementary goals of water and sanitation interventions: mitigating adverse health effects, contributing to human dignity, reducing drudgery, and emancipating women. Good projects are delayed because they are less than optimal; poor

projects go forward in the hopes that they will be better than nothing.

Despite the controversy, certain kinds of interventions clearly have higher probabilities of success than others. In subsequent sections, after introducing concrete examples of sanitation failures in the developing world, this paper returns to the issue of effective project design and reviews local and global policy implications.

Water and Sanitation on the Miskito Coast: A Case Study

This section, to lay the groundwork for the discussion that follows, examines water and sanitation problems along the Caribbean coast of Central America, beginning with a review of those aspects of local geography, climate, hydrology, history, and culture that have contributed to the lack of adequate services in the region.

Background

The Miskito Coast—named for the area's predominant indigenous group—comprises the eastern coastal plains of Honduras and Nicaragua. The territory stretches from Cabo Camerón in Honduras, at the top of the Central American "shoulder," down to Río San Juan at the southern Nicaraguan border (Nietschmann 1973). The Miskitos, with a current population of approximately 170,000 (15,000 in Honduras and 155,000 in Nicaragua), support themselves primarily through fishing and small-scale agriculture centered around coastal villages and riverside settlements (SIL 1998). The region is characterized by pine savannas, lowland tropical forests, mangrove swamps, brackish lagoons, sand beaches, and a chain of near-shore islands and cays.

Miskitos have always looked eastward into the Caribbean for their livelihoods and for trading opportunities. In the 17th and 18th centuries, they built alliances with British traders and used newly acquired firearms to keep the Spanish at bay and drive other indigenous peoples away from the coast and into the interior. The British maintained their influence in the region through the mid-19th century, when the United States displaced them as the dominant force in the Caribbean (Nietschmann 1973). Although the Spanish-speaking governments in Tegucigalpa and Managua gained nominal authority over the Miskito Coast after signing treaties with Great Britain in 1859 and 1860, the political, commercial, and missionary interests of the United States overshadowed the influence of the Honduran and Nicaraguan governments until World War II (LOC 1998).

For 300 years, Miskitos have strenuously resisted social integration with Hispanic society. Despite Afro-Caribbean and Northern European genetic admixtures, they continue to maintain a strong ethnic identity—speaking their own language and adhering to distinct traditions. Their struggle for political autonomy continues even though national sovereignties are now firmly established (LOC 1998).

The geography of the region reinforces their isolation from the majority populations of the central highlands and Pacific coast. Land travel in the territory is difficult. During the rainy season, rivers frequently flood their banks, and the ground in low-lying areas remains saturated for extended periods. Consequently, there are no reliable land routes out to either country's urban centers, and the coast remains largely undeveloped.

Recent history has exacerbated traditional antipathies between Miskitos and the Spanish-speaking central governments. After the Sandinista takeover of Nicaragua in 1979, Contra rebels, supported by the United States, established bases in Honduran areas of Miskito territory and raided across the border into Nicaragua. In response, the Sandinistas attempted forced resettlement of scattered Nicaraguan Miskito populations into central, defensible locations. Both sides targeted Miskito men for involuntary conscription, local communities were uprooted, the subsistence economy collapsed, and civilian populations suffered significant casualties. Many coastal residents fled to live as refugees in Honduras, Costa Rica, or the United States (LOC 1998).

After the electoral defeat of the Sandinistas in 1990, Miskitos reestablished their communities. The civil unrest left both Honduras and Nicaragua among the poorest nations in the hemisphere, however, and the governments allocated their limited resources to rebuild the economies of central and western zones (UNDP 1997). Miskitos currently receive only limited social service support from the central governments. Their insistence on political autonomy and their geographic, cultural, and linguistic isolation perpetuate well-established patterns of neglect.

Examples of Potable Water and Sanitation Failures

During two separate visits to the region, the author of this paper spent an extended period—several days to a week—in three different Miskito villages, one in Honduras and two in Nicaragua. These communities illustrate the sanitation problems typical of the area. In each case, the author noted water sources and sanitation facilities in common use and interviewed local residents to determine their attitudes and expectations regarding these services.

Las Marías

Las Marías, a community of 500 people, half of them children, is located on the bank of the Río Plátano in Honduras, approximately 100 kilometers up-river from the coast. There is no regular transportation to the outside world; a round-trip journey to the settlement at the mouth of the river requires three to four days of travel by dugout canoe, the most common form of transport. Las Marías has neither wells nor latrines. Drinking water is taken directly from the river, which is also used for bathing, laundry, and waste disposal.

Tuapí

Tuapí, a community about the same size as Las Marías, is built on the inland side of a brackish lagoon on Nicaragua's northeast coast. A 20-kilometer unpaved road connects the town with the port city of Puerto Cabezas, which serves as district administrative center. As a result, Tuapí has significantly greater access to materials and supplies than Las Marías. The sanitary situation is little better, however. The town's approximately 40 families share 12 latrines in various stages of disrepair. During the rainy season, the ground is saturated. The latrine pits fill with water, and deposited waste seeps out directly into standing puddles, rivulets, and other semi-permanent surface waters. Six shallow dug wells have been installed. Since the terrain is flat, the wells were not built on higher ground, and poor construction allows continuous inflows of contaminated surface water.

Haulover

Haulover, so named because it is a convenient place to haul fishing boats over the bar, is situated approximately 60 kilometers south of Puerto Cabezas on a spit of beach 50 to 100 meters wide lying between the Caribbean Sea and the Waunta Lagoon. The town can be reached only by boat—by sea in the dry season or along inland waterways in the rainy season.

Because the village is built on sand, problems of standing surface water are reduced. Sanitation problems remain, however. There are 15 latrines in this community of approximately 50 families, and the quality of construction and maintenance varies considerably. Several are well-built privies—the pits lined with concrete blocks. Others are ramshackle affairs without pits that provide only limited privacy and no sanitation benefits. In this village, the latrines belong to particular family groups; most residents have no access to even these modest facilities.

The town has seven wells. Four are poorly constructed and easily contaminated by surface runoff. The remaining three, designed to meet international standards, were built in 1992, after the civil war, by a crew from the non-governmental aid organization Médecins Sans Frontières. Concrete block walls from five feet below to three feet above ground level prevent surface water contamination. Concrete aprons around the wells at the surface reduce erosion and help maintain structural integrity. As originally constructed, the openings were capped, and hand-crank siphons were installed for drawing water. The wells no longer have covers, however. Villagers report that as soon as the construction crew moved on they opened the wells so as to be able to obtain water by dropping buckets into the shafts as was their custom. Since buckets are not handled in a sanitary manner, well reservoirs are now contaminated.

Discussion

Despite variations in geography and hydrology, all three villages have inadequate sanitation facilities. Several common factors not previously mentioned exacerbate the problems. First, in all three villages, pigs, chickens, dogs, and other domestic animals range freely and defecate at will. This further contaminates surface waters and provides alternate means for transmission of disease agents. Second, none of the villages has an operating health clinic or school. Consequently, residents are not educated as to the techniques and benefits of effective hygiene practices, and demand for sanitation improvements is limited.

The Médecins Sans Frontières project in Haulover seems to have failed for three reasons: lack of community involvement in decisionmaking, lack of community investment in construction, and lack of ancillary programs to provide education, support, and follow-up. According to residents, a crew from the organization moved up the coast from village to village installing wells. Workers moved on as soon as they completed work in each settlement. The advantage of this kind of program design from the point of view of donor agencies is that the project can be completed rapidly and at relatively low cost. Recipients acquiesce, since they are getting something for nothing. The intervention fails, however, because improper use or inadequate maintenance of the new installations subverts the objectives. The benefits of this kind of program are not sustained.

Effective Project Design

General Recommendations Offered by Leading Agencies

Major international development institutions have published guidelines for effective water and sanitation interventions in the developing world.

The Water and Sanitation Program, jointly sponsored by the United Nations Development Programme and the World Bank, offers the following recommendations: projects should be demand driven; community education and capacity building should be integrated into the design; and recipients should participate in management of project finances (UNDP/World Bank 1998).

The United States Agency for International Development (USAID), in coordination with UNICEF, urges project managers to: promote demand for sanitation among recipients; involve community leaders (particularly women) in project design, management, and financing; match costs to willingness-to-pay; emphasize behavioral changes in hygiene practices; and build inter-sectoral links with education and health institutions (LaFond 1998).

The World Health Organization (WHO) focuses on post-intervention evaluations. To ensure that improvements in health and well-being actually occur, medical professionals should evaluate morbidity rates before and after interventions, and social scientists should assess changes in recipients' behavior to find objective demonstrations of satisfaction (Franceys et al. 1992).

Practical Difficulties

Applying the WHO recommendations would be helpful in framing an intervention—that is, in setting objectives and establishing evaluation procedures. Standard minimum goals should include 1) measurable health improvements and 2) sustainability. Collateral benefits, such as strengthened institutional capacity, mitigation of local environmental degradation, and the opportunity for a more dignified way of life, will flow naturally from a program if these primary goals are achieved.

Project personnel should establish evaluation procedures to assess the extent to which primary objectives are met. Judging success in achieving measurable health benefits would require pre- and post-intervention health assessments. Ideally, all residents would be tested, although random samples would suffice. Simple statistical analyses could then be applied to determine whether significant improvements had occurred. Evaluating sustainability would require observation of lasting behavioral changes. A useful proxy measure for desired social adjustments would be the condition in which community members maintained their new or reconstructed wells and latrines.

Setting clear goals and establishing evaluation procedures will not avoid practical and ethical problems of implementation, however. The most obvious fall into three categories: medical, educational, and financial.

Each is considered in turn. To add context, the village of Haulover serves as a model.

First, in order to establish a baseline against which the project's health effects can be evaluated, preliminary medical testing of village residents is required. Since there is no health clinic in Haulover, and residents receive no routine health care, physical examinations are certain to reveal a variety of ailments requiring attention. This presents a dilemma. Providing full medical care to the afflicted is likely to be beyond the budget of a project to install low-cost wells and latrines; yet it would be unethical for a medical team to diagnose ailments without providing opportunities for treatment. Second, the project's success will depend to a large degree on whether residents adopt effective hygiene practices. Haulover has no viable education program, however. The school building is dilapidated and largely abandoned. The roof leaks, there are no supplies, and at the time of the author's visit, in the summer of 1997, a year had passed since the government teacher's last appearance in the village. Consequently, the inter-sectoral links recommended by USAID are impossible, and health education will have to be provided as component of the intervention, adding considerably to the cost and duration of the project.

Third, although all village residents are poor by the standards of the developed world, income distribution in Haulover is not uniform. Residents with boats and nets in good working order are more or less assured of subsistence food supplies. Those few with outboard motors are able to generate cash income by ferrying to market fish harvested in the village beyond subsistence requirements. In contrast, those without fishing equipment are destitute and desperate. Again there is an ethical and practical dilemma. If World Bank recommendations of basing the project on recipient demand and willingness-to-pay are followed, those most in need of services will be least likely to receive them, and community divisions will be exacerbated. If those recommendations are abandoned, and latrines and wells are simply donated, the failures of the Médecins Sans Frontières project are likely to be repeated.

Project design can fall along a continuum from a straightforward, technical approach—simply construct wells and latrines and move on—to full, long-term engagement with the target community. Expenditures and returns associated with these various designs will vary wildly, and are likely to be idiosyncratic. Economic theory would suggest equalizing marginal benefits and marginal costs in each project to ensure efficient allocation of limited social development resources. Unfortunately, neither damage nor abatement functions are well characterized.

CONCLUSIONS

Local Implications

Although individual Miskito villages may benefit from projects funded by donor organizations, the larger population is likely to continue without sanitation improvements. Adequate funds are simply unavailable in present circumstances. When international development agencies do choose to intervene, however, a review of past experiences along the Miskito Coast and in other parts of the world may help program managers design more effective interventions.

The analysis presented in this paper suggests that the following factors increase the probability of success. First, integrated projects that include health, education, and capacity building are more likely to have positive outcomes than stand-alone infrastructure improvements. Second, a long-term commitment to the target communities—a minimum of several months and possibly up to several years—is required. Third, aid workers should understand and build upon local social norms. Fourth, residents' preferences should be recognized, and projects should be designed to accommodate those preferences where possible. Finally, members of recipient communities should be encouraged to invest in the projects and take responsibility for maintaining infrastructure improvements and continuing good hygiene practices. Building wells and latrines in a village is straightforward; ensuring that a project permanently enhances well-being is substantially more difficult.

Global Implications

This accounting of complications associated with local projects implies that the global commitment required to eradicate the adverse health effects of contaminated water and inadequate waste disposal is severely underestimated at present. The United Nations suggests that annual investments of $5 billion to $9 billion would be sufficient to provide universal access to safe water and adequate sanitation using low-cost technologies (Nigam and Rasheed 1998). Yet the World Bank estimates that developing countries are already spending on the order of $25 billion per year in this sector while efforts to provide services to impoverished populations continue to lose ground (Nigam and Rasheed 1998; World Bank 1992). Back-of-the-envelope calculations can give a rough approximation of actual expenditures required. Since health care, education, and capacity building have to be integrated into most sanitation projects, the cost of constructing wells and latrines will constitute only a fraction of total outlays; yet even this represents a significant figure. In rural areas alone,

approximately 1.5 billion people lack basic services (World Bank 1992). If an average family comprises five persons, 300 million families need outhouses and access to clean water. One estimate suggests that ventilated, improved pit latrines appropriate for use in outlying areas can be installed for between $100 and $200 per unit (World Bank 1992). This figure may be lower in places where materials are available locally; in more isolated areas, transportation costs may increase budgetary requirements. Taking the higher number, to cover maintenance, and doubling it to account for water as well as sanitation, gives a first estimate of $120 billion. Since this figure does not include urban and peri-urban areas and omits the more expensive social components, total expenditures required worldwide will be significantly greater, perhaps by a factor of 10 or more.

In the past, the World Bank has published cost estimates that are more realistic than the current annual figures of $5 billion to $9 billion quoted by the United Nations. In 1978, for example, the Bank suggested that total expenditures of $600 billion would be required (Agerwal et al. 1981). In 1982, Bank analysts calculated that $800 billion was necessary (Kalbermatten and Listorti 1984). Converted to 1998 dollars, both figures would approach $1.5 trillion. Predictably, these numbers were dismissed as "patently unattainable" (Kalbermatten and Listorti 1984, 135).

If nations were to decide that the present state of affairs was unacceptable, however, perhaps the requisite resources could be found. For perspective, military spending worldwide currently stands at approximately $850 billion per year—$200 billion in developing nations USACDA 1998). Actions to mitigate climate change already agreed to in principle are expected to cost about 2 percent of gross world product annually, or $500 billion in the current global economy (Houghton 1997). If the international community allocated equivalent outlays to social improvements, it could eliminate water and sanitation problems in the developing world in four to five years. With a more modest reallocation of resources, the goal could certainly be achieved in 10 to 15 years. Although full treatment of these issues is beyond the scope of this paper, such juxtapositions raise discomfiting questions of international and intergenerational distributive justice (Schelling 1997).

An alternate response, in lieu of direct redistribution, would be the enactment of policies to elevate the productivity of rural workers in developing countries (Lewis 1978). As returns to labor rose, so would private demand and ability to pay for social services. Simultaneously, more public resources to finance infrastructure improvements would become available as the tax base broadened. This type of fundamental restructur-

ing, however, would also require significant long-term flows of domestic and international capital to areas that currently lack external investment. Several conclusions emerge from this analysis. First, demand-driven, market-based models that depend on recipients' current willingness-to-pay cannot solve financing problems. The World Bank estimates that poor people in rural areas of the developing world may be willing to pay 2 to 5 percent of income for water and sanitation improvements (World Bank 1992). If annual per capita income in this population averages approximately $500, and if 1.5 billion people are affected, total annual revenues from this source may be between $15 billion and $40 billion. This might suffice for maintenance of existing infrastructure, but it would not cover capital costs or social support services.

Second, multilateral development institutions and non-governmental organizations may be able to provide expertise and establish model projects, but they cannot bear full responsibility for providing universal access to safe water and adequate sanitation. The combined annual budget of such agencies—for food aid, emergency relief, peacekeeping, technical cooperation, economic support, and all other concessional funding—is less than $20 billion (World Bank 1997).

The responsibility to ensure that basic water and sanitation services are provided in the developing world therefore falls to national governments—to developing country governments directly and to industrialized country governments indirectly. The price tag is higher than presently acknowledged, but within our means nonetheless. Given a reasonable and appropriate reordering of global priorities, the goal of "clean water and adequate sanitation for all"—left unrealized after the International Drinking Water Supply and Sanitation Decade of the 1980s—could be achieved early in the next century. The result would be a substantial reduction in human suffering.

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