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Bridging Environmental Health Gaps

Lessons for Sub-Saharan Africa Infrastructure Projects

Main Report (Volume I)

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Health cannot be attained by the health sector,
either alone or even primarily.

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FOREWORD

This work was generated as part of the "Regional Study on Urban Waste Management: Examples and Best Practices in Africa." In considering past and on-going projects, it became clear that, despite its importance to sustainable development, very little information existed on the environmental health linkages beyond the very strong associations with diarrheal diseases, still one of the most important causes of death and disability in developing countries. It was decided to conduct a study on Sub-Saharan Africa (SSA) infrastructure operations to assess their environmental health dimensions and extract lessons that could be transferred to projects without necessarily complicating project management. Although multisectoral, this work concentrates on infrastructure, and within that presents a more detailed analysis of the water supply and sanitation subsector, particularly factors related to waste management, the overall context of the exercise. "Bridging Environmental Health Gaps" addresses four questions:

- Why is environmental health important?
- What are the main cross sectoral environmental health issues that need to be addressed?
- What can Infrastructure Task Managers (TM) and Country Officers (CO) do about them?
- If interventions would not conform easily to a Bank project, or if the Bank does not have a comparative advantage in executing them, what other measures are practicable?

"Bridging Environmental Health Gaps" consists of three volumes, each aimed at integrating environmental health into operations, but with a different emphasis:

- The Main Report (Volume One) is intended primarily for technical staff responsible for infrastructure sector programs in Sub-Saharan African countries. In addition, the Main Report should be of use to staff engaged in Environmental Assessments (EAs) of sector policies and programs. It would also be of interest to staff dealing with public health policies as well as water resource management. The main conclusion is that the contributions of infrastructure projects toward poverty alleviation and improvement in living conditions could be significantly enhanced by systematic consideration of opportunities for health improvement.

- Volume Two consists of a cross sectoral literature review used as background, and contains an annotated bibliography.

- Volume Three raises questions about the compatibility between environmental health and sustainable development and makes recommendations about how treatment of environmental health issues can be improved within the Bank.

The latter two volumes are expected to be of use to a wide audience not specialized in environmental health, since the two volumes approach environmental health as lying at the core of poverty alleviation and sustainable development, whether in policy or operations.

The Main Report is published as an AFTES Divisional Paper and may eventually be issued for broader circulation as an AFT Technical Paper. The two companion volumes are issued as Working Papers. The preparation of the three volumes was largely funded by the umbrella Trust Fund for Environmental Studies established by the government of Norway.

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BRIDGING ENVIRONMENTAL HEALTH GAPS

VOLUME ONE: LESSONS FROM SUB-SAHARAN AFRICA INFRASTRUCTURE PROJECTS

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VOLUME TWO: Cross-sectoral LITERATURE REVIEW & ANALYSIS

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List of Acronyms

AGETIP	Agence d'exécution des travaux d'intérêt public
BOD	biochemical oxygen demand
CAS	Country Assistance Strategies
CFC	chlorofluorocarbons
CO	carbon monoxide
DALY	disability adjusted life years
EA	Environmental Assessment
ECA	Europe and Central Asia
EHP	Environmental Health Project
ENVLW	Environment Department: Land, Water & Natural Habitats Division
EPA	(United States) Environmental Protection Agency
GIS	Geographic Information Systems
HIV/AIDS	human immunodeficiency virus / Acquired Immune Deficiency Syndrome
IDWSSD	(United Nations) International Drinking Water Supply and Sanitation Decade
IMO	International Maritime Organization
LAC	Latin American and the Caribbean
LPG	liquified petroleum gas
MNA	Middle East and Northern Africa
MOAg	Ministry of Agriculture
MOH	Ministry of Housing
NEAP	National Environmental Action Plan
NGO	nongovernmental organization
NO	nitrogen oxide
O_3	ozone
O&M	operations and maintenance
OD	Operational Directive
ORT	oral rehydration therapy
PAH	polyaromatic hydrocarbons
PCR	Project Completion Report
PM	particulate matter
RAIN	Regional Air Pollution Information System
RWSS	rural water supply and sanitation
SAR	Staff Appraisal Report
SO	sulfur oxide
SPM	suspended particulate matter
SSA	Sub-Saharan Africa
STD	sexually transmitted disease
TA	technical assistance
TB	tuberculosis
TM	task manager
TOR	terms of reference
TSP	total suspended particulate matter
VOC	volatile organic compounds
WHO	World Health Organization
VIP	ventilated improved pit latrine

I. OBJECTIVES

1. **Context.** "Bridging Environmental Health Gaps" is set in a context of several activities aimed at better management of water supply, wastes and the natural environment in Sub-Saharan Africa (SSA), all of which share some common goals of identifying best practices and lessons learned from past projects. This work differs somewhat from these activities by being broader in scope. Like environment, human health is multisectoral, and has sometimes fallen between the cracks of projects outside the health sector. Environmental factors have had the benefit of nearly a decade of institutionalized advocacy within the Bank, but environmental health has not. "Bridging Environmental Health Gaps" helps redress this imbalance.

2. **Content.** The study is divided into three complementary volumes.

a) Volume One (this volume, the Main Report) is project-oriented and includes environmental health background material and a checklist showing the major linkages environmental health and remedial measures which can be feasibly included in projects. It reviewed 203 SSA infrastructure projects from 1984-1994, 62 Project Completion Reports (PCRs), 124 environmental reviews, and 25 National Environmental Action Plans (NEAPs). The analysis indicates that input from health specialists in all of the above documents has been minimal.
b) Volume Two contains a cross-sectoral analysis of the literature and an annotated bibliography. Drawn from some 2,000 books and articles, and about 300 published Bank documents, it summarizes the major themes of the literature and shows that health has not played a significant role in setting policies and priorities outside the health sector *per se*.
c) Volume Three discusses the compatibility of environmental and health considerations, their policy implications in the Bank including their potential for "doing harm," and recommendations for future work and in collaboration with other agencies. Recommendations focus on tapping the potential of sectors outside health to improve human health.

3. **Objective.** The main objective of this study is to provide a project-planning and decision-making tool to recommend how environmental health considerations could be addressed in practicable ways in Bank projects. For the Bank, this means helping TMs and COs to identify problems which can be addressed in projects without making them cumbersome to manage, or exploring how such problems could be addressed in parallel with a project but administered by another sector or agency. These main objectives are addressed in Volume One, in particular the "Checklist for Integrating Environmental Health Considerations into Projects" (Sections V-VII). Borrowers could also use the information to glean a better understanding of cross-sectoral linkages together with a clear notion where inter-agency cooperation is practicable.

4. A subordinate objective is to prepare an information package combining important health, ecological, and economic data addressed to investment decision-makers, most of whom will not have a health background. These are addressed in Volumes II and III and should help facilitate information exchange among professional groups who normally do not routinely communicate with each other in the performance of their work.

5. **Audience.** As a tool to facilitate project management, the immediate audience is Africa Region TMs and COs in the infrastructure sector, but the paper could be used by other regions and sectors, as well as by client government officials and professionals from other fields. An overriding concern for all audiences lies with providing the right amount of non-technical information on health linkages and their consequences. What might be advisable and feasible to tackle in a project? For Bank staff, in light of realistic constraints posed by budgets, work programs, and Bank procedures, what practicable alternatives are available? For borrowers, what are realistic goals for a five-year budget, and how does one evaluate requests for investment in pollution abatement?

6. **Definition.** Environmental health is *the body of knowledge concerned with the prevention of disease through control of biological, chemical, or physical agents in the air, water, and food, and the control of environmental factors that may have an impact on the well-being of people.*[1] Environmental health differs from public health in that it stresses prevention and concentrates on the human living environment. According to USAID, which consolidated several of its health-related programs under the Environmental Health Program in 1994, environmental health prevents illness by reducing exposure to adverse environmental conditions and by promoting behavioral change. Environmental health is often discussed as "occupational and environmental" health, since occupational health, with its focus on the living environment concentrated in the workplace, was its precursor.

7. Environmental health is as much a way of thinking as it is a set of facts; preventing disease, death, and disability is at its core. It means looking at a problem simultaneously in its broad *and* narrow settings. In a broad context, it reduces exposure to adverse environmental conditions and promoting behavioral change. In a narrow context, it includes diseases and injuries associated with:

a) the lack of basic water (quantity and quality), sanitation,[2] and solid waste disposal, e.g., diarrheas;
b) improper water resources management and poor drainage, e.g., malaria and schistosomiasis;
c) crowded housing and poor ventilation of household smoke, e.g., respiratory infections;
d) exposures to vehicular and industrial air pollution, e.g., respiratory diseases and cancers;
e) alterations in feeding and breeding grounds of disease vectors like mosquitoes, e.g., dengue fever;
f) "occupational health" problems that become public health problems because they are so widespread, e.g., pesticides intoxications;
g) exposures to naturally occurring toxic substances, e.g., arsenic poisoning; and
h) alterations to the natural resource base which create safety problems, e.g., mudslides and flooding.

In the Bank, however, there is no clear definition for environmental health.

8. **A Different Approach.** The approach revolves around the potential of remedial measures rather than around the diseases *per se* and is posited on the adage that the whole is greater than the sum of its parts in three ways:

a) environmental health aims at preventing human illness and injury;
b) even if the health sector is achieving a better balance between curative and preventative measures, its interventions are curtailed by the sheer number of problems in sectors outside their control;
c) a cross-sectoral examination combining the notions of diseases and remedial measures outside the health sector can accomplish more than interventions executed by separate sectors.

9. **Message.** A vital concept is stressed throughout, viz., the major determinants of health outcomes lie outside the health care system itself. Thus, the relative importance of different sources of disease, injury, and death and the relative importance of their effects on human health need, at a minimum, to be considered collectively when planning for projects. Integration of this concept is intended to convey two important messages:

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[1] *The VNR Dictionary of Environmental Health and Safety*; Frank S. Lisella, ed.; New York: Van Nostrand Reinhold; 1994; 357 pages.

[2] "Sanitation" in this document refers to various forms of excreta and wastewater removal; defined in para. 60.

a) The infrastructure sector contains enormous *untapped potential* not available to the health sector to help improve the quality of life. As much as 44 percent of the burden of disease in SSA is amenable to infrastructure investments (paras. 25-28).
b) A focus on pollution control can give a false sense of achievement in environmental health improvement. *Define half a problem; propose half a solution.* This cautionary message should not be misinterpreted to avoid investments in pollution abatement, but to alert them to the realistic possibilities of doing harm if pollution is taken out of context of broader health considerations. (See Volume Three, Section II.)

10. **Lessons Learned and Best Practices.** Since this is the first cross-sectoral environmental health analysis in the Bank, lessons are limited. The few lessons that exist come from the Water Supply and Sanitation Sector where pertinent experiences are greatest after almost twenty-five years of lending. No other sector in the Bank has had the same breadth and depth of work on integrating health into their procedures. Useful examples of this come from work on Appropriate Technology for Low-Cost Water Supply and Sanitation of the 1970s, and the UN International Drinking Water Supply and Sanitation Decade of the 1980s. More than a set of replicable lessons, these experiences caused a changed in thinking to incorporate behavioral factors: *handwashing is as important as physical infrastructure.* In addition, the Bank was able to be more systematic in trying to integrate a basic engineering concept into lending: *sanitation and drainage need to accompany water supply, otherwise the water introduced can lead to disease*, even though political pressure favors the latter. Over the past decade, a better understanding of community involvement and institutional strengthening has also evolved, but such lessons are not unique to the infrastructure sector.[3]

11. The closest to best practice comes from the application of a technique, comparative risk/exposure assessment, which has been used by epidemiologists for about a decade, but not yet by ecologists. The technique helps identify the multiplicity of sources that might otherwise be missed from a single-sector focus, even though it accentuates pollution. Thus far, only a few such studies have been conducted, but point to the desirability of a comprehensive view of environmental health problems when setting policies and priorities. (See Volume Three, paras. 8-10.) However, the opposite seems to be occurring as agencies and professions become more specialized.

12. By comparison, a list of questions has arisen from the SSA Water Resources Strategy Paper, the first such study looking comprehensively at the cross-sectoral aspects of water for drinking, irrigation, and hydropower. An important dimension of this work identifies the potential conflicts that arise from competing uses and their respective costs, wherein cost recovery from the user is expected from urban drinking water but not necessarily from irrigation. Some potentially negative lessons may be implicit when examining rural drinking water supply executed under irrigation projects. These questions have not yet been systematically analyzed or drawn into lessons and are available as anecdotal evidence in various reports. For example, a retroactive analysis of the Bank's first decade of rural water supply lending (1974-84) showed that lending under irrigation within the agriculture sector was equal to lending under the water sector but was not subjected to the same scrutiny for compliances with Bank policy and procedures. It was also apparent from health analyses of other reports that malaria and schistosomiasis had also increased, due in part to the extension of the habitats of the mosquitoes and snails that carried the diseases. Providing drinking water was viewed as an inexpensive, overall benefit for villagers, since the irrigation operations were already there. More recently, figures derived from an examination of Bank involvement in rural infrastructure in SSA between 1975-94, show that lending for rural water supply under the agriculture sector is actually about double that under the water/sanitation sector, i.e.,

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[3] For a detailed discussion, with particular emphasis on the International Drinking Water Supply and Sanitation, see: *Lessons Learned In Water Supply, Sanitation and Health — Thirteen Years of Experience in Developing Countries;* Water and Sanitation For Health Project, USAID; Washington, D.C., 1993.

US$361.9. and US$182.4, respectively. (For sanitation, the figures are US$15.7 under agriculture, but nothing for water/sanitation.)

13. **The Stakes.** The stakes vary greatly for the Bank and Borrowers; the stakes can be enormous since they entail human suffering, not only projects and money. For *projects* an environmental health approach can anchor health benefits or bring them forward by only marginal additional investments, e.g., 1-2 percent project cost. Precedents for this lie with the Water Supply and Sanitation subsector, where health/hygiene components are now automatically considered as potential for projects and credited with reducing diarrheal diseases. (An important point to note here is that, because of the number of variables at play simultaneously, human health does not always show visible signs of improvement until the last of several factors has its impact, even though progress is being made.) For the *Bank* it means helping improve project efficiency through cross-sectoral cooperation, getting a better idea of how sectoral policies interact toward improving the quality of life of its clients, and focusing health-related research at key gaps. Conversely, the stakes can also be very high if sectoral priorities are incorrectly applied to different regions without looking at their environmental health repercussions.

14. For *Ministries of Health* (MOHs), an environmental health approach can help address the myriad of factors which exert their effects outside their institutional jurisdiction, but for which they do not have staff or budget to get involved with other ministries. Examining respiratory diseases, the second most important burden of disease in Africa, is indicative. The major determinants of air pollution come from three sectors: domestic energy, i.e., household cooking, lighting and heating fuels; transportation, i.e., ambient air pollution; and, to a lesser extent, waste management, i.e., localized air pollution from waste sites. Yet, MOHs have little say (and virtually no budget) in setting policy from these sectors, except for their participation on inter-agency boards setting standards. A better understanding of the relative importance of the contributions of different sectors at the policy level might help reduce respiratory infections merely by aligning interagency priorities when possible. For *other ministries* the situation is similar in that cooperation might help compensate for their lack of in-house health expertise.

15. **Advantages.** The advantages for the Bank and Borrower of following an environmental health approach are numerous: get a better idea of the potential for and the limitations of projects to improve health; identify the populations at risk; estimate economic costs of health damage; improve investments in infrastructure, pollution abatement and health care delivery; identify low cost projects or components; identify pollution monitoring equipment appropriate to local circumstances and avoid purchase of unnecessarily sophisticated equipment; define areas of practical collaboration, e.g., reduce research and monitoring costs by promoting information exchange on environmental health issues; reinforce other environmental programs dealing with pollutants; forge links with the MOH to compensate for budget constraints by having more than one agency address the same type problems.

16. **Poverty.** Finally, an environmental health approach can help bring poverty analyses into clearer focus by singling out discrete areas for Bank interventions. For example, a growing body of health literature points to the recurrent theme of poverty's negative effects on health throughout adulthood, confirming in studies what had been postulated. That is, low birthweight leads to poor formation of vital organs, which, in turn increases susceptibility to disease. The short-term effects on investment patterns from an environmental health analysis are less clear than those described above, but certainly can be helpful in devising more targeted research strategies searching for infrastructure interventions outside the health sector which have the greatest impact on the poor. In defining the daily onslaughts of poverty, the analogy to a sinking boat is appropriate: women and children do come first.

17. **Health Protection vs. Promotion.** Despite the positive message of this work, TMs may be worried at the prospect of adding environmental health criteria to those of poverty, gender, and environment, potentially compromising project success by combining too many objectives. This report draws a distinction between health protection and promotion. The former should be an implicit objective

in every project, but the latter depends upon individual project goals. For example, in an urban or water supply project, there is no question that removal of human excreta and other waste from neighborhoods is crucial and could meet general project objectives of improving living conditions. Yet, improper disposal of the waste could simply transfer the problem to another area rather than resolve it. Taking it a step further, by merely considering the potential for groundwater pollution, a standard engineering procedure in waste disposal, the project could also do harm by not incorporating procedures for disease control through vector control, in particular mosquitoes. The latter is not necessarily a standard procedure, except perhaps for sanitary engineers or those with training and experience in health. More typically, many engineers would automatically consider pests (rodents, flies, mosquitoes) as nuisances, but not necessarily health risks. The issue might not even arise in an environmental assessment.

18. This observation is not meant to criticize any profession, but to confront a dilemma. The danger for doing harm in projects stems from the increasing likelihood that projects with important engineering and health-related components are not being managed by specialists in those fields. Frequently, much of the work, particularly for engineering, is contracted to expatriate companies without first hand knowledge of local conditions. Thus, the checklist helps trigger the right set of questions to avoid harm and protect public health, which should be an objective in all Bank programs. The cases of Guinea worm and onchocerciasis eradication show that such combined objectives of health protection and promotion can be achieved (see box).

TWO SUCCESS STORIES: TOWARD ERADICATION OF GUINEA WORM DISEASE & RIVER BLINDNESS

Amidst the gloomy stories of disability and disease, there are always glimmers of light. The eradication of Guinea worm disease, *dracunculiasis*, is one such story — all the more salient in this case since the most important measures were undertaken by the infrastructure sector. Guinea worm disease is the only disease spread exclusively by drinking water. Loosely translated it means "infection with a small snake" and was first described in Egyptian medical texts in the 15th century B.C. A study in Nigeria estimated that Guinea worm infection cost US$20 million in lost labor each year and was responsible for about 60 percent school absenteeism.

Guinea worm eradication was initiated during the UN International Drinking Water Supply and Sanitation Decade of the 1970s, and WHO officially called for its eradication in 1986, when the number of cases was estimated at 3.5 million, with 100 million with unsafe water supply at risk. By 1995, infection rates dropped to less than 100,000 through protection of water supplies, mainly digging wells/boreholes, application of larvacide, and filtering the water. Guinea worm disease is limited to 18 countries, 16 of which are in Africa. It is hoped that by the year 2000, Guinea worm eradication will be added to that of smallpox eradication as accomplishments of the 20th Century — a success of practical collaboration of health programs outside the health sector *per se*.

A second case illustrating the power of interagency collaboration is the Onchocerciasis (River Blindness) Control Programme (OCP) in western Africa, begun in 1974 — an even more daunting task considering that: the blackfly, which spreads the disease, has a flight range of up to 400 km.; the population at risk covered 11 countries in a belt from Senegal to Benin, mostly along the main rivers; individuals carrying the disease can remain infective for 10-15 years; and remedial measures would have to be in place for 20 or more years. Initially, the OCP entailed collaboration among seven poor countries in western Africa, but was expanded in the early 1980s to 11 countries to ensure that the blackfly was eliminated in the broad region. In December 1995, a follow-up to the OCP, the African Programme for Onchocerciasis Control (APOC), was launched to attack the problem in the remaining 19 countries in a swathe running eastward from Benin to Ethiopia, and from Angola and Malawi, where onchocerciasis still exists. The OCP was successful in that it has virtually eradicated the disease within the 11 western African countries. Currently some 15 million are infected in the remaining 19 countries of APOC.

The blackfly breeds in fast-moving water of rivers, streams, spillways, and drainage canals (where the aerated water provides the larvae the high amounts of oxygen they need to develop) — precisely where people wash clothing, fish, bathe, swim and collect water. Socioeconomic costs of the disease were high because up to 50 percent of local population could be infected, 30 percent with impaired vision and 10 percent blind. Often, entire villages were abandoned for higher ground, but less fertile soil. Remedial measures centered on insecticide application, medication, education, and to a limited extent, future resettlement of abandoned areas.

19. **Realistic expectations.** This work is designated a "checklist" rather than "Guidelines" because, until similar results are available from other sectors in order to incorporate their lessons (one of the recommendations in Volume III). Studies on the health damages of air pollution, for example, have permitted a rank-ordering of some pollutants, such as lead being more cost-effective than sulfur dioxide in improving health and preventing disease. However valid application of such studies might be toward a single sector, they are inputs into a broader picture, which is the context of this report. Because of the large number of variables at play simultaneously, it is not yet possible to prioritize broad sectoral investment potentials and their expected rates of return in economic or human terms, e.g., whether water supply has a greater impact than does either solid waste or improved housing because cross-sectoral lessons are still inconclusive. Even if it is clear that the infrastructure sector has enormous potential to improve health, the relative importance of similar factors in agriculture, particularly the role of irrigation in the spread of vector-borne diseases, or in energy, particularly the role of indoor air pollution, have not yet been analyzed. In addition, other cross-sectoral factors, such as the role of global warming, cannot be fully addressed for their health implications until there is a broader picture of environmental health sectoral linkages. The checklist, nonetheless, provides ample information to make decisions on avoiding harm and promoting health improvement in infrastructure projects on a case-by-case basis. After a better cross sectoral analysis, it might be possible to transform the checklist into guidelines.

20. **Operationalizing Environmental Health Analysis and the Checklist.** In keeping with the overall objectives to opertionalize the lessons from Environmental Health in Africa, Volume One, i.e., the Main Report, is pertinent in Country Assistance Strategies (CAS), Environmental Assessments (EAs), Sector Reviews, Projects, and Monitoring. Section III, Infrastructure Interventions in Transmission and Control of the Burden of Disease (13 pages), provides environmental health background; Sections IV-VIII, Checklist for Integrating Environmental Health into Projects (38 pages), apply the background material to common situations in projects. Typical uses might be:

a) CAS and Sector Reviews: Sections V-VIII gives a 1-2 page summary at the beginning of each sub-sector of lessons from the literature, plus a table of the main cross-sectoral linkages.
b) EAs: Section III explains main causes of environment-related diseases. Sections V-VIII give a 3-7 page description of main health-related issues by infrastructure activity, e.g., industrial waste.
c) Projects: Sections V-VIII give a 3-6 page checklist of typical health-related issues and proposals for main remedial measures.
d) Monitoring: The explanations in Section III contain material (e.g., prevalence, transmission, sources) that could be adapted as monitoring criteria.

Volume Two is pertinent for reference readings and summaries of the main environmental health problems in different sectors, together with the strengths and weaknesses of the literature.

II. THE ROLE OF INFRASTRUCTURE IN THE ENVIRONMENTAL HEALTH BURDEN OF DISEASE

21. **A Different Approach.** The approach followed in the analysis below and later in the checklist is based on the notion that environmental health aims at prevention. Instead of concentrating on death, disease, and disability, the focus shifts to the potential for remedial measures. The approach also hinges on the premise that solutions need to be considered in their broad settings, *then* broken into manageable parts. Otherwise, important technical and cost-related details can fall between the cracks and compromise long-term potential for success. Starting with the definitions and prevalence of the burden of disease put forth by the health sector, the approach then repackages individual diseases and causes of injury according to the relative importance of their solutions outside the health sector, in this case infrastructure investments. This approach shows that infrastructure has an important role to play in nearly half the burden of disease in Africa. A step in that direction took place at the All Africa Rural Water Supply and Sanitation workshop and conference (Abidjan, 1990), when representatives of 46 African countries and 30 international and national agencies and NGOs agreed on the Abidjan Accord promulgating an integrated approach based on technical and institutional factors, resource mobilization, community participation with an emphases on the role of women, health and environment.

22. **Measurement Techniques.** In the health sector, the inadequacy of traditional measurements of morbidity and mortality to convey the full economic cost and social hardship has spawned the formulation of different measures, e.g., "years lived with disability" and "disability adjusted life years (DALY). The DALY is a weighted average for disability years and deaths, based on an average 82-year life span. These concepts lead to the "burden of disease." Despite these revolutionary improvements, analyses of environmental health are still fraught with inaccuracies. Most notable is a bias toward capturing and accentuating mortality, when morbidity appears more important.

23. Similarly, measuring environmental health has proved evasive largely because analysis requires estimates of a myriad of potential variables; however, the methodologies used to estimate the variables are still in their formative stages. Cost estimates of health damages are also very rough, but the most significant problem stems from data inadequacies on three counts. First, environmental health data are lacking, even in industrialized countries. Second, existing data tend to favor time-series mortality, when long-term morbidity tends to be more important with environment-related diseases. Some attempts are being made to help overcome these problems, such as comparative risk assessment.[4] Third, agencies which produce the data often have different objectives from those of the Bank. For them, there are important epidemiological differences among upper/lower and acute/chronic respiratory infections, which are insignificant or too fine-tuned for much of the Bank's work outside the health sector *per se*, namely, does improved housing reduce respiratory diseases? Consequently, much of the data on environmental health is taken out of context because the data are the best available.

24. Thus, in some Bank documents, the average age in calculating costs to human health of environmental damage, even in Africa, becomes 82, a statistical norm for human longevity. Similarly, in estimating costs of remedial measures for air pollution, one finds sums based on air-borne vehicle-generated lead for calculations because this is the largest source of lead. In fact, the studies from which the data were taken estimates (with provisos of inaccurate data monitoring) that up to 70 percent of actual total human intake could come from water and up to 90 percent from food, which could entail air-borne

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[4] Comparative risk assessment was recently developed to distinguish actual risk from potential exposure. A strength is being able to compare and evaluate the effects of two or three pollutants or hazards. A limitation is its reliance on animal studies, and focus on limited risks. Because few such epidemiological tools exist, they are often overextended or misapplied.

deposits for both.[5] Several other measurement techniques exist that have not been designed for health measurement, but could easily be adapted to do so, e.g., GIS, computerized models in the Asia Region, e.g., the Regional Air Pollution Information System (RAINS), used in monitoring acid rain by predicting SO_2 distribution and disposition in Asia.[6] Despite the apparent precision of some measurements, Task Managers and Country Officers should be advised that using epidemiological measurement is still an imprecise science.

25. **Analyzing the Data.** The burdens of disease in this analysis combine two complementary sources. The first, drawn from *Better Health in Africa*[7] lists those diseases responsible for about 10 percent of the total for males and females, in order to capture gender differences and occupational settings. These are roughly equivalent to the top five burdens of disease: malaria, injuries, respiratory infections, diarrheal diseases, the childhood cluster, plus the human immunodeficiency virus and acquired immune deficiency syndrome (HIV/AIDS) and other sexually transmitted diseases (STDs); they also account for roughly half the total burden of disease (Table II.1). The second source, *Global Comparative Assessments in the Health Sector*,[8] is used to give a more detailed picture of the top five by showing their collective socioeconomic impact (Table II.2). This table combine years lived with disability and annual death rates into "Disability-Adjusted Life Years" (DALYs, see para. 22). In order to keep the subsequent analysis in its broad context, other vector-related diseases and intestinal worms are added because their "years with disability are high," and they are intimately linked to adequate infrastructure and entail some of the same remedial measures.

Table II.1: Rank and Share of Burden of Disease in SSA (1990)

Female		Male	
Rank	**Share (%)**	**Rank**	**Share (%)**
1. Malaria	11	1. Injuries	13
2. Respiratory infections	11	2. Respiratory infections	11
3. Diarrheal diseases	10	3. Malaria	11
4. Childhood cluster	9	4. Diarrheal diseases	10
5. HIV/AIDS & other STDs	9	5. Childhood cluster	10
Top five sub-total	49	Top five sub-total	55

Source: *Better Health...*, Table 2-4

26. The basic linkages of infrastructure interventions in solving the top five are summarized in Table II.3. To reflect the potential of infrastructure interventions, Table II.4 reorders the burdens of diseases by DALY to help classify their relative importance as public health problems and thereby prioritize infrastructure interventions. These are: respiratory illness, vector-related diseases, water/sanitation-related diseases, and injuries. Because malaria and other vector-related diseases are dealt with largely by the same types of remedial measures, they are merged into the same category as those dealing mainly with wastewater and drainage.

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[5] "Comparing Environmental Health Risks in Cairo ...;" *op cit.*; part III, pp 19, 22, and Appendix 4, p.9.

[6] For information, contact the Asia Region, Environment & Natural Resources Division, Technical Department (ASTEN).

[7] *Better Health in Africa: Experiences and Lessons Learned*; The World Bank, Washington, D.C.; 1994; 240 pages.

[8] *Global Comparative Assessments in the Health Sector: Disease Burden, Expenditures and Intervention Packages*; C.J.L. Murray and A.D. Lopez, eds.; The World Health Organization, Geneva, 1994; 196 pages.

Table II.2 : Burden of Disease in SSA by DALY (1990)

Disease/Condition	Yrs. with Disability	Annual Deaths	DALY
Respiratory disease (of which:)	**3,017,000**	**1,565,000**	**45,312,000**
- respiratory infections (of which:)	1,714,000	1,029,000	31,639,000
– children under 5	575,000	756,000	25,834,000
- TB	1,303,000	536,000	13,673,000
Malaria	**4,708,000**	**805,300**	**31,504,000**
Diarrheal disease (of which:)	**662,000**	**887,100**	**30,356,000**
- children under 5	81,000	795,900	26,663,000
plus			
Intestinal worms (of which:)	**806,000**	**1,439**	**852,000**
- ascaris	419,000	1,439	440,000
- trichuris	290,000	not avail.	304,000
- hookworm	97,000	not avail.	108,000
Childhood cluster	**1,501,000**	**788,000**	**28,093,000**
Injuries (of which "Unintentional:")	**5,322,000**	**335,300**	**15,067,000**
- traffic	398,000	114,000	3,710,000
- falls	2,522,000	20,400	2,985,000
- drowning	<1,000	48,300	1,554,000
- burns	607,000	13,000	1,006,000
- poisoning	10,000	19,500	535,000
- occupational	18,000	15,500	405,000
- other	1,767,000	104,600	4,872,000
Tropical Cluster or Vector-related (of which):	**3,356,104**	**318,000**	**4,418,104**
- schistosomiasis	2,887,000	21,000	3,490,000
- onchocerciasis	182,000	297,000	641,000
- filariasis	184,000	not avail.	184,000
- Guinea worm	*103,104	not avail.	*103,104
SUBTOTAL (from above data)	19,372,104	4,700,139	155,602,104
SUBTOTAL (remaining burden of disease)	**48,158,000**	**3,236,861**	**137,236,104**
GRAND TOTAL	67,530,104	7,937,000	292,838,208

Source: *Global Comparative...*, Annex Table 9 *calculated separately for this table; 618,621 cases in 1990

27. The childhood cluster (perinatal conditions, i.e., whooping cough, poliomyelitis, diphtheria, measles, and tetanus) is not included in the remaining analyses because interventions are primarily limited to health care *per se*. In addition, HIV/AIDS and other STDs have not been included in the numerical analysis illustrating the enormous role of infrastructure even though there are numerous implications from the transport sector, most notably from truckers who play a role contributing to the spread of STDs. *Better Health* lists HIV/AIDS at 6 percent of the total burden of disease from women. Adding 3 percent, from the other STDs, would bring the collective STD total to about 9 percent, and thus number 5 in Table II.1. Since there are so many other factors involved in spreading STDs besides truckers, they are omitted. The role of truckers, however, is included in discussions in the Transport Checklist.

Table II.3: Infrastructure Interventions for Burden of Disease

Disease/Condition	Type of Infrastructure Remedial Measure
Respiratory disease	improved housing and air-pollution abatement
Malaria	vector control, sanitation and drainage
Diarrheal diseases and intestinal worms	improved drinking water supply and waste management
Childhood cluster	health care and education
Unintentional injuries	reduction of household and traffic injuries
Tropical Cluster or Vector-related	vector control, sanitation and drainage

28. **Infrastructure-related Burden of Disease.** Rearranging the above table to reflect infrastructure interventions gives a different perspective on their relative importance. Health statistics vary enormously in presentation throughout the world.[9] (In conducting the literature review, Vol. II, random searches encountered eight different "most important" causes of disease.) Arrangement *is* important since it can affect priorities and budgets. For example, health data tend to report tuberculosis (TB) separately from other respiratory infections; one can halve or double the importance of respiratory disease simply by including TB. The issue is not to quibble over statistics but to point out that Infrastructure Sector investments have an enormous but untapped role to play in reducing the burden of disease, and might be able to improve the quality of life enormously if the health dimensions of investments are systematically considered, viz., vector-related, sanitation-related, injuries, and respiratory diseases. In this case, four of the top five burdens of disease remain the same, but remedial measures would change by looking outside the health sector to infrastructure. (Remedial measures are discussed in Section III.) Thus the infrastructure burden of disease constitutes about 44 percent of the total burden of disease as measured in DALYs.

29. **Economic Benefits.** Economic benefits will vary enormously; many, if not most, will be difficult to quantify because so many variables are working simultaneously, and many pollution-related diseases, most notably cancers, take up to 30 years to develop. The modes of transmission, health effects and remedial measures for each of the disease groups listed in Tables II.1-4 are summarized in Section III. Nonetheless, a notional cost estimate suitable to initiate further analysis could be derived by using the information in Table II.2 and by considering the qualitative benefits by subsector as summarized below, and described in detail in the checklist (Sections V-VIII) and the literature review (Volume I). In addition, considerable work has been done in the Bank in the health sector and in USAID, e.g., in their Vector Biology Control Project, on the economics of malaria. Some of these figures could serve as rough estimates for the effects of other vectors. If using the DALY, rather than death or disability figures, in an African setting, calculations would have to be adjusted down from an 82-year neutral average life span to about 50 years, a standard that is frequently used without adjustment in calculating economic costs of degradation, even when applied to Africa.[10]

30. In each of the infrastructure subsectors, economic benefits could be calculated by adjusting notional estimates (para. 29) and adjusting the figures for the project beneficiary population from the general benefits described below, and described in detail in their appropriate sections of the checklist. An important concept has yet to be integrated into health economics and can help justify economic

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[9] Renata Plaut, "Communicable Disease Mortality: Now You See It, Now You Don't;" Epidemiological Bulletin; Pan American Health Organization; vol 13, No. 2, July, 1992; pp. 1-6.

[10] *BHA*, p. 13; Life expectancy at birth: high income country, 77 yrs; middle income, 68 yrs.; low-income, 62 yrs.; SSA, 51 yrs.

justifications. That is, partial benefits do accrue, even though they are not visible to health practitioners (i.e., "clinically manifest"). Disease can result from a combination of a dozen factors acting simultaneously, e.g, malnutrition, diarrhea, and respiratory disease, but progress in returning to good health might not begin to be visible until the first ten reasons have been dealt with. Thus, a low estimate, e.g., 2-15 percent of a potential benefit already available, e.g., lost labor, would not be out of line, as long as it is clearly labelled an estimate. Collectively, a series of small benefits can build up into a justification that would be missed otherwise merely because data are not available. The basic difference between the approach proposed in this report and a typical Bank infrastructure project lies mainly in the sets of linkages identified and thus the number of basic questions asked in defining project objectives, designing components, estimating costs, and calculating rates of return.

Table II.4: Burden of Disease in SSA Rearranged by Main Remedial Measures (1990)

Remedial Measures Disease/Condition	Yrs. with Disability	Annual Deaths	DALY
Improved housing & air pollution abatement			
Respiratory disease (of which:)	**3,017,000**	**1,565,000**	**45,312,000**
- respiratory infections (of which:)	1,714,000	1,029,000	31,639,000
--children under 5	575,000	756,000	25,834,000
- TB	1,303,000	536,000	13,673,000
Vector control, sanitation, drainage			
Tropical Cluster or vector-related (of which:)	**8,064,104**	**1,123,300**	**35,922,104**
- malaria	4,708,000	805,300	31,504,000
- schistosomiasis+	2,887,000	21,000	3,490,000
- onchocerciasis	182,000	297,000	641,000
- filariasis+	184,000	not avail.	184,000
- Guinea worm+	*103,104	not avail.	*103,104
Improved water and waste management			
Water/sanitation-related (of which):	**1,468,000**	**888,539**	**31,208,000**
- intestinal worms (of which:)	806,000	1,439	852,000
-- ascaris	419,000	1,439	440,000
-- trichuris	290,000	not avail.	304,000
-- hookworm	97,000	not avail.	108,000
- diarrheal disease (of which:)	662,000	887,100	30,356,000
-- children under 5	81,000	795,900	26,663,000
Household & traffic injury reduction			
Unintentional injuries (of which:)	**5,322,009**	**335,300**	**15,067,000**
- traffic	398,000	114,000	3,710,000
- falls	2,522,000	20,400	2,985,000
- drowning	<1,000	48,300	1,554,000
- burns	607,000	13,000	1,006,000
- poisoning	10,000	19,500	535,000
- occupational	18,000	15,500	405,000
Health care & education			
Childhood cluster	**1,501,000**	**788,000**	**28,093,000**

* approximations calculated separately for this table; + could also be counted as water/sanitation-related

31. **Rates of Return.** TMs may encounter a hurdle when they need to calculate rates of return for projects. The dilemma comes from trying to estimate damages to human health without accurate figures or with only a partial input of information. Methodologies to estimate health costs due to environmental degradation are still crude compared with other areas in health and natural resource management, but are

slowly being developed (see Volume Two, paras. 76-81).[11] The same issue was confronted in 1975 when the Bank sought to justify the health effects in water supply and sanitation projects through a special study. The study concluded that there were not enough data to justify projects on health grounds; it did not suggest that positive effects did not exist, just unmeasurable. Now, such benefits are an accepted part of project management in that sector.[12]

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[11] Guidance on assessing the importance of behavioral change, as compared with interventions of the health care system or environmental factors is available in: James A. Listorti, *Environmental Health Components in Water Supply, Sanitation and Urban Projects*; IBRD Technical Paper, No. 121, 1990.

[12] For a discussion of 144 studies, see: S.A. Esrey, et al.; "Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma;" Bulletin of the World Health Organization; 69 (5): 609-621; 1991; and Esrey, S., and J. Potash, L. Roberts, C. Shiff; *Health Benefits from improved Water Supply and Sanitation: Survey and Analyses of the Literature of Selected Diseases;* Technical Report No. 66; WASH, USAID, Washington, D.C., 1990.

III. INFRASTRUCTURE INTERVENTIONS IN TRANSMISSION AND CONTROL OF THE BURDEN OF DISEASE

32. **Organizational Framework.** The top five burdens of diseases identified in *Better Health in Africa*, viz., malaria, injuries, respiratory infections, diarrheal diseases, and the childhood cluster directly linked to potential for infrastructure interventions are discussed briefly below under headings of "transmission" and "control" in terms of project management issues and suggestions for remedial measures.[13] Whereas descriptions of transmission are presented by order of numerical severity — in this case, a spurious distinction because they are all important — the paragraphs on control regroup the diseases by the type of infrastructure project interventions that would be required. In looking at remedial measures, the discussions identify other important diseases that do not fall within the top five, e.g., cholera and filariasis, when project interventions could address more than one disease at the same time or when slight modifications in approach will make a difference.

33. This also includes suggestions that remedial measures be excluded in projects *per se*, but instead be considered if practicable in parallel activities outside the project, when management of such a component would not be feasible in a Bank project — it goes beyond the project cycle, or when the Bank does not have a comparative advantage. Prevention is stressed throughout. Thus in the water/sanitation section, emphasis is placed on excreta (contamination, removal, and disposal), since water would not be as polluted in the first place if human feces were prevented from contaminating it. This stress on prevention should be considered as a complement to, not a substitute for, health care interventions, hygiene education, and promoting awareness among the population.

34. Section IV repackages the information for use in EAs; Sections V-VIII, the checklist, discusses the information in terms of typical cases that could be made into project components in each of the infrastructure subsectors. Proviso: Not all the remedial measures identified under remedial measures in Section III can be addressed, directly or indirectly, in IBRD/IDA lending instruments. They are listed for background so that project analysis can be conducted in an appropriately broad context to help avoid environmental health factors from falling between the cracks.

35. **Respiratory Infections: Transmission.** Over the past decade, the epidemiological importance of respiratory infections has increased markedly, and they now share top billing with diarrheal diseases. Part of the increase is attributable to the ability to disaggregate respiratory diseases from their typical "package deals," i.e., childhood pneumonia-diarrhea-malnutrition, and part to the success of the United Nations International Drinking Water Supply and Sanitation Decade of the 1980s (IDWSSD). In SSA, the aggregate of respiratory diseases is responsible for 1,635,000 annual deaths (respiratory infections 1,030,000; TB 535,000) and 3,010,0000 years lived with disability (respiratory tract infections 1,710,000; tuberculosis 1,300,000)[14]. Respiratory ailments cover a broad range of chronic and acute illnesses of the nose, ears, throat, and lungs, i.e., colds, influenza, pneumonia, tuberculosis, bronchitis, and lung cancer. Children under five account for nearly 75 percent of the cases of lower respiratory disease in SSA. Recently, it has become clear that indoor air pollution has been recognized as an extremely important source of respiratory disease, which has been attributed mainly to vehicular and industrial emissions, largely because ambient air has been systematically monitored, but indoor air has not.

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[13] A 1-2 page explanation (description, transmission and interventions) for 25 of the most common diseases is available in: Listorti, *Environmental Health Components...; op cit.*

[14] *Ibid.*; pp. 47 and 84/85.

36. **Respiratory Infections: Control.** Two of the most important lessons from the literature come from the recognition of indoor air pollution from cooking, heating, and lighting sources, and of tobacco smoke to overall human health. Epidemiological evidence also shows that TB should be reduced by reduction in overcrowding, but that acute respiratory infections require a number of additional factors, including medical care and improved hygiene. Earlier, many respiratory disease causes were attributed to industrial and vehicular air pollutants largely because they were the only areas studied. Regarding air pollution abatement, even though vehicular air pollution is not widespread in Africa because population/vehicle ratio is low, transport-related respiratory disease is serious for the population at large around public transportation depots and is an occupational hazard for traffic police and others exposed to vehicle congestion for long periods.[15] (Nigeria is the only country in SSA currently considering phasing out leaded gasoline over the medium term.) The situation is aggravated by high levels of air pollution from cooking, heating, and lighting fuels. A Bank energy study shows that, even when the poor go up the energy ladder as income rises, they tend to keep the same cooking fuel, a major contributor to respiratory illness.[16]

37. The literature generally refers to six pollutants as most important, i.e., the "criteria" pollutants: particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, and ozone. Whereas they are indispensable to understanding outside air pollution, *they only represent a part of the puzzle in understanding respiratory disease*, which requires at least an equal input from indoor pollution, and, as appropriate, the harmful effects of tobacco smoke. The major sources of respiratory illness and the main pollutants are listed below in Tables III.1, III.2 and III.3. While all analyses cannot be comprehensive, at least the major pieces to the puzzle should be identified. For the sake of simplicity, scientific analyses often eliminate indoor pollution and tobacco smoke or, by comparison, focus on a single pollutant like lead, without allowing for other equally important sources of pollution which are not airborne. The latter can lead to a false sense of security in reducing the sources of pollution, or conversely can underestimate the range of variables that need to be considered in a strategy to reduce respiratory diseases. In addition, the literature is biased toward the results of measurement of the criteria pollutant, which focus on ambient air pollution.

Table III.1: Air-Pollution-Related Respiratory Illness

Pollution Type	Main Sources	Remedial Measures
Indoor	cooking, heating, lighting fumes; intrusion of outdoor pollution; dust	better ventilation; less polluting fuel source for cooking, lighting and heating; protection from external air pollution and dust; adjustments in fuel prices; education
Outdoor	vehicular exhausts; traffic, construction, solid waste dust; industrial and energy emissions; dust	pollution abatement; traffic management, emission standards, vehicle maintenance, adjustments in fuel prices; protection from dust as appropriate, e.g. tree barriers; education
Tobacco Smoke	important as predisposing/exacerbating factor because it contains concentrations of many indoor/outdoor pollutants	better ventilation, education, specific anti-smoking campaigns, tobacco levies as appropriate
Occupational	varies	varies

[15] WHO standard for lead exposure is 50ug/m^3 for 8 hrs.; 0.5 for ambient air; the US Environmental Protection Agency (EPA) sets ambient air standard at 1.5.

[16] "Energy for Rural Areas for the Poor: A Strategy for Developing Countries"; Power Development, Efficiency & Household Fuels Division, Industry and Energy Department; Draft, April, 1995.

38. The main constituents of ambient air pollution and their sources are listed in Table III.2. Two categories have been added to the six commonly used "criteria pollutants" to accommodate the role of indoor pollution, viz., "other smoke/fumes," and "inorganic dust." Table III.3 indicates the range of sources for lead, for which automobile exhaust is only a minor source, even though it is often considered the main source, while other equally important factors are neglected.

Table III.2: Major Components of Air Pollution

Pollutant	Main Sources
Particulate Matter	essentially refers to suspended matter small enough to penetrate the lungs less than 10μ); includes virtually anything that produces dust or smoke (also referred to as: SPM, TSP TPM, PM_{10}, PM_5)
Carbon Monoxide (CO)	primarily from transport sector (vehicular exhaust); household emissions from cooking/heating; tobacco smoke
Sulfur Oxides (SO_x, SO_2)	combustion of coal, petroleum, wood (electricity, cooking, space heating, oil refineries, smelters, paper manufacture, refuse burning); major component of tobacco smoke
Nitrogen Oxides (NO_x, NO_2)	combustion of coal, oil, natural gas, motor vehicle fuel; biomass/fossil fuels esp. important for indoor pollution; tobacco smoke, whose effects are worse in presence of motor vehicle emissions; component of smog
Lead	primary source *as air pollutant* from vehicular emissions, smelters; but other sources can be more detrimental to health
Ozone (O_3)	main component of smog, reacts with $N0_x$ and other pollutants, esp. hydrocarbons, with sunlight; used in food industry to extend shelf-life; high-voltage electrical equipment; used to purify water and sugar
Other smoke/fumes	fossil fuels: coal, oil, kerosene, natural gas; biomass fuels: wood, charcoal, vegetable, dung, biogas (also referred to as Volatile Organic Compounds, VOC, and Polyaromatic Hydrocarbons, PAH)
Inorganic dust & other miscellaneous	essentially the remainder of factors not considered separately under another chemical designation and can lead to a wide range of respiratory illnesses: including mites, mold, mildew, hair, stored products (e.g., household cleaning, pesticides), residues from building materials, etc.

39. For Bank projects, practical interventions that can help reduce respiratory illness deal with poor quality, overcrowded housing, and irritants to the respiratory tract which lead to infections. Any projects with housing construction should try to incorporate proper aeration and sunlight in design to help reduce person-to-person transfer and proper ventilation to help eliminate smoke and fumes. Out of home exposures also play a significant role, e.g., vehicle exhaust, especially near markets and stations, and recurrent exposure to dust and other particulate matter. Often, small components play a large role in reducing the basic irritation which predisposes people to respiratory infections.

40. Air pollution abatement needs to be considered collectively from its major sources: indoor, outdoor, and occupational. Lead deserves special mention because it is so frequently cited as a major pollutant. Unquestionably, lead is a serious public health problem globally, but its relative role, especially in African cities, might be overstated merely because studies on other equally important factors have been less publicized, even in the industrialized countries. The reader should be alerted that because lead is routinely included in environmental assessments, it does not necessarily make it important unless an association can be drawn to areas of high exposure, e.g., populations in markets near bus stations where vehicle emissions are excessively high. The varied sources of lead, which can be even more important that gasoline fumes, are listed in Table III.3.

Table III.3: Multiple Sources of Lead

Medium/Method	Sources
Air/inhaled	automobile emissions, primary and secondary lead smelters plus foundries producing other metals, factories producing ceramics, glass, and armaments, weathering of lead-painted surfaces, combustion of lead-painted materials and of solid waste; recycled motor oil used as fuel for industry and energy; recycled dust (up to 30 years)
Water/drunk	lead-lined storage tanks, lead pipes, fittings/couplings; air-borne particulates settling on water
Food/ingested	soil/dust deposits eaten directly, air deposits taken up in food, fertilizers, irrigation water, solder in canned foods, lead-glazed cookware and plates, painted surfaces, pencils (by school children)
Occupational	smelter workers, traffic police, garage mechanics
Other	diarrheal remedies, cosmetics (esp. eye, e.g., kohl)

41. **Vector-related Diseases: Transmission.** Malaria, schistosomiasis, and filariasis are, epidemiologically, the most important vector-related diseases in SSA; mosquitoes and snails are the major factors in the transmission of these diseases. Flies, roaches, fleas, and other such insects are also common in areas with poor infrastructure services. However, compared with the widespread epidemiological significance of mosquitoes and snails, they are generally more a nuisance than a major player in disease transmission, but they can be and are profuse in localized areas. Guinea worm disease and onchocerciasis are also important vector-related diseases, which account for a much lower share of the burden of disease. However, because successful programs are in place that have had a major impact in reducing their prevalence (overall number of cases) and incidence (new cases), they are included below. Transmission routes are summarized in Table III.4.

42. Malaria. Malaria in SSA is responsible for some 800,000 deaths annually, and for 4,700,000 years lived with disability.[17] Malaria is a parasitic blood disease, transmitted among humans by mosquitoes spreading contaminated blood. Breaking the cycle of transmission concentrates on five points: reducing human contact with mosquitos, reducing the number of human hosts, destroying the parasite, and reducing mosquitoes together with their breeding sites. Disease control has concentrated on drug treatments, spraying to reduce breeding/feeding areas, and, to a lesser extent, drainage where appropriate. Control programs are complicated by the life cycle of the mosquito and human behavior. Malaria appears to be staging a resurgence because the parasite is developing a resistance to chloroquine and other anti-malarial drugs. Malaria is spread by *Anopheles* mosquitoes (Table III.4).

43. Filariasis. Mosquitoes also spread filariasis which accounts for 184,000 years lived with disability. Filariasis is also called "elephantiasis" because of its most visible symptoms. In advanced cases, the disease causes such swelling of the legs that they look elephant legs. Filariasis is spread mainly by *Culex* mosquitoes, but can also be spread by *Aedes* and *Anopheles* (Table III.4).

44. Three mosquito species are important to the transmission of the diseases noted above: *Aedes sp.*, *Anopheles sp.*, and *Culex sp.* Their different breeding habits call for different approaches to breaking the transmission cycle; the implications for infrastructure projects stem from the type of habitats that projects can create, alter, or eliminate. For example, because *Anopheles* mosquitoes breed in natural marshes as well as impounded water, Mother Nature's role may be far more significant than water or irrigation projects. By comparison, because *Culex* mosquitoes breed in organically polluted water and *Aedes* in clean standing water, infrastructure can significantly contribute to habitat alteration.

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[17] *Global Comparative Assessments in the Health Sector*; C.L. Murray and A.D. Lopez, eds.; Geneva: WHO, 1994, pp. 47 and 84.

45. Current research, however, shows that some of these breeding, feeding, and biting habits appear to be changing, with an overall tendency to have predominantly rural diseases extending to urban areas. It is not yet clear whether these changes are due to urbanization, e.g., by creation of year-round habitats independent of seasonal change, to global warming, e.g., geographic extension of habitat, to pesticide applications, e.g., genetic changes, or to spreading the human hosts pool through population movements. Technically, only India is considered to have endemic urban malaria, but evidence shows that anopheline mosquitoes are adapting to urban conditions in Nigeria and Turkey. Likewise, *Aedes* mosquitoes appear to be spreading in urban areas, but the rural-urban transition is less clear since *Aedes* breed in urban water storage containers. This change might be accounting for the increase of dengue fever in Central and Latin America, already considered by some to be an epidemic, and in some Asian cities. Dengue fever exists in Africa, but is not as important as the other diseases listed above. Its relative importance could increase, however, based on the above, but it is difficult to assess since dengue is not tracked systematically by the World Health Organization (WHO) as part of the Tropical Cluster.

46. Schistosomiasis. Aquatic snails spread schistosomiasis (also called Bilharzia) which is responsible for 21,000 deaths annually, and 2,900,000 years lived with disability. Irrigation and dams, however, are the main contributing sources to endemic schistosomiasis. Inadequate excreta disposal allows the snails to become infected (Table III.4). The worms deposit large numbers of eggs in the urinary tract and intestines. The presence of worms and their eggs and migration of both can cause a range of problems involving the liver, intestines, and urinary tract (depending on the species) and can lead to other consequences, such as obstruction of the bladder. Humans remain infective as long as they discharge eggs, usually one-two years (but up to five years is possible; in species not common to SSA, humans can be infective up to 30 years.) Schistosomiasis becomes an "urban" disease by virtue of the number of cases requiring hospital care, which reflect an urban bias, or the number of people who have contracted the disease in their home villages and migrate to cities for jobs. The importance of agriculture in Africa underscores the need for a cross sectoral approach to such diseases, where the sectors have a common goal, but different priorities and policies. Schistosomiasis is also indirectly linked to urban areas in that some of the snail habitat, i.e., irrigation channels and bare shores of dams, result from providing urban food and power.

47. Guinea Worm Disease. Guinea worm disease is on the verge of eradication in SSA because of the Global 2000 Program and thus gets special mention.[18] (See Box, page 6.) Guinea worm is the only disease spread exclusively by water. Guinea worm disease accounts for 620 annual deaths and is responsible for 103,104 years lived with disability.[19] Humans drink a small water flea (*Cyclops*) which over a 2-3 month period develops into a worm 2-3 feet (1 meter) long and causes pain, fever, and nausea. Long-term effects include recurrent infections, arthritis, tetanus, and crippling. It typically migrates to the lower extremities, from which the female penetrates the skin and emerges, causing an open ulcer. Immersion in water triggers the worm to shed eggs when people fetch water, or try to cool the itching/burning from the blister in water. This debilitating disease is mainly a rural problem and can be controlled by protecting water sources with stepping stones and well caps to prevent immersion of feet/legs in water. Where it is endemic, as much as 50 percent of a population can be infected, and up to 30 percent incapacitated for up to three months, which is devastating to agricultural productivity or those who depend on seasonal labor. Consequently, any rural infrastructure project in an endemic area should examine the feasibility of including a small water supply, filtering, or monitoring component.

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[18] Guinea worm exists in: Benin, Burkina-Faso, Cameroon, Chad, Cote-d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan, Togo, and Uganda.

[19] *Ibid.* pp. 47, 84.

48. River Blindness, or Onchocerciasis, is responsible for 29,700 annual deaths and 182,000 years lived with disability.[20] It is spread by flies which breed in/near fast moving water, such as natural courses or spillways from various forms of water impoundments or irrigation channels. Thus, like schistosomiasis, onchocerciasis is a predominantly rural disease for which a risk can be created by infrastructure, such as dams to provide power and food, needed to service urban areas. Considerable progress has already been made in reducing the disease, which has virtually been eliminated in western Africa because of an international program. (See Box, page 5.)

49. **Vector-related Disease: Control.** Vector control is a complicated matter which is ill-suited for a component in a typical infrastructure project because curative and preventive measures will probably require control measures for years beyond the project cycle and for miles outside the project zone. Neglect, however, can lead to devastating consequences. Nonetheless, numerous short-term measures can be incorporated into projects in three ways: a) by providing technical assistance to help design an appropriate response outside the project, b) by adapting some of those measures as appropriate into the project zone, and c) engineering design geared toward reducing breeding habitats. Solid waste and drainage components should always be considered, since both types of components could be designed to reduce or eliminate vector breeding sites. In peri-urban and rural areas, irrigation has permitted a sequence of multiple crops that used to introduce a natural interruption of breeding sites in the dry season. There are two key factors to consider in breaking the cycle of transmission:

a) interrupting breeding patterns through infrastructure interventions, and by killing the vector and larva, proceeding with extreme caution in application of pesticides;
b) interrupting human exposure through infrastructure interventions, behavioral change, and medication.

Considerable information on pesticide use is readily available in the Bank and outside on the agricultural dimensions of integrated pest management, a combination of natural resistance, biological control, e.g., use of natural predators, cultural practices, using pesticides when the non-chemical methods fail to maintain pests below economically damaging levels.[21] See also Operational Directive (OD) 4.03 "Guidelines for Use, Selection and Specification of Pesticides in Public Health Programs," which deals with spraying to reduce vectors, but does not deal with general pesticide use in the agriculture sector.

50. If vector-related diseases are a local problem or mosquitoes are a nuisance, a TM should consult with the MOH to determine what programs exist or could be extended to the project area. DDT has been banned in some countries for widespread pest control based on ecological reasons; but it not been banned for public health uses such as malaria control (mosquito spraying) in and around houses. There is increasing evidence, however, being confirmed through additional studies, that postulate that DDT is carcinogenic in humans; hence that "approval" might change. Self-help preventive measures at the household or village level are possible through the intervention of NGOs or a community participation component. In addition, a component could realistically include studies to establish basic ecological and epidemiological background information (e.g., identification of species, their habitats, and feeding/breeding habits, socioeconomic description of local population, designation of population at risk, etc.), and the type of follow-up needed by the MOH and the community. In general, the recommendations might be best executed outside the project, but a component could support a pilot project or include works within the project zone. Ongoing monitoring, however, would be appropriate

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[20] *The World Health Report, 1995:...; op. cit.*, p. 18.

[21] Agnes Kiss and Frans Meerman; *Integrated Pest Management and African Agriculture*; World Bank Technical Paper, No. 142; 1991.

in a project. Table III.4 shows the linkages with diseases where water and excreta disposal plays an important role in vector transmission.

Table III.4: Vector-Related Diseases

Disease Vector	Breeding Environment/Primary Means of Transmission	Diseases
Mosquito: Anopheles	fairly clean, slow-moving brackish/fresh water, e.g., irrigation water, ponds, marshes; flight range up to 3 miles	Malaria, Filariasis
Mosquito: Aedes	clean fresh/salt standing water, e.g., water pots, cisterns, small containers, temporary pools, periodic flooding; flight range up to 50/100 miles	Yellow fever, Dengue, Filariasis
Mosquito: Culex	fresh/salt water polluted with organic matter, e.g., pit latrines, clogged storm drains, open sewers, waste stabilization ponds, soakage pits; flight range up to 10 miles	Filariasis
Snail	breeds along river/lake banks or irrigation/drainage canals; worm eggs in excreta develop into larvae (miracidia) infect snails; snail eggs hatch into larvae (cercariae) that penetrate skin; larvae need to find host within 6-48 hrs.	Schistosomiasis (Bilharzia)
Rodents (rats)	breed and feed in uncollected solid waste and in waste disposal sites; urine and feces can spread disease, through direct contact or ingestion	Leptospirosis (Weil's disease)
Water flea (Cyclops)	breeds in small freshwater ponds; causes ulcers on leg/foot, from which worm sheds eggs that develop into water fleas (copepods) that people drink	Guinea worm (Dracunculiasis)
Blackfly	breeds on vegetation and rocks near/in fast-moving waters, e.g., dam spillways and irrigation channels; disease spread through fly bites	River Blindness (Onchocerciasis)

51. **Water/Sanitation-related Diseases: Transmission.** Water/sanitation diseases cover a broad spectrum of symptoms and causes. This section gives background material on the two most important ones, diarrheas and intestinal worms, followed by Table III.5 which gives more detail on other important diseases. (The distinctions among terms like sanitation, wastewater, drainage, waste management, etc., are clarified below in the section on control, where the distinguishing features are important to project management.)

52. Diarrheas. Diarrheas remain one of the greatest causes of death and disease despite the progress of the IDWSSD of the 1980s. Currently, they account for 887,000 annual deaths and 662,000 years lived with disability (skewed relatively low because the mortality is so high among those under five years old). Epidemiologically, diarrheas are important because mortality can be very high if untreated due to dehydration and depletion of essential body chemicals. Diarrheas are a broad category of diseases. Diarrheas can be the main symptom of over 30 infectious diseases but can also occur as a side-reaction to another disease or its treatment, or result from travel, change of diet, or stress.

53. The infectious diseases, e.g., cholera and dysentery, are the most important (see Table III.5). In effect, humans ingest small amounts of feces which contain pathogens that cause the diarrhea. Three interrelated factors contribute, often simultaneously, to the process of contamination. Inadequate excreta removal is probably the single greatest cause, followed closely by poor personal hygiene, which accounts for hand-to-mouth transmission, and finally by drinking contaminated water. The problem is compounded by inadequate drainage, especially in slums and squatter settlements, when storm drains clog and become contaminated with all types of waste, exposing infants and children to high risks. Crowded housing conditions worsen the situation, since poor personal and domestic hygiene and food preparation practices account for a large share of the transmission, especially in cholera epidemics.

54. Intestinal worms. A large part of the developing world is afflicted with intestinal worms[22]. Intestinal worms, however, do not receive high publicity or priority because they are common, not dramatic, and often go undetected since the symptoms --- interference with digestion, absorption of needed nutrients, anemia and diarrhea --- are an accepted way of life among the poor and often themselves go undetected; they sap the body's energy slowly, and except in cases of heavy infestations, they do not kill their host. In SSA, intestinal worms account for about 800,000 years lived with disability.[23] The two worms most important worms are *ascaris* and *hookworm*. Ascaris is an important contributor to malnutrition; it is spread when people eat worm eggs deposited on poorly washed or uncooked vegetables that have come into contact with feces where they are grown or processed, and also through interpersonal contact. (Curiously, vegetables are often contaminated after they leave the fields where contamination risks appear greatest --- from water used to keep them fresh.) Hookworm is an important factor in anemia and one of the most common causes of hospitalization. Due to inadequate disposal of feces, when hookworm eggs are deposited in moist soils, they develop into the larvae. The disease is spread when the larvae penetrate the feet, most commonly around defecation sites.

55. Others intestinal worms, such as tapeworm, threadworm, pinworm and whipworm are also public health problems associated with poor collection and improper disposal of feces. As with diarrheas, inadequate excreta disposal is probably the single greatest cause of intestinal worms. Although anemia is an important problem, and one of the main causes of hospitalization in Africa, the health literature tends to focus on nutrition, especially iron deficiency, while neglecting that deficient sanitation is a fundamental contributing cause of anemia. (Technically, schistosomiasis and filariasis could also be classified as intestinal worms, but are discussed under vector-control.)

56. **Water/Sanitation-related Diseases: Control.** Project interventions can play an important role in control of water/sanitation-related diseases and hinge on three key factors:

a) protection of drinking water quality and provision of adequate quantity;
b) provision of adequate sanitation and drainage, and
c) hygiene education, which covers personal, domestic, and food preparation habits.

Hygiene education is equally important for water quantity/quality and sanitation/drainage, but is not discussed below since the type of response in projects would likely be some form of component based on the socioeconomic and behavioral aspects of water and waste management. Such components are not unique to infrastructure and would be in keeping with general desirability of community involvement.

57. Like the term environmental health, there is no definition or consistent use of the terms related to sanitation within or outside the Bank. Consistent with the Bank's subsectoral designations, titles for tables and chapter headings use "Water Supply and Sanitation," but the section below differentiates among the various terms (b above, and Box below) that have been used inconsistently inside and outside the Bank. "Pollution Control and Waste Management" also fall under the "Environment and Natural Resource Management" sector in the Bank.

58. Water quality and quantity. Basic water supply services range from open wells with buckets, to boreholes with pumps, to roof catchment systems, to communal fountains and standpipes, to yard taps and house connections. Infrastructure projects even outside the water/sanitation subsector project can contribute in a variety of ways to the elimination of diarrheas through components that address any of

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[22] *The World Health Report, 1995: Bridging the Gaps*; Table 5, Global health situation; WHO, Geneva, 1995; p. 18; ascaris, 214,000,000 people, and hookworm, 96,000,000 people.

[23] *Global Comparative..., op. cit.*, p. 87.

the three factors noted above (para. 56). The primary lesson from the literature points squarely to the need for water and waste management as an integrated set of services, not merely water supply alone. Oral rehydration therapy (ORT, packets of essential nutrients to replenish those lost through dehydration) is one of the most important curative interventions that should also be considered to combat diarrheas.

59. Because Guinea worm is the only disease linked exclusively to drinking water (para. 47), control measures are discussed under "water/sanitation" rather than "vector-related." Control measures should focus on protecting water sources from immersion of feet and lower legs while fetching water. Boiling, filtering, and treating water are also effective, but holding tanks have not been as effective as they are for some other vectors because the water flea (copepod), which spreads the disease, can survive for long periods in holding tanks.

60. Sanitation and drainage. From a health perspective, water supply, sanitation, drainage, and hygiene education *should always be considered as a package, although project responses will vary enormously and not necessarily contain all four.* About 75 percent of the water introduced into areas for domestic and industrial uses, plus rainwater, needs to be removed. Nonetheless, sanitation and drainage are frequently neglected because political pressure is strongest for promoting water supply rather than sanitation and drainage --- politicians like to cut ribbons at dams and airports, not at sewage treatment plants and latrines! The range of complementary services between the two all consist of collection, removal and disposal of:

a) excreta, in solid and liquid forms
b) liquid wastes, whether contaminated or not with excrement, and excess water from precipitation,
c) solid wastes, whether domestic or industrial, contaminated or not with excrement and hazardous materials.

The emphasis accorded to each depends on local conditions. To help overcome the confusion stemming from the inconsistent use of waste management, basic terminology is defined in the Box. (See also Annex C: Glossary.) Because sanitation and drainage tend to be forgotten, they are described in detail below.

61. Sanitation technologies for the safe collection, removal, treatment and disposal of human excreta range from off-site sewage treatment plants to on-site latrines. The key factors in all of the above situations are the degree to which fecal matter can be:

a) rendered biologically safe through natural or biochemical methods to release to the natural environment, or
b) kept from reaching humans while still pathogenic.

In this regard, the choice of on-site and off-site options are important because the reliability of the system will, in turn, determine the potential for exposure. Since excreta removal is so important to the control of water/sanitation related diseases, it is presented in Table III.5, which lists the main excreta-related diseases and their control measures.

62. Sewage treatment spans a wide spectrum of options and should be decided according to local circumstances. Too often, the selection of "latest and the best" are bought for political rather than technical reasons. (See Table VII.1 for range of systems.) Even if they are expensive, off-site systems may be appropriate in high-density urban areas for getting rid of excreta, but they can also be disasters. For example, where frequent power outages, service cuts/scheduling, or low pressure are inadequate to maintain a self-cleansing capacity of the sewerage. That is, if the quantity of water is insufficient, solids and suspended solids can settle and can clog the system. (In extreme cases, the sewage can evaporate and become a solid crust.)

Sorting Out the Confusing Terminology of Waste Management

Confusion abounds in the use of waste management terminology. Because so many systems worldwide consist of sewerage and buried stormdrains, many terms have acquired a meaning pertinent to the industrialized countries, passed on in university training, with applications not always appropriate for developing countries. Engineers recognize each others' dialects and readily overcome semantic differences. The problem arises when the non-specialist from TM to mayor uses the terms in project management. The problem is exacerbated when multidisciplinary teams work together --- a factor to be encouraged --- but, one that leads to many health dimensions falling between the cracks because terms of reference and other documentation do not always include definitions. For example, in some places "sanitation" refers mainly to street cleaning, but an environmental dictionary also defines it as culling diseased branches from trees. The job of a "sanitary inspector" changes from maintaining overall neighborhood cleanliness in one country to surveying the food industry in another.

The definitions below refer to the main health dimensions of waste management as used in this work. Sanitation and drainage represent two ends of a spectrum of services in waste management with different emphases and, together with medical care, are at the very core of public health.

"Sanitation" deals with wastewater and solid waste. From a broad health perspective, removal, treatment, and disposal of human excreta should be considered uppermost. The importance of solid waste will vary depending on its content and amount, but can be equally important.

"Wastewater" generally refers to the removal of liquid waste, which consists of "sewage" (mainly excreta) and "sullage" or "greywater" (from bathing, laundry, food preparation in domestic, industrial and commercial uses). Sewage, and sometimes sullage, is conveyed in sewers; the sewer network is "sewerage"; "sludge" is a residue from sewage treatment. Sewage treatment consists of three interrelated stages, for which the full sequence is not always considered necessary: "1° treatment" focuses on physical removal, e.g., of grit, grime and grease; "2° treatment" emphasizes biological quality for the receiving waters; and "3° treatment" addresses the remainder not eliminated in 1^0 and 2^0 stages. (However, even after 3^0 treatment, water is not necessarily suitable for drinking.) There is no term commonly used for the wide range of non-sewerage options.

"Solid Waste" refers to non-liquid waste emanating from domestic, commercial, and industrial sources. "Municipal waste," "domestic waste," and "garbage" generally refer to the same thing and constitute the bulk of solid waste. It can, however, contain some excreta, deposited directly or as sludge. Solid waste also covers toxic and hazardous waste. "Hazardous waste" and "toxic waste" generally are synonymous and require special handling, but have a slightly different emphasis. Material can be hazardous by virtue of the risk of fire and injury without necessarily being toxic. More important is the distinction between industrial wastes, which will vary from city to city, and hospital waste, which is likely to be a constant.

"Drainage" deals with the removal of excess stormwater and greywater/sullage. The overriding concern of drainage is the removal of water which has not necessarily been contaminated. Prevention of flooding and the attendant risks of injury, drowning, loss of housing, and contamination of drinking water are the prime health concerns. The spread of vector (e.g., mosquito) habitats will vary depending on local circumstances.

63. Many on-site or off-site alternatives have been designed to accommodate smaller amounts of water or have other factors adapted for collection, treatment, and disposal in developing countries. Small-bore sewers, for example, have the added advantage of not needing to be buried so deep, thus allowing for reduction of construction and maintenance in appropriate situations. Where land is available, waste stabilization ponds allow Mother Nature to do most of the work after wastewater is conveyed to the ponds through conventional sewers or other means. The long retention time allows for pathogens to die-off or otherwise loose their viability, and the worm eggs settle to the bottom and can be removed in the sludge Many of these are low-cost systems designed so that they can be upgraded. Ventilated-Improved-Pit (VIP) latrines, septic tanks, pour-flush, and low-volume flush toilets all have interesting features which provide different service levels that can accommodate the needs of different users.

64. Greywater or sullage is frequently discharged from buildings without any form of disposal, but needs to be given separate consideration for two reasons. First, accumulated water needs to be removed

to avoid providing breeding grounds for mosquitoes or having the water become contaminated, with all the attendant hazards to children playing nearby. Second, its treatment needs will be different, since it does not contain fecal pathogens, theoretically. However, greywater often does contain high pathogen levels because of overall poor sanitation. Greywater can be accommodated by sokaways, drainage pits, or a range of lined/unlined, covered/uncovered drains, and is often emptied into sewers. The key factors for avoiding health hazards are the degree to which the drains can be maintained free-flowing, avoid ponding and prevent accidents posed by the drains themselves.

Table III.5: Main Excreta-related Diseases

Disease	Main Transmission Routes and Effects	Main Control Measures
Diarrheas:		
a) general	a) fecal-oral route: interpersonal contact, drinking water, contaminated food, and unwashed hands; causes dehydration; can cause death, esp. in children	- General: waste disposal to avoid water contamination in the first place and to ensure personal and food-preparation hygiene; water *quantity* crucial for hygiene;
b) dysentery (Amoebiasis)	b) as above; rapid onset of "bloody diarrhea" causing anemia, fever, vomiting and cramps; even low-dose can cause infection	- General: medication and oral rehydration therapy (ORT); immunization of carriers, e.g., typhoid
c) cholera	c) as above; water/food contaminated by infected person; rapid onset of diarrhea, vomiting, cramps, dehydration, shock; mortality high if untreated	- General: in epidemics, e.g., cholera, heavy chlorination
d) typhoid (Salmonellosis)	d) as above; intestinal infection causing fever, headache; can be fatal	
Intestinal Worms:		- General: deworming medication
a) Ascariasis	a) ingested on food contaminated with worm eggs; worm inhabits intestines, main effects malnutrition; can cause other problems	a) improved sanitation, esp. near living quarters (children main reservoir); personal hygiene and food preparation
b) Hookworm	b) worm larvae penetrate feet or lower legs; blood-sucking worm "hooks" itself to small intestine, can cause severe anemia	b) improved sanitation, esp. for reuse as fertilizer; education, wearing shoes/sandals if possible; attention to defecation sites
Vector-related:		- General: curative and preventive medication
a) Malaria	a) spread by mosquitoes (See Table III.4);	a) control of mosquito breeding grounds, e.g., through landfill or insecticide oils
b) Schistosomiasis (Bilharzia)	b) spread by snails (See Table III.4); bladder infection with worm/eggs, very debilitating	b) improved sanitation, avoiding human exposure to larvae, eliminating snail habitat
c) Filariasis (Elephantiasis)	c) spread by mosquitoes (See Table III.4); infection by worm can cause headaches, nausea, fever, painful swelling of legs, genitals, breasts	c) ventilated-improved-pit (VIP) latrines effective in dealing odors and insect breeding
d) Leptospirosis (Weil's disease, Mud fever)	d) direct exposure to rodent urine or in water, esp. rainy season; sudden onset of fever, aches, hemorrhaging; can cause kidney failure and death	d) workers/scavengers at waste disposal sites, esp. where rats present; protective clothing and education appropriate; medications

65. Stormwater can be accommodated by the a wide range of drains or various forms of water diverters, ranging from stone-lined ditches to buried stormdrains. Water from houses or industries cover an equally wide range of technologies from simple soakaway pits outside a house to elaborate plumbing systems connected to sewers. Stormdrains, however, need to accommodate large surges of water that can lead to flooding and soil erosion, with the their attendant problems of accidents and contamination

of the living environment. Stormdrains in residential areas are often cement-lined ditches covered by cement slabs or metal grates. In short order, however, the covers disappear, and the drains become open sewers because of overall contamination. In these cases, the drains themselves become the hazard. Otherwise, the major health problems stem area-wide flooding which can cause fecal contamination of living areas, particularly in urban areas where roadways and haphazard residential development have cut off natural flow patterns. Injuries and drowning are also common. In addition, standing water can allow for mosquito breeding, which can occur within a week. If this is a problem, it can be addressed by a component relying on community involvement to keep the drains flowing. Such components, however, are only practical in areas where there are well organized or active community groups, NGOs, small enterprises (AGETIP type activities), or business associations that perceive a benefit.

66. Solid waste disposal also plays a key factor in control of diarrheas and intestinal worms, but it is often given the wrong emphasis, based more on smell and unsightliness than sound epidemiology. From a health perspective, the two ends of the waste disposal spectrum are most important, i.e., household/neighborhood collection and the final disposal site. The full spectrum consists of:

a) collection from the household to local consolidation points,
b) sometimes, transfer, where it is further consolidated for bulk transport, e.g., trucks, from the transfer station to the disposal site,
c) transport to the disposal site, and
d) operation of the disposal site itself.

Each of these stages has public/occupational health and safety concerns. An important but often overlooked institutional aspect of these concerns is that different municipal or regional agencies, as well as private contractors, might be responsible for each of the four steps, including the three collection stages. Thus, even though health and safety concerns might be clear from the household to the disposal site, they can easily fall through institutional cracks because terms of reference, budgets, and legal jurisdictions do not spell out details for monitoring or responsibility to enact corrective measures.

67. The household/neighborhood level is important because diarrheas are most prevalent in children and infants, who spend most of their time there, and are exposed to a wide range of contaminants. Neighborhood level is also very problematic to management of the whole waste disposal system because of the enormous role of socioeconomic and behavioral factors involved with the organization and payment of waste disposal. These are weakest in poor neighborhoods. The greatest hazards of the disposal site are contamination of groundwater and overflow of the site itself during rains. In addition, children are at risk at disposal sites because they often are charged with disposing household waste and go there to play.

68. **Injuries: Cause.** "Unintentional injuries" covers a broad range of accidents and accounts for 335,000 deaths annually, and for 5,500,000 years lived with disability.[24] The five largest components in terms of mortality are traffic, falls, drowning, burns, poisoning, and occupational, with falls accounting for nearly half of the years lived with disability (not traffic because of high mortality, see Table III.1). The most straightforward factors to address fall under road safety and have been integrated into the transport sector for years. Similarly, a large portion of injuries are work-related and can be incorporated into components based on existing best practices. In most developing countries, there is no safety net to help people harmed by occupational injuries. Drowning, household falls, and burns can often be addressed in structural designs in the neighborhood or the house.

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[24] *Ibid.*; pp 47 and 86. "Intentional injuries" include suicide, homicide and violence, and warfare.

69. **Injuries: Control.** Not all projects can control construction designs and standards, but when they do, modifications to stoves and cooking areas, inclusion of protective barriers or catwalks in housing projects near/over water, fencing around landfills, etc., can be built into projects at low cost. A technical assistance component could be appropriate to identify practical risks and recommend solutions for implementation outside the project *per se*, especially where they may require behavioral change and inclusion of an accident-prevention component might be difficult administratively to incorporate directly into a project.

70. Apart from traffic fatalities, data on injuries are difficult to obtain, except for broad categories. Injuries are particularly high among teenagers. The literature, however, does clarify many causes through case studies and indicates that teenagers are at very high risk. Remedial measures for traffic accidents are already dealt with by the transport subsector, although the links to erosion as a cause of pedestrian and vehicular accidents could be strengthened. That is, erosion can eat away the shoulder, forcing pedestrians to walk on the road. In extreme cases, erosion can eat into the roadway itself forcing vehicles into another lane.

71. Because the remaining broad categories are difficult to define, it is hard to design precise project interventions. However, general remedial measures could be designed to include the following. To prevent falls, TMs can follow best practices that are often standardized safety precautions during project construction. For drownings, burns and poisoning, the MOH or local clinic might be able to provide information indicating if these are serious problems. Remedial measures would vary by including safety measures and education in a component through a local NGO. For drownings, determine the degree to which children slip into water from paths that are in settlements near water courses, or fall from catwalks or residences in housing built over water. For burns, determine the degree to which burns are caused by home cooking, lighting, and heating fires. For poisoning, separate out, if possible, cases due to intentional poisoning and suicides, which might account for the majority. If the remainder is significant, determine the degree to which poisonings are caused by improper storage. Occupational measures for each of the subsectors are discussed in those sections.

IV. CHECKLIST FOR INTEGRATING ENVIRONMENTAL HEALTH CONSIDERATIONS INTO PROJECTS

72. **Suitability for Inclusion in Projects** The checklist aims to identify areas that can be addressed in Bank loans including: the range of potential problems, high risk groups, intersectoral linkages, and institutional factors. Where there are important problems that may be difficult to incorporate into a Bank project, or where the Bank might not have a comparative advantage in its implementation, the checklist suggests that the TM seek assistance in a parallel program outside a Bank project. For example:

a) community education to protect local populations from hazardous wastes and monitor its sources might depend on the existence of specialized business/merchant associations or NGOs; or
b) mosquito spraying in a sites and services component might not be practical because spraying, to be effective, needs to go beyond the project area.

Such interventions would last longer than the typical project cycle. It would, however, be appropriate for a project to include a technical assistance (TA) component to help structure a long-term response through the MOH, an international agency or NGO as appropriate. (In the checklist, TA refers to conditions where local resources might need outside assistance.) In addition, for the benefit of TMs own time management, the terms "preparation Terms of Reference (TORs)" and "implementation TORs" are used in the checklist to designate overall stages when interventions are appropriate. Thus, whereas the overall issues to be addressed by "implementation TORs" should be identified at preparation stage, direct TM or consultant intervention can be delayed until a later stage.

73. **Background Information for Sub-sectors.** For the benefit of Country Officers, each subsector except Telecommunications begins with a 1-2 page summary of the literature and ends with a table of major cross-sectoral linkages. For Task Managers, the material in the middle contains a description of health issues and a checklist of typical components by subsector, and suggested remedial measures which could lead to health benefits. The checklist follows the Bank's sectoral codes; components in hybrid projects are cross-referenced in each subsector as appropriate, but described under their primary sector.[25] Whereas the text is based on potential issues, the selection of components listed in the tables reflects actual titles which were drawn from the 203 Staff Appraisal Reports (SARs).

74. Additional information is available in the literature review (Vol. II); it is organized into 2-5 page sections by sector: Agriculture, Energy, Industry, Infrastructure (General, Housing and Urban Development, Transportation, Water Supply and Sanitation), Population and Human Resources, Environment, and Economic Evaluation. Each section discusses major themes, strengths and weaknesses of the literature pertinent to developing countries, irrespective of project implications. The annotated bibliography, with about 100 entries, is organized by title only.

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[25] "Sectors" refers to the Bank's designation of: "Agriculture and Rural Development:" fishing; irrigation & drainage; livestock; marketing; agro-industry; perennial crops; research & extension; food security; forestry; and other agriculture --- "Infrastructure and Urban Development:" telecommunications; highways; ports & waterways; rural roads; transportation sector; urban transport; aviation; railways; other transportation; housing; solid waste; urban development; other urban; rural water supply & sanitation; sewerage; urban water supply; and other water; "Industry and Energy:" energy sector; oil & gas exploration & development; oil & gas transportation; refining; storage & distribution; other energy; power distribution & transmission; hydropower; nuclear power (e.g. clean-up); power sector; thermal; other power; tourism; fertilizers & other chemicals; engineering; industry sector/IDF; small scale enterprise; paper and pulp; industrial restructuring; iron & steel; textiles; and other industry. Mining (and other extractive) is under Multi sector; "Population and Human Resources:" population, health & nutrition; other population, health & nutrition, AIDS, social benefit administration, human resources, employment, education (all levels); "Environment and Natural Resources:" environmental institutions, natural resources management, pollution control & waste management, resettlement, environment sector, other environment.

75. **Focus on Disease Control and Transmission.** The checklist reflects an application of the literature review (Vol. II) to Bank SSA infrastructure projects in view of suggesting up to three areas per subsector where traditional projects might be improved because such factors have been neglected in the past. Improvements could include:

a) minor alterations in project design,
b) addition of a low-cost, easy-to-manage component,
c) recommendations for studies that could be useful in future projects, or
d) collaboration with another agency better equipped to implement a component.

76. Many important issues cannot be readily transferred into infrastructure loans despite their importance. For example, one of the most important innovations in the literature over the past decade is the attention now focussed on the role of stress to the urban poor, as opposed to the more traditional topics which deal mainly with provision of basic services to keep people housed, clothed, and fed. These stress-related factors are manifest in such ways as urban violence, drug/alcohol abuse, child abuse, and malnutrition because there is no money left for decent food. Stress, as such, is too all-encompassing for easy adaptation to infrastructure projects. There are, however, numerous aspects which can be disaggregated to fit into infrastructure projects or studies by a better cross-sectoral interchange. That is, many topics which have the greatest negative impacts on the poor, like the effects of energy prices on food or rent, are already being handled in health and energy sector projects. In some cases, their results can be transferred to infrastructure under a TA umbrella.

77. **Summary of Main Benefits by Sub-sector.** The main environmental health benefits are listed below. The salient points for incorporation into EAs are summarized in Table IV.1. The Table is labeled "Sample" because Volume I has not been field-tested to accommodate EA procedures since these procedures do not (yet) exist. Recommendations in Volume III cite the need to identify for TMs the type of environmental health information readily available for use in EAs, the type and practicality of studies that might be required to allow for sound decision-making, guidelines on how to interpret health data, and suggested criteria for measuring project progress.)

78. Housing and Urban Development. Housing and urban development subsector projects can help alleviate respiratory disease by better ventilation in general and improved cook stoves where appropriate. Reduction in overcrowding should also help, but statistically significant associations have not been demonstrated because there are too many other variables involved. Improvements to neighborhood environments can help reduce accidents, for example, by modifications to paths, walkways, and cooking areas. Improved water supply, sanitation and drainage, frequent components in housing and urban development, when linked with increased awareness and hygiene education, can help markedly to reduce diarrheal and vector-related diseases (see para. 81). In areas with houses already constructed over water, upgrading projects can help control drownings, mainly from infants and toddlers.

79. Telecommunications. Telecommunications subsector projects mostly have indirect effects on health and are thus more difficult to describe. Health benefits are likely to be small, since the impacts are themselves small, except for avoiding injury and death due to extreme events. Better communication would facilitate more rapid responses of emergency health services and allow for advance warnings for extreme events like storms and floods or major industrial accidents. Noteworthy for SSA, they can avoid extending mosquito habitats when digging holes for transmissions lines. However, transmission poles appear on the decline with advances in telecommunications in general. Satellite and other wireless communications, for example, would also reduce the need for relay stations and thus for air conditioning. These would decrease chlorofluorocarbon (CFC) use which contributes to depletion of the ozone layer. The latter can cause cataracts and skin cancers, minor health problems in SSA compared with infectious diseases. Other slight benefits from better telecommunications, such as faxes and computers, might result in a reduction in the use of motor vehicles and thus reduce air pollution.

Table IV.1: Summary of Main Points for Consideration in Environmental Assessments

Disease/ Condition	Sample Sector or Project Components	Sample Steps for EA
Respiratory disease - respiratory infections - TB	- Housing - Community facilities - Traffic management - Air pollution abatement - Sites and services schemes	- Review health records to determine levels of respiratory disease and overcrowded housing - Determine levels of uncontrolled burning and other dust from waste management sites - Determine degree of transport and industrial air pollution monitoring
Vector-related - malaria - schistosomiasis* - filariasis* - Guinea worm* - onchocerciasis*	- Vector control - Stormwater drainage - Sanitation - Solid waste - Sites and services schemes - Rural water supply - Roads	- Review health records to determine presence of malaria, and other vector-borne diseases (may be necessary to inquire from MOH because records for diseases other than malaria are not kept systematically) - Determine degree of transport and industrial water pollution monitoring - Determine conditions of drains in project area - Review geographic information systems (GIS) type information to determine flood-prone zones and frequency of flooding - For any rural infrastructure project, review health records for current/past presence of Guinea worm
Water/Sanitation-related - intestinal worms - diarrheal - schistosomiasis* - filariasis* - Guinea worm* - onchocerciasis*	- Water supply - Sanitation - Solid waste - Drainage - Vector control - Road rehabilitation - Sites and services schemes - Hygiene education	- Review health records for diarrheal diseases and vector borne-diseases - Consult project zone health centers for local information (or health districts that include project area) - Review GIS-type information to determine flood-prone zones and frequency of flooding - Review municipal records for distribution of industries, unsafe roadways, pollution distribution and waste sites for effects on local populations
Unintentional Injuries - traffic - poisoning - falls - burns - drowning - occupational	- Housing - Public facilities - Erosion control - Traffic management - Solid waste management	- Review health records on injuries, with special focus on traffic and burns, for the latter if they are children or household - Review municipal records for distribution of industries, unsafe roadways, pollution distribution and waste sites for effects on local populations

* counted in two categories because of complementary remedial measures

80. Transportation. The transport subsector can help reduce ambient air pollution, a contributing factor of respiratory disease in congested urban areas. Better port management can help reduce water pollution, and improve handling of hazardous materials. Better drainage can also help reduce water pollution and curtail the spread of vector habitats. Better road maintenance can reduce traffic fatalities and injuries. Better traffic management can help reduce air pollution, which plays a contributing role to respiratory disease in congested areas. Proper disposal of i) vehicles can help reduce the spread of mosquitoes, and ii) wastes from vehicles, e.g., oils, batteries, and from transport maintenance workshops can help reduce water pollution. Project interventions are less clear for other areas, but they do exist. Air travel is contributing to the spread of TB, currently staging a global comeback. And rehabilitation of railway cars can contribute to lung disease because of the presence of asbestosis insulation in the cars.

81. Water and Sanitation. Water, sanitation and drainage would have their greatest impacts on diarrheas and vector-related diseases. Provision of water can markedly reduce diarrheas by providing for basic hygiene, but this must go hand-in-hand with improvements in sanitation, which is one of the

major reasons why water is contaminated in the first place. Intestinal parasites would be reduced by improved sanitation. Better waste management and drainage plus improved water storage at the household level could reduce the spread of mosquito habitat; improved drainage can reduce flooding, which in turn can contaminate food and water, and cause injury and death. Proper management of waste disposal sites can help reduce water and air pollution affecting workers and residents near disposal sites.

82. **High Risk Groups.** There are two sets of high risk groups: the poor and workers. The main high risk groups in infrastructure are women and children in each of the subsectors. Poor families are the most sensitive and vulnerable to the adverse effects of environmental degradation of all sorts: they live in undesirable parts of the city, where often it is technically difficult to provide water and waste management services; they have least access to other basic infrastructure; they live near dumps, or have them placed in their neighborhoods; they live in crowded accommodations, poorly ventilated housing, and are forced to cook, heat, and light with the cheapest but most polluting fuels. It is important for TMs to have these groups identified and include remedial measures as appropriate.

Table IV.2: Sample Occupational-Health Risks by Sub-Sector

Sub-sector	Sample Occupational Risks
Housing and Urban Development	accidents and exposure to excreta and toxic material at solid waste sites to workers, scavengers, and children playing after-hours; added risk of accidents from children playing in unfinished construction after hours; unprotected cutting/handling of asbestos construction material
Telecommunications	exposure to vector-borne diseases of road crews or local populations not already exposed
Transport	intense air pollution from fuel/exhaust fumes to drivers/mechanics, to road crews of dust and surfacing fumes, and to merchants near heavily travelled roads, congested intersections, and passenger stations; exposure to vector-borne diseases of road crews not already exposed
Water & Sanitation	accidents and exposure to excreta and toxic material at solid waste sites to workers, scavengers, children playing after-hours; heavy dust to residents along site access roads; unprotected cutting of asbestos pipes

83. Workers become a second high risk group because occupational health infrastructure is poor throughout SSA, e.g., "health rooms," protective clothing, health insurance, and ambulance services. Owing to the similarity of problems in each of the subsectors, the main occupational risks are summarized in Table IV.2. These are consolidated here and stress the point that remedial measures need to be kept in a broad, cross-sectoral framework, even though interventions might be within a single sub-sector.

84. **Institutional Issues.** The main institutional issues stem from infrastructure agencies not having personnel to consider health issues and of MOHs not having capabilities to reach out beyond the health care system. For example, water supply might be under the Ministry of Health in rural areas, but the Ministry of Works in urban areas. The Ministries of Transport and Industry measure ambient (and sometimes occupational) air pollution, but do not coordinate their work with the MOH or the Ministry of Energy. The Ministry of Agriculture might be responsible for monitoring pesticide contamination of the food chain, but the MOH concentrates its efforts on the food packing/processing industries (and sometimes public food markets) for reasons other than pesticides. It is important for TMs to be aware of these cross-sectoral issues and include remedial measures as appropriate. In many instances, merely identifying institutional strengths and weaknesses is a positive step toward future operations.

85. **A Word of Caution.** The information provided in the checklists should be viewed as general observations since sources of problems and their solutions change radically from place to place.

V. HOUSING AND URBAN DEVELOPMENT

86. **Lessons from the External and Bank Literature Review.** The literature contains a confirmation of many stock-in-trade issues that have been at the core of housing and urban development lending since it was initiated in the Bank in the early 1970s, viz., the provision of basic services and an increasing understanding of cost-recovery mechanisms to ensure that these services can be properly managed and maintained as important determinants of basic health. Areas that can be improved include housing designs and construction standards which can be better adapted to affordability for the poor through studies that go beyond the cost of rent but also look at expenditure patterns on food, education, fuel, and health care. Similarly, there is overall tendency for low-cost housing to locate on lands of marginal economic value which are prone to flooding or are close to waste disposal sites and industrial concentrations. Whereas new construction is adequately covered by environmental assessment procedures, the incorporation of these principles in upgrading of established neighborhoods is more difficult, especially when local zoning restrictions or construction standards have already been determined prior to project involvement. One way to help overcome this is to incorporate community participation components. Community groups and NGOs have become increasingly aware of the active role they can play in improving environmental conditions. Such actions can be as general as community education about self-help efforts or as specific as affordable pollution monitoring kits that can help compile actual data rather than merely express community concern.

87. Many Housing and Urban Development sub-sector projects are hybrids, consisting of components from other sub-sectors. The most common types are: a) urban development, which include solid waste management, refuse collection, drainage, street maintenance, and traffic management, and; b) urban water supply, which include drinking water, municipal wastewater management, and on-site sanitation systems. These components are described under the water supply and sanitation subsector, whereas traffic management is treated under the transportation subsector. Conversely, urban planning and management components have not been discussed in the checklist because they tend to be oriented more toward policy and fiscal management. However, in these cases, it would be appropriate to see that an environmental health assessment is conducted to see that urban policies, projects and programs have not excluded local health needs.

88. Three distinct areas to help improve environmental health through housing and urban development projects are:

> Indoor air pollution: Indoor air pollution as a major contributor to respiratory infections has been neglected in housing and urban development components, but readily lends itself to remedial measures, such as adaptations in housing design to improve aeration, sunlight, and ventilation of smoke from cooking, lighting and heating sources. Similarly, technical assistance based on actual consumption patterns and their changes by income groups would help identify high risk groups and fuels that exacerbate household pollution, especially cooking fuel, which appears not to change as incomes rise.[26]
>
> Food chain: Whereas addressing the problems of malnutrition has become an accepted part of health care over the past decade, contamination of the food chain has not. At best, studies call attention to the use of pesticides and, to a lesser extent, selected industrial pollutants, e.g., mercury. The growth of agribusiness and peri-urban agriculture have increased the use of pesticides and fertilizers and reuse of wastewater, all with known risks to human health ranging

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[26] *Household Energy and Nutrition: A Study of Low Income Housing in Lusaka*; Stockholm Environment Institute; Stockholm, 1994; and World Bank, "Energy for Rural Areas...", *op. cit.*

from diarrheas to cancer. Technical assistance can help assess the practical risks by examining food sources, agricultural practices, and consumption patterns for given areas.

Epidemiology of housing and rural/urban changes: Numerous socioeconomic studies have been done on spending habits and health studies are done on nutrition and disease patterns of urban populations, but few of these relate spending to health, e.g., effects of housing costs on food/nutrition, fuel/respiratory infection. Background data from different subject areas could be merged to get a better idea of the links among housing, urban development, and health.

89. Other generally less common issues that could be dealt with through housing and urban development projects are listed below. Though "minor" sector-wide, they might be important in localized pockets and could be addressed through components involving community participation, if appropriate. More likely, it would be most feasible for TMs to seek cooperation with an agency that would collaborate with the project. These issues are discussed below and consolidated in Table V.1. as cross-sectoral linkages.

90. **Mosquito Breeding.** Beyond being an important public health problem, mosquitoes are nuisances which might not be considered significant enough to include in a public health project. Nonetheless, mosquitoes still might be important enough to local residents for them to take remedial measures. Such measures at the household level could focus on water storage containers, roof catchments, and a wide range of water-retaining receptacles near living areas, e.g., discarded tires and tins, defunct vehicles, etc. Numerically, malaria is the most significant, but filariasis, dengue, and yellow fever are also important locally. (See "Vector-related diseases" Section III, paras. 41-50, and Table III.4) for description of mosquito breeding.)

91. Possible interventions: A community education component could focus on local self-help measures; a mosquito control component, with TA, would help set up a long-term response.

92. **Intestinal Worms: Hookworm.** The most common worms are ascaris and hookworm. (See "Intestinal worms" Section III, para. 54 and Table III.5.) Hookworm is important to housing because it is spread commonly near defecation sites which are frequently near households, schools, and places of employment. Because the larvae penetrate the feet, it is more common in areas of poverty where people do not wear shoes or sandals. Schools often have deworming campaigns, but reinfection levels (recidivism) are very high because children easily get re-exposed at home.

93. Possible interventions: A community education component with TA could help target schools and high-risk groups to design programs which incorporate deworming campaigns based on regular cycles, e.g., three times per year, the emphasis being on how to break the cycle of transmission over a five-year period. (For details on control measures, see "Intestinal Worms" under Water Supply and Sanitation below.)

94. **Proximity to Large-scale or Hazardous Pollution.** The top industrial sources of hazardous waste are involved with the industrial processes for: wood preservation, paints, chemicals and pharmaceuticals, agrochemicals (fertilizers and pesticides), explosives, petroleum refining, iron and steel, textiles and dyeing, tanning, electroplating, smelting, cement, and pulp/paper mills. Food processing sources include dairies, slaughterhouses (abattoirs), and feed lots. Granaries, silos, and grain storage near ports/harbors often emit contaminated grain residue from fumigation settles in the immediate area. (To prevent spoilage, the stored grain is aerated up through the silo.) The waste of industrial parks or export processing zones is harder to characterize, but should be considered potentially dangerous, although often it is not, as in the case of large-scale garment manufacturing. By comparison, municipal dumps and specialized markets, such as those dealing with sale of animals or vehicle repair, could generate enough waste which becomes hazardous because of its volume, e.g., animal feces, used motor oil or battery acid,

in the example cited. Settlements near any of these should be examined for potential exposures and accidents. These factors are likely to be considered in projects with new construction, but harder to deal with in upgrading because it is beyond the project scope to change the surrounding area.

95. Possible interventions: The objective in these cases would be to assist communities devise self-help methods to:

a) build protective enclosures/barriers,
b) monitor pollution at the neighborhood level (e.g., low-cost monitoring kits that can be used to alert authorities when permissible pollution standards are surpassed),
c) devise first aid or emergency responses to accidents,
d) recycling,
e) tree planting, etc.

In many cities, a potential-hazard inventory has never been prepared, and could be done at very low cost by a local university, NGO, or other development agency. Such inventories might be as useful to identify neglected areas as they might be to illustrate that threats of pollution are often exaggerated or underplayed because they are unknown. *A word of caution is in order*: many pollution abatement issues are politically explosive because of treatment in the local press or other information sources based on political posturing, vested interests, and inaccurate information. If this is the case, the TM should seek advice from staff who have dealt with such issues before, e.g., the resident mission, Regional Environment Division, the Environment Department (ENVSP and ENVLW), or others with experience dealing with community participation, resettlement, and access to project-related information. See also, OD4.12 Involuntary Resettlement, OP/BP/GP 17.50 Disclosure of Operational Information, and OD14.70 Involving NGOs in Bank Operations.

96. **Tinkering, Cottage Industries, and Artisan Markets.** The hazards of artisanal markets can be similar to the large-scale hazards noted above on a smaller scale, but nonetheless large enough to affect the population in the immediate area. Of particular importance, and often neglected as a realistic health hazard, is exposure to lead in processing brass, copper, silver, and gold. Jewelers and metalworkers are at risk occupationally, but they also generate lead waste that can affect the local community. Dyeing cloth and tanning are common and particularly severe on local surface water. The circumstances for small scale specialized markets are similar to those for the large-scale markets noted above.

97. Possible interventions: These would be similar to interventions for large-scale and hazardous pollution (para. 94), but probably need to be more labor intensive because of the difficulty in identifying small operations.

98. **General Markets.** General markets can create a variety of health problems by virtue of the waste they generate as described below under "Municipal and Domestic Waste Generation" under Water Supply and Sanitation. Likewise, the congestion resulting from markets can be the source of air pollution and pedestrian accidents as described under "Passenger Transport: train/bus/rail/taxi stations" under Transportation Subsector below.

99. Possible interventions: An urban project could make a substantial contribution to improving health by undertaking basic studies appropriate to overall fiscal management and potentially the basis for revenue generation where such basic information is lacking. These would entail, e.g., a market inventory, flow of products in/out, traffic patterns, specific water/sanitation/drainage issues, etc. A component could outline the overall framework for conducting such studies over the long term, with TA if necessary. Or a component could build on existing information to recommend procedures for better management of environmental factors.

100. **Injuries.** i) Fire: Low-income groups commonly cook, heat, and light using methods such as kerosene lamps, or charcoal for which the risks of burning children are great, and the risks are great of spreading fire throughout the area built of wood and other combustible materials; as income rises, so do the types of fuel for heating and lighting, and eventually cooking. ii) Drowning: Low-income housing sites are often constructed over or near water (in particular latrines); risks are high for infants and toddlers to fall off or through walkways into the water. iii) Disasters and "extreme events": Flooding, storms, earthquakes, carry with them a high toll of injury and death, and set the stage for a wide range of diseases, many of which are exacerbated by poor quality housing, drainage etc., especially in disaster-prone areas. iv) Mudslides and erosion: Housing on/near hillsides and flood-planes can be destroyed in storms, and lead to the same effects as disasters and extreme events.

101. Possible interventions: A community education, "safe stove" component could help address these risks through self-help and modest construction in the project. Considerable work has been done throughout Africa on stoves, but often more from an ecological than a safety basis. These programs are nonetheless adaptable to include health and safety dimensions. Modifications to housing design can help withstand storm damage. In flood-prone areas, basic infrastructure, e.g., retaining walls, drainage canals, etc. can help reduce impacts of flooding. Planting vegetation in areas prone to erosion, especially hillsides can help reduce risks of mudlides and similar hazards.

Table V.1: Main Cross-sectoral Linkages with Housing and Urban Development

Sector/Ministry	Linkages
Agriculture and Rural Development	"urbanization" of rural diseases, e.g., malaria and dengue, by providing year-long habitats for breeding through infrastructure; contamination of the food chain through pesticides/fertilizers from rural and peri-urban agriculture; indoor air pollution and accidents from storing agrochemicals
Energy	contribution of heating/lighting/cooking fuel to indoor air pollution
Industry	siting of settlements near industrial areas: risk of large-scale accidents, exposure to toxic pollution
Infrastructure: Telecommunications	better communications can help warn/preprare for "extreme events" (e.g., floods, storms) and facilitate emergency responses to these and industrial accidents; other minor linkages: can reduce traffic congestion and improve emergency communications; holes for transmission-line poles can spread vector habitat
Infrastructure: Transportation	minor contributor to pedestrian traffic accidents from lack of road maintenance, erosion and flooding; major contributor to pockets of localized air pollution; in general, minor contributor to respiratory illness (in African cities); risk of traffic accidents to children fetching water
Infrastructure: Water Supply and Sanitation	deficient water supply, sanitation and drainage are major sources of excreta-related diseases; deficient drainage a major contributor to insect-borne diseases and of flooding, which can cause contamination of food, injury/death; risk of accidents to children fetching water

102. Table V.2 gives a summary of the major health-related issues and appropriate remedial measures which could be considered in typical components for each of the Infrastructure subsectors. More detailed reference material is available in the annotated bibliography of outside literature and Bank publications, the Environmental Assessment Sourcebook, and Operations Manual.

TABLE V.2: HOUSING & URBAN DEVELOPMENT CHECKLIST

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES and COMMENTS
Housing Construction (incl. Temporary Worker Housing)	a) pools of standing water and flooding can lead to increased incidence of malaria and other mosquito-borne diseases, especially during rainy season; workers and local residents at risk	a) preparation TORs should ensure that proper measures are taken during construction and afterward to eliminate breeding and feeding grounds, and to accommodate proper drainage in flood-prone areas, esp. in rainy seasons; may also be appropriate to include component for residents in community education
	b) poor ventilation associated with cooking, heating, and lighting sources (other than electricity or gas) can lead to respiratory diseases, especially important to women when cooking and children who spend time indoors	b) if housing designs are to be specified, preparation TORs should include provisions to maximize ventilation and, as appropriate, cooking area exhausts; if designs are completed, it may be appropriate during implementation to include TA in a community participation or other type component
	c) accidents can occur: i) during construction, when workers and nearby residents are at risk of flooding, erosion, and mudslides; children are also at risk when playing after hours at construction sites; ii) during implementation and after, children are at risk of burns from unprotected cooking, heating, and lighting sources; in housing near/over water, infants/children are also at risk of drowning	c) i) implementation TORs should ensure that proper occupational health and safety measures are provided for workers and to limit access of children after hours; ii) if housing designs are not complete, preparation TORs should accommodate ventilation and safety features; the latter might be pertinent in a community education type component
Sites and Services	a) see "Housing Construction," above	a) see "Housing Construction" above
	b) poor maintenance of neighborhood services can lead to full range of excreta- and vector-related diseases, main weak points: clogged storm drains, poor drainage at water distribution points, inadequate trash collection and special needs of markets	b) preparation or implementation TORs should provide for community education and, as appropriate, cost recovery schemes to cover maintenance costs; might be appropriate for involvement with local NGOs, religious groups, etc.; preparation TORs should ensure adequate water, sanitation, drainage services are included as a component
Drainage	--- see Water/Sanitation Subsector ---	
Dredging	--- see Transportation Subsector ---	

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES and COMMENTS
Public Facilities: markets	a) public markets can contribute to vehicular congestion, which contributes to air pollution and injuries; see also Transportation subsector	a) preparation or implementation TORs should ensure that proper measures are taken to identify groups at risk of pedestrian injuries or regular exposure to vehicle exhausts, and propose remedial measures as appropriate.
	b) public markets frequently lack toilets, trash receptacles, for customers, as well as drainage if drinking water is available	b) preparation designs and implementation TORs should allow for customers needs in new markets and as appropriate for upgrading
	c) improperly managed solid waste can i) clog storm drains, cause flooding, create garbage heaps in surrounding areas, provide breeding/feeding grounds for mosquitos, flies and rodents; collectively, these can cause diarrheas, parasitic infections, injuries; ii) specialized markets, such as live animals or automobile repairs, would need separate attention to accommodate waste, e.g., animal excreta, motor oils, etc.	c) market designs should include space for waste receptacles, protected storm drains, and a plan for general waste removal; assuring proper O&M and cost recovery could be adequately addressed through a community participation component
	d) see also "Water/Sanitation Subsector" for waste management of the markets themselves	
Public Facilities: washing/bathing and toilets	— see Water/Sanitation Subsector —	
Public Facilities: public buildings	a) pools of standing water and flooding can lead to increased incidence of malaria and other mosquito-borne diseases, especially during rainy season; workers and local residents at risk	a) preparation designs should ensure that proper measures are taken during construction and afterward through implementation TORs to eliminate breeding and feeding grounds, and to accommodate proper drainage in flood-prone areas, esp. in rainy seasons; may also be appropriate at preparation or implementation to include TA for residents in community education type component
	b) public facilities often fall into disrepair for lack of maintenance, setting the stage for accidents and poor waste management	b) implementation TORs should include provisions for proper waste management, citing special conditions for industrial and other hazardous materials; see also Solid Waste Management under Water Supply and Sanitation Subsector
	c) hospitals should always be considered a special case, see Water Supply and Sanitation Subsector	
Water Supply	— see Water Supply and Sanitation Subsector —	

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES and COMMENTS
Sanitation	--- see Water Supply and Sanitation Subsector ---	
Waste Management	--- see Water Supply and Sanitation Subsector ---	
Urban Transport	--- see Transportation Subsector ---	
Traffic Management, Road Rehabilitation	--- see Transportation Subsector ---	
Motor Parks	covered motor parks can lead to build-up of air pollution from vehicle exhausts inside and through natural exhaust streams outside	implementation TORs should incorporate appropriate ventilation procedures and monitoring where appropriate
Capacity/Institution Building	community involvement is an important aspect in devising curative and preventative measures for health; local talent is often not tapped because of poor community organization rather than lack of knowledge to solve technical problems	design component as appropriate; may be useful during preparation to solicit help of NGOs for topics difficult to deal with under during works or after project cycle, e.g.: accident prevention; collection of contributions for O&M of communal facilities; appropriate methods to eliminate improper water storage, standing pools of water or clogged drains that can breed mosquitoes; household methods to reduce injuries (esp. burns and drowning); efficient waste management of markets and other community facilities

VI. TELECOMMUNICATIONS

103. **Lessons from the External Literature Review.** The outside literature contains very few lessons about environmental health of direct importance to Bank projects. For example, some of the main topics discussed pertain to electromagnetic fields and improper posture from extended time spent in front of video terminals, or repetitive-motion muscular problems. In general, the literature speaks of the positive contributions that telecommunications can make to reducing air pollution by decreasing vehicle use and by improving emergency health care by facilitating health interventions.

104. In the telecommunications subsector, Africa's technological tardiness relative to other parts of the world is actually an advantage from an environmental health perspective. Telecommunications projects have been reducing the use of freon in the relay stations which must be cooled, thus reducing the contribution of ozone-depleting substances. The most important environmental health problem that can fall between the cracks entails the spread of mosquito vectors in the process of digging holes for transmission line poles. (Mosquitoes can breed in less than a week.) Malaria is the most serious of the diseases which has been spread. Occupational hazards entail the use of creosote or other wood preserving paints for phone lines and could be reduced by newer products less dangerous to humans or the natural environment. With the increase of satellite-dish and digitalized communications, the need for hard transmission lines will undoubtedly decrease, but, until then, the spread of malaria should be considered a potential hazard in urban and peri-urban areas where such poles are still being erected. Remedial measures are minor, e.g., coordinating schedules for digging holes and erecting poles or adding a cup of oil to the hole (when used judiciously, a light oil covering to the water deprives the larvae of oxygen).

VII. TRANSPORTATION

105. **Lessons from the External and Bank Literature Review.** The transportation literature is reasonably straightforward on environmental issues with health repercussions, concentrating mainly on pollution control. The most salient lessons come indirectly from a change of focus in cause and effect of transport-related pollution, e.g., that vehicle emissions can be a major contributor to water pollution. Considerable efforts are being devoted to assessing the health effects of air pollution internationally. Because there are so many variables involved with the air entering the lungs, it has been difficult to draw statistically significant conclusions about the role of single pollutants to human health. This is because single pollutants do not enter the respiratory system --- a mixture of vapors, acid aerosols, and suspended particles do --- together with tobacco smoke, which is by itself a major contributor to health damage. Consequently, epidemiologists have been working on perfecting ways to compare large groups and cities in order to establish causality. Regrettably, the literature on such topics is still less than a decade old, too new to gather enough evidence to compensate for the restrictive focus of single-pollutant studies. In addition, the costs and sophistication of studies have tended to favor certain pollutants, such as lead, because it is easier to study.

106. Although the role of transportation in the spread of sexually-transmitted and vector-borne diseases is hardly new, these relationships receive scant attention in the literature as a whole. Because of its current socioeconomic importance, the role of truckers in spreading AIDS is discussed. The contribution of air travel to the spread of infectious disease internationally, in particular the current resurgence in TB, is also beginning to appear in the literature.[27] Where as sexually-transmitted and vector-related diseases lend themselves to remedial measures in projects, e.g., education and vector control components, it is not yet clear what practical interventions are practicable in transport projects.

107. There are gaps in the literature about the health dimensions of what happens to cargo between production, import, and final use. These dimensions include storage of hazardous chemicals while being off-loaded or transferred, their repackaging for their ultimate use by someone who is often unaware of any of the hazardous properties. An emerging literature on the health consequences of global warming implicates transportation pollution as an important contributor. Increased temperatures can move vector habitats inward from coastal areas and more north toward temperate climates, resulting in the spread of diseases like malaria and precipitating increase in epidemics like cholera and plague.

108. Three areas to help improve environmental health through transportation subsector projects are:

> Estimation of health damages from air pollution: This is less than a decade old and suffers from a lack of clarity about cause and effect of the role of transportation --- largely because statistically significant scientific studies need to limit the variables studied. Focus thus far has been on the air pollutants, especially lead, not necessarily on populations or public health, except for occasional inter-city comparisons. Technical assistance should design studies that put transport-related contribution to respiratory disease in a public health context, for example, a collective evaluation of problems from lead, sulfur dioxide, nitrogen dioxide, particulates, and ozone on local populations.
>
> Role in transmission of disease: The role of truckers in spreading sexually-transmitted disease and AIDS has been made clear, but the links among vector diseases, construction sites, and workers' camps has not yet been accepted. Technical assistance could help define relative risks by

[27] TB spread normally requires prolonged exposure and risks are greatest for family members or co-workers. The physical closeness and recycled air appear adequate to facilitate the spread.

identifying potential vectors, their breeding/feeding habits, the distribution of susceptible population, the role of drainage and of construction camps. If a reasonable risk exists, appropriate mitigating measures should be designed.

Passenger transport: train/bus/rail stations: Although ambient air pollution is not considered a major health problem in SSA, the low level of vehicle maintenance, coupled with the use of leaded fuel, makes it potentially severe in urban pockets, where the population is subjected to widespread long-term, high-dose exposure to fumes. These cluster around public transport facilities like bus and taxi stations, which are often near open-air markets where trucks exacerbate the problem. Occupational exposures, such as for traffic police, drivers and service station attendants, tend to be hazardous. Similarly, the location of schools along or near major urban thoroughfares puts children at risk. Project interventions include identification of risk groups, protective barriers, change in traffic flow if appropriate, economic incentives or construction, e.g., space for a proper terminal, and alternatives to disperse the congestion.

109. Other generally less common issues that could be dealt with through housing and urban development projects are listed below. They might, however, be important in localized pockets and could be addressed through components involving community participation. More likely, it would be most feasible for TMs to seek assistance through cooperation with an agency which could work in collaboration with the project. These issues are discussed below and consolidated into Table VII.1.

110. **Injuries.** Accidents and road safety have been a fundamental part of transportation sector projects for years. Factors contributing to road accidents include: (1) lack of driver and pedestrian education (drunken driving remains a major factor); (2) poor maintenance of vehicles and roads; (3) inadequate inspection of vehicles; (4) erosion of roads and shoulders; and (5) inadequate sidewalks, pedestrian paths, signs and stop lights. Mitigation of these factors relies on behavioral change — wherein Bank project interventions are curtailed — and carefully designed programs with Bank help, e.g., insurance and liability schemes. Children fetching water or disposing garbage are often the victims of road accidents, especially after dark, a neglected element of accident programs.

111. Possible interventions: To help prevent these injuries, a component could provide lighting, signs, protective barriers, paths, cross-walks or pedestrian bridges, plus education.

112. **Ports and Harbors.** Traditional approaches have focussed on safety, the wastes of the port itself and of the vessels using it, with a thrust toward ecological damage, not human health. Port waste covers five categories based on the International Convention for the Prevention of Pollution from Ships (MARPOL, 1973, modified in 1978) of the International Maritime Organization (IMO):

a) oil,
b) noxious liquid substances shipped in bulk,
c) harmful substances carried in packaged form,
d) sewage from ships, and
e) garbage from shops.

In addition to the MARPOL categories for vessels, typical port waste would include: oils (dirty ballast/bilge water, sludge, fuel residues), liquid residues of transported materials, material damaged in shipment, septage, domestic waste, and materials lost or damaged during loading and storage. Fishing industries, maritime commerce, and, if appropriate, naval operations are major players. Relatively little has been done on other linkages to pollution, for example, analysis of the types of industries that tend to cluster near ports, and their relative risks to the health of the people in the immediate vicinity and a larger area. These might include granaries and grain storage, fumigation of silage (to prevent spoilage), and the risk of exposure to fumigants of the local residents, dockworkers (shipping and receiving), and

those cleaning vessel holds. Storage of flammable gases (liquefied petroleum gas, i.e., LPG, propane, butane), with special attention to those normally needing pressure/refrigeration, e.g., ammonia, plus fuels (jet, diesel, and regular gasoline), and other petroleum products, tend to receive careful attention because the consequences, ranging from fires to disasters, are reasonably well known.

113. More problematic because of the larger number of people effected by carelessness is the storage of hazardous materials, such as industrial chemicals, pesticides, and fertilizers. Some chemicals, such as ammonium nitrate, are common components of fertilizers and become hazardous because they are stored in large quantities where the accumulation of small leaks can lead to explosions of toxic clouds. Similarly, power stations and water treatment plants require large amounts of chlorine to disinfect water. Weak points in the system are ship-to-shore transfer, temporary and permanent port storage, delivery to bulk user, and distribution-repackaging to ultimate user.

114. Air pollution at ports and harbors would depend on the volume of traffic and the nature of commercial activities clustering around the port. These would be covered more appropriately under industry, waste management, or urban development activities.

115. Possible interventions: A component dealing explicitly with health and safety factors of port and harbor management would be appropriate. Only one SSA project had a health risk assessment of port activities, i.e., Mauritius: Port Development and Environmental Protection (1995). Where local capabilities, or the absence of an overall port/harbor management plan does not exist, a component could help set up a mechanism to deal with long-term solutions, providing TA if needed.

116. **Dredging.** Dredging operations can spread sewage and toxic materials that have accumulated to surrounding areas, contributing to diarrheas, skin and eye irritations, and poisoning to people in contact with water. Disposal of the sludge can contaminate local ground water and surface water. In some cases, dredging can cause salt water intrusion to drinking water, forcing local populations to rely on other sources of poor quality or more expensive water. Likewise, suspended sludge can also contaminate the food chain if fish and shell fish are harvested. The health dimensions of inland navigation are similar to those of dredging and port management.

117. Possible interventions: An environmental health study could help determine the relative importance of local risks, particularly to local populations from occupational or recreational activities; a community education component could help to alert local populations about risks and the means to take protective measures.

118. **Airports.** The environmental health hazards of airports fall into two broad categories: those involved in the operation of the airport itself, and those linked to passengers. In terms of airport management, the major health hazards are pollution and ozone depletion from jet emissions. Planes create noise pollution, which can be a major contributor to physical stress, which, in turn, can reduce the body's overall resistance. Airport runoff can contaminate water supplies. Planes and vehicle traffic contribute to air pollution in general and bring it to a hazardous level for local populations. Jet fuel contributes to ozone depletion, which can cause cataracts and skin cancer, although the latter would not rank high in SSA health priorities.

119. Possible interventions: Components could be designed to deal with environmental health dimensions of airport management, noise control, and resettlement away from direct pollution paths close to the airport (if appropriate).

120. **Vehicle-related Factors: Pollution.** Vehicle-related pollution covers a wide spectrum of potential health repercussions. Disposal of vehicles contributes to water pollution from petroleum products and batteries. Discarded tires and stripped-down carcasses can provide vector breeding grounds for

mosquitoes. Regular vehicle maintenance contributes to ground and surface water pollution from washing and oil changes --- however, used motor oil, if applied judiciously, is a good control for mosquito breeding because the oil layer on the water deprives the mosquito larvae of needed oxygen. Air pollution from vehicles can be considerable in localized areas, and can become an occupational hazard for drivers, traffic police, and those employed in the vehicle service industry.

121. Possible interventions: A component to help establish systematic recycling of vehicles and parts could help reduce environmental health hazards created by current haphazard practices that are now based largely on values for reuse or resale. Depending on current recycling activities, TA could help set up long-term measures for recycling and internalizing disposal costs and health risks, where vehicles are part of an overall program. Roads projects (paras. 124-128 and Table VII.2) components can address the safe disposal of transport waste. Traffic management projects could include provisions for protective measures to high risk groups, e.g., education, protective clothing/masks, work schedules, and to help overcome air pollution, e.g., protective barriers near markets, stations.

122. **Vector-related Factors: Habitat Changes and Disease Spread.** The transportation sector contributes in three major ways to the spread of vector-borne diseases, of which malaria, filariasis and schistosomiasis are most important. First, construction activities can spread the habitat for mosquitoes and snails, e.g., burrow pits, sand/gravel mining, temporary or permanent excavations, deposition of construction debris, holes for utility poles. Second, drains and drainage areas which are inadequately constructed or maintained retain water, which allows mosquitoes/snails to breed, readily spreading these diseases to non-endemic areas Third, road crews can either bring in or be susceptible to various vector-related diseases. The use of "imported" road crews, however, appears to be on the decline. A major problem relates to construction activities, particularly the spread of malaria, although typically the role of truckers in spreading disease tends to receive more attention.

123. Possible interventions: Projects with construction activities could contain vector-control components, based on the potential risks of spreading vector habitat. Where drainage and waste disposal are involved, and the risks of exposure of local populations and road crews to vector-borne diseases, TA would most likely be available from the MOH for education and prophylactic medications, as appropriate.

124. **Roads.** In general, Bank road/highway projects deal with existing rehabilitation or upgrading of existing networks. Health consequences fall into two broad categories: those of the road or highway itself, and those of the users. Road safety is a generally accepted practice in such projects. In addition, inadequate drainage and waste disposal at construction camps can contribute to the spread of diarrheas among the workers and local population.

125. Mining for construction materials can pose several health repercussions that might be significant in localized areas. Quarries and burrow pits can spread mosquito habitat; they can also increase the risk of accidents for workers and local children. Mining for sand and small gravel can cause erosion of roadways leading to vehicle and pedestrian accidents. Deposition of construction materials can contribute to accidents and the spread of mosquitos. Whereas contractors are still often recruited from abroad, the tendency has been to use road crews from local villages, thus reducing the potential for spreading epidemics.[28]

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[28] Resistance to disease can be limited to only one out of a large number of strains; nor is resistance always for life. "Imported" workers might not have been exposed to local disease strains and could fall victim to serious illness that might be mild to locals. Conversely, "imported" workers could carry a strain of malaria or another disease that could get passed on to local populations, e.g., by mosquito bites, and cause an local epidemic.

126. When construction camps go beyond temporary worker shelter and equipment storage areas, the potential health risks increase markedly. Asphalt plants, storage of blasting materials, and fuel can increase risk of accidents and cause local pollution, in addition to the normal range of problems involved with provision of shelter, water, and waste services. In these larger operations, blasting can create accidents as well as air and water pollution.

127. Truckers are major contributors to the spread of AIDS and sexually-transmitted diseases. The latter is exacerbated in the rainy season when road barriers are erected to allow flooding to subside or unpaved road surfaces to dry up. Truckers frequent prostitutes to fill up free time.

128. Possible interventions: Road projects could contain components for pollution control (para. 121), and vector-control (para. 123). Projects with mining of construction materials could contain provisions for proper disposal of debris, worker safety, and protection of mining sites through public education and barriers, with special consideration to children. Where truckers are an appropriate audience, a component could address risk awareness, with TA available from the MOH.

129. **Railways.** The potential for asbestos-related problems has been linked to the asbestos insulation used in railroad cars. This potential hazard would be highest as an occupational hazard in construction of railway cars, which is not important economic activity in Africa. But a significant hazard can exist wherever imported older cars are refurbished; it can be also be significant for maintenance workers, particularly when recycling or "cannibalizing" parts, service personnel working in cars and frequent passengers.

130. Possible interventions: Railway projects could contain a component on waste disposal, worker and pedestrian safety, and worker protection from exposure to asbestos, the latter of which might require expatriate TA.

Table VII.1: Main Cross-sectoral Linkages with Transportation

Sector/Ministry	Linkages
Agriculture & Rural Development	transport, storage and shipment of agricultural products; rural roads as a factor in spreading vector-related diseases
Energy	contribution to indoor/outdoor air pollution from cooking/heating/lighting fuel, and to global warming from inefficient energy production and use; global warming can spread vector-borne diseases like malaria by extending vector habitats or diarrheas like cholera by allowing longer survival time of pathogens in warmer water
Industry	type of industrial development facilitated by transport system, type of industries clustering around ports
Infrastructure: Housing & Urban Development	contribution to indoor air pollution from vehicular emissions and to global warming (can spread vector-borne diseases like malaria by extending habitats, turning predominantly rural diseases into urban ones)
Infrastructure: Telecommunications	(minor contribution to reducing air pollution by reducing traffic)
Infrastructure: Water Supply & Sanitation	disposal of vehicles can contribute to spreading mosquito habitats; risk of accidents to children fetching water and disposal of garbage; special needs of waste disposal for ports, railways, airports, and motor vehicles (can be hazardous, e.g., oils, battery acid)

131. Table VII.2 gives a summary of the major health-related issues and appropriate remedial measures that should be considered in typical components for each of the Infrastructure subsectors. More detailed reference material is available in the annotated bibliography of outside literature and Bank publications, the Environmental Assessment Sourcebook, and Operations Manual.

TABLE VII.2: TRANSPORTATION CHECKLIST

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Roads: Rehabilitation & Maintenance	a) works can spread mosquito-related diseases, esp. malaria, by extending breeding areas in water accumulated in holes, disposal of construction materials, digging for sand/gravel	a) preparation TORs should determine importance of malaria locally and risks of its spread; and include provisions for mosquito control for worksites as appropriate
	b) improper disposal of excreta and domestic waste at workcamps can pollute local water leading to vector-related diseases, particularly malaria and schistosomiasis	b) preparation TORs should determine importance of vector-related diseases locally and risks of their spread; should include provisions for proper waste disposal and vector control as appropriate
	c) digging for sand/gravel can cause road erosion; road erosion can lead to pedestrian and vehicle accidents; if not properly disposed of, mining debris can lead cause flooding and extend vector habitats	c) preparation TORs should contain provisions for safety, with appropriate instructions for subcontractors providing the materials, as well as conditions for disposal of debris
	d) asphalt production and work dust can cause local air pollution, aggravating respiratory disease	d) implementation TORs should contain provisions for reducing air pollution as appropriate, designs should incorporate provisions accordingly
	e) communal/rural roads may require special assistance to educate community on hazards described above	e) TORs should contain provisions for community education awareness, with help from local NGOs as appropriate
	f) see also "Drainage," below	f) see also "Drainage," below
Roads: Construction	a) conditions and risks are similar to those of "Rehabilitation and Maintenance," except for scale	a) see "Rehabilitation and Maintenance" above
	b) with larger scale, probability might be greater for established work camps and expatriate personnel to contribute to spread of vector-related diseases and AIDS	b) implementation TORs should cover worker education appropriate; basic on-site health facilities might also be appropriate

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Roads: Drainage	a) blockage of stormdrains plus inadequate drainage of general area can cause flooding which contaminates water supply and cause injuries; can cause vehicle and pedestrian accidents, and can spread mosquito-related diseases b) in rural and peri-urban areas near dams and irrigation schemes, blocked drains can extend snail habitat and spread schistosomiasis c) see also "Drainage," Water/Sanitation Subsector	a) implementation TORs should provide for regular maintenance of stormdrains, which may require component for community education and participation; designs should include provisions for proper drainage of project zone and contiguous areas as appropriate b) if schistosomiasis is endemic in the general region, implementation TORs should provide for appropriate preventive measures to keep drains from spreading habitat; health component might also be appropriate to curtail spreading c) see "Drainage," Water/Sanitation Subsector, below
Roads: Workshops	liquid and solid waste from workshops can contaminate local surface- and groundwater supply and spread vector habitat (NB, motor oil can be reused for mosquito control)	designs should include proper waste disposal facilities
Roads: Safety	safety components can be useful to address a wider range of issues than traffic accidents: i) accident prevention in construction activities; ii) safe handling of hazardous chemicals and wastes; iii) AIDS and sexually-transmitted diseases (STDs), including immunizations for vector-related diseases and STDs	implementation TORs should incorporate, as appropriate, wider health and safety concerns
Roads: Private Sector Development (Labor Intensive)	a) improper disposal of excreta and domestic waste at workcamps can pollute local water leading to vector-related diseases, particularly malaria and schistosomiasis b) work crews, particularly those not local, can introduce vector-related diseases (and contribute to the spread of AIDS and sexually-transmitted diseases)	a) preparation TORs should determine importance of vector-related diseases locally and risks of their spread; implementation TORs should include provisions for proper waste disposal and vector control as appropriate; b) preparation TORs should provide for appropriate immunizations and education
Roads: Conservation Management	ecological issues could be enhanced to include preventive measures for workers' spreading disease vectors	preparation TORs could also address reduction of disease vectors in consultation with MOH as appropriate
Traffic Management	air pollution can be important direct or predisposing factor for respiratory disease; high risk groups are traffic police and concentrations of people at congested areas (esp. bus/taxi stations), markets/schools/workplaces near heavily travelled roadways	preparation TORs should define appropriate high risk groups and current air pollution monitoring efforts, assess relative hazard with MOH, and propose designs as appropriate, e.g., protective kiosks/masks, barriers

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Pollution Management	a) for air pollution see "Traffic Management" above b) for water pollution see "Ports" below	a) for air pollution see "Traffic Management" above b) for water pollution see "Ports" below
Railways: Rehabilitation	a) passenger trains can contribute to excreta- and vector-related diseases in congested areas where toilets empty directly onto tracks b) combustion-engine smoke can be major contributor to respiratory disease to residents along rail airshed c) rehabilitation of railroad cars can expose workers to asbestos (used in insulation)	a) preparation TORs should determine if excreta removal is a problem; if so, implementation TORs should recommend locally acceptable methods for collection, removal, or disinfection; community education component might be advisable b) preparation TORs should determine if smoke is a problem; if so, recommend locally acceptable methods; might require design modifications for trees or other protective measures; community education component might be advisable during implementation c) implementation TORs should design worker protection measures
Railways: Workshops	— see "Roads: Workshops" above —	— see "Roads: Workshops" above —
Ports	a) storage and transport of hazardous chemicals can cause serious damage to workers and any local population exposed to regular transport or accidents b) congregation of traffic can lead to air pollution and accidents c) vessels can cause pollution by domestic and hazardous waste; see "Ports: Pollution Control," below	a) preparation TORs should determine types and volume of hazardous chemicals passing through, and, as appropriate, implementation TORs should design safety component b) preparation TORs should include provisions for assessment of traffic management data on congestion/pollution and port accidents, and implementation TORs should include recommendations for improvements c) see "Ports: Marine Pollution," below
Ports: Dredging	improper disposal of sludge can pollute surface- and ground-water and lead to diarrheas, poisoning (from chemical content); can also create mosquito breeding grounds causing malaria/filariasis and other vector-borne disease	preparation TORs should contain provisions for appropriate disposal of sludge in terms of pathogen removal, chemical content, and vector-breeding

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Ports: Petroleum/Cement Terminal	a) petroleum refinement and shipping can cause air and water pollution; uncontained fires and accidents at refineries can become world class disasters b) cement dust is primarily a nuisance, but an important irritant to workers and residents in its airshed, causing respiratory disease	a) preparation TORs should make provisions for appropriate treatment of waste, controls for air pollution, emergency procedures, and first aid; may require formal loan/credit covenant b) preparation TORs should ensure that assessment of dust is considered; implementation TORs should make recommendations for dust reduction as appropriate from manufacture and local transport
Ports: Marine Pollution	a) discharge of domestic wastes from pleasure craft, commercial boats and, passenger transport, worsened by absence of convenient on-shore waste discharge points, can lead to excreta-related diseases and skin and eye infections b) discharge of maintenance and bilge cleaning can contaminate food supply if seafood and shellfish are harvested locally	a) preparation TORs should recommend provisions for pleasure, commercial, and passenger boats; solid waste component might be advisable; implementation TORs consumer education might also require special consideration for signs, translations, etc. b) implementation TORs should include provisions for pollution monitoring in ports and make appropriate recommendation
Ports: Workshops	— see "Roads: Workshops" above —	— see "Roads: Workshops" above —
Rivers	— see "Ports" above —	— see "Ports" above —

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Airports/Aviation	a) air/water pollution from plane fumes and fall-out can exacerbate respiratory illness; noise pollution can be serious to stress; ozone depletion caused by jet fuel can contribute to cataracts and cancers	a) preparation TORs should ensure provisions are made to reduce air-noise-water pollution as much as possible, might entail designs for physical barriers; response to ozone might be appropriate in collaboration with Global Environment Facility activity
	b) traffic congestion from vehicles servicing airport can lead to air pollution (and possibly accidents)	b) implementation TORs should contain provisions for proper traffic management
	c) hazardous chemicals passing through	c) preparation TORs should contain provisions for handling, storing, and transporting hazardous waste, including first aid and washing facilities for workers
	d) possibility of air accidents	d) implementation TORs should contain provisions for formulation and implementation of emergency airport procedures
	e) basic health precautions for international travellers	e) implementation TORs should contain provisions for collaboration with MOH on appropriate inspection, inoculation, and quarantine procedures as appropriate
Airports/Aviation: Workshops	— see "Roads: Workshops" above —	— see "Roads: Workshops" above —
Capacity & Institution Building: Public Health & Safety	a) inadequate attention to road and driver safety can cause accidents from a myriad of factors: poor maintenance of vehicles, drunk driving, no driver education or seat-belt campaigns, etc.	a) preparation TORs should contain provisions for maintenance, enforcement and public awareness campaigns as appropriate; involving NGOs in community participation might be advisable
	b) truck drivers are at a high risk of spreading or getting sexually transmitted diseases; because of AIDS, these are often handled separately; see below	b) see "AIDS awareness" below
Capacity & Institution Building: AIDS awareness/prevention	truckers can be *major* factor in spread of AIDS and other sexually transmitted diseases; in small towns, depots, "rain barrier stops," local circumstances might allow for tailored response not possible in cities	education component appropriate to truckers; may also be appropriate to consult with MOH, religious groups or NGOs for "tailored" response, and if appropriate, incorporate into project

VIII. WATER SUPPLY AND SANITATION

132. **Lessons from the External and Bank Literature Review.** In general, the lessons from the 1970s and 1980s can be best summarized in one point: washing hands is as important to human health as the very water itself. Literature examining 19th and 20th Century practices shows that the radical improvements in human health took place not because of the expansion of sewerage services or the invention of antibiotics as had been commonly postulated, but a combination of improvements including better water supply, the extension of sewerage, improved literacy, and nutrition and medical care. The literature also establishes the need for direct community participation in designing the type of services and in formulating realistic procedures for cost recovery and maintenance, i.e., the demand-driven 1990s. The literature also helps clarify a lingering definitional hurdle, with governments and citizens alike, about low-cost waste management other than high-tech solutions since many incorrectly equate all latrines with offensive odors and all sanitary landfills with open dumps. The technology for sewage treatment and solid waste management has also helped reduce odors and curtail pollution. The 1970s and 1980s helped modify the emphasis on the water-health linkage from water purity to establishing the importance of water quantity, personal hygiene, sanitation, and drainage. However, sanitation and drainage are still dealt with separately as accoutrements to water supply, and often excluded from projects because of costs.

133. Despite the strength of the lessons from the 1970/1980s, the literature is weak in five areas which are pertinent to Bank operations and for which Bank help might be appropriate in studies, technical assistance, or projects.

a) Articles on privatization have not examined health repercussions, e.g., service distribution and effluent quality, which are likely to be based more on costs than social objectives.
b) The risk of contamination of the food chain with pesticides, fertilizers, and animal wastes has been largely ignored as a water/sanitation issue. This is a striking omission, given the large portion of the population in Africa engaged in agriculture. Only the disposal of pesticide containers gets occasional mention. Similarly, little attention has been paid to the health effects of reusing urban water for irrigation or urban agriculture.
c) Public health and ecology, while theoretically compatible, do not always lead to the same project objectives because civil/municipal engineers, public health engineers, and other public health specialists do not always collaborate on the same projects. The different emphasis from professional groups often accentuates pollution with an opportunity cost of not addressing other equally important factors in environmental health.
d) A confluence of factors has set the stage for a possible worsening of vector-related diseases: (1) provision of consistent water supply for drinking and irrigation; (2) inadequate attention to the drainage of the same water; (3) the generation of solid waste faster than it can be removed; (4) the spread of urban and peri-urban agriculture; and (5) increasing resistance of mosquitos to chemical prophylactics. This has effectively compromised the technical capability of drainage to help control mosquitos by eliminating their habitats. [29]
e) Regrettably, the area of air pollution related to solid waste management is considered the opportunity cost of providing a sanitary waste disposal that is far more dangerous to human health. This is one area where future research should be encouraged, because empirical evidence is virtually non-existent.

134. Three distinct areas to help improve environmental health through water/sanitation projects by integrating them in country studies and individual projects are:

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[29] Currently, India is considered the only country with endemic urban malaria, but the designation could easily be applied to SSA.

Consideration of water, sanitation and drainage as inextricably linked: Projects could be designed to provide for integrated planning of water, sanitation and drainage, looking at the ecological *and* the health dimensions of cross-sectoral issues. Projects need not tackle all elements, but at least should consider them together by providing technical assistance to help formulate an integrated, long- term, incremental approach for comprehensive water/waste management suited to local circumstances. The technical dimensions of incremental service levels have already been worked out under the Appropriate Technology Series,[30] and enough economic studies have been done to make such integrated planning more of a cut-and-paste exercise than one requiring empirical research (as would be the case, however, with air pollution).

Spread of vectors to year-round habitats: A better understanding of the role of disease vectors, primarily mosquitos and snails, as part of a comprehensive water and waste management strategy (above) would be useful. Technical assistance could be designed to help forge links between the MOH responsible for vector-related diseases with the other infrastructure agencies involved with creating and extending the vector habitat, adapted to local capabilities.

Private Sector Participation: Although much has been written about financing and decentralizing services for the industrialized and developing countries, the literature is virtually silent about the health repercussions of privatization of water and waste services, even in the industrialized countries. Much analysis goes into cost-recovery, but little consideration goes to microeconomic repercussions on the poor or other vulnerable groups that could be created or affected. How would private businesses and governments respond differently as cost considerations increase? For example, would lower-cost technology have higher health risks? Would cost factors relax the application of pollution standards to unsafe levels? How would costs effect extension of new services and maintenance of old ones in poor neighborhoods? Technical assistance could be designed at the country level to consider these neglected dimensions.

135. To these it is also appropriate to cite two additional areas which have been identified as important, viz., development of sound institutional frameworks and direct involvement of communities. Thus far, much progress has been made with both in water and waste management, but they have not always been geared to integrating the range of cross-sectoral issues that have been identified as crucial. Such integration would call for a broadening of the skills mix, collaboration among institutions in sharing data, work programs, etc. Women's co-ops, for example, might focus on employment opportunities, but not necessarily about hazards to women's or children's health, such as exposure to toxic chemicals in recycling. Similarly, ministries of agriculture, health, and water supply might each monitor water quality for which the collective costs could be reduced by slight alterations in monitoring procedures to allow each ministry to use the data, thus "freeing" budget for other mutually beneficial uses.

136. Other less common issues that could be dealt with through water supply and sanitation projects are listed below. Though "minor" sector-wide, they might, however, be important in localized areas and could be addressed through modifications of studies and through components involving community participation, if appropriate. More likely, it would be feasible for TMs to seek assistance through cooperation with an agency which could work in collaboration with the project. These issues are discussed below and consolidated into Table VIII.1. In the discussions below, waste management is used in its broad sense to refer to sanitation (sewerage, latrines, disposal of human excreta, latrines), solid waste removal and disposal, and drainage (storm and sanitary).

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[30] *Appropriate Technology for Water Supply and Sanitation Series: Technical and Economic Options*; J.M. Kalbermatten, DeAnne Julius and Charles Gunnerson; World Bank, 1980.

137. **Disposal/Treatment of Human Excreta.** Sewage, septage, night soil, greywater, and other forms of wastewater and their sludges can all contain fecal matter responsible for a broad range of diseases that include diarrheas (most common/serious are dysentery, gastroenteritis, cholera, giardiasis); intestinal worms (most common/serious are hookworm and ascariasis, plus tapeworm, threadworm and whipworm); hepatitis; typhoid; polio; plus a range of fevers and blood parasites. In addition, filariasis and schistosomiasis are spread to humans indirectly by vectors, mosquitoes, and snails, respectively, that depend on excreta for their life cycles (see Table III.4). The diarrheas and intestinal worms are epidemiologically and economically important throughout Africa; the others can be important in pockets.

138. Animal excreta is an important factor where exposure to animal urine exists. Leptospirosis is spread by exposure to urine of rodents (especially rats), dogs, swine, and cattle. It is an important occupational hazard for scavengers (see "Scavenging" paras. 155-157).

139. Waste stabilization ponds and conventional treatment. TMs and governments frequently confront a confusing array of sewage treatment technologies. Waste stabilization ponds (sewage lagoons or oxidation ponds) and conventional sewage treatment (activated sludge, trickling filters, etc.) represent two ends of the technical spectrum, infrequently explained in context of each other. They have different emphases and measurement criteria. BOD and COD[31] are ecological standards; pathogen reduction is a public health standard. Conventional treatment plants can deliver high levels of BOD reduction, but organic matter remaining in the effluent technically is pathogenic. By comparison, waste stabilization ponds can render effluent up to 99 percent pathogen free. As a rule of thumb for a city of 100,000, a waste stabilization pond system would need about 15 hectares and take about one month (more sun, higher temperature reduce time but not necessarily space), but other alternatives are available which reduce space requirements. By comparison, a conventional treatment plant would occupy about 1-2 hectares and require only a few hours for treatment. Main points are listed in Table VIII.1.[32]

Table VIII.1: Highlights of Differences in Waste Stabilization Ponds and Conventional Treatment

Type of Sewage Treatment	Objective	Advantages	Disadvantages
Conventional treatment	high removal of organic matter (low BOD) for direct release to receiving waters	smaller overall processing area, shorter treatment time	high capital cost; high O&M and skilled labor requirements; poor pathogen removal, needs tertiary treatment; produces large vols. of sludge
Waste Stabilization Ponds	high removal of pathogens, prepares for land disposal or to receiving waters	low capital costs, flexibility in operation; reasonably pathogen free effluent; low O&M; can reuse effluent	land requirement high for holding ponds

140. Undefined-technology in sewage treatment. In many new projects, technologies for sewage treatment are not determined by the project appraisal or negotiations stage, especially in those with privatization. Because of advances in technology, disposal options will vary widely according to the range of factors highlighted in Table VIII.2. In these circumstances, bidding documents or other

[31] BOD, biochemical oxygen demand, is a measure of the amount of oxygen in water needed to decompose organic matter and the propensity of water to eutrophy, i.e., become unable to support aquatic flora and fauna. COD, chemical oxygen demand, is a measure of the amount of oxygen needed to oxidize all organic and inorganic matter in water. Whereas BOD can be used as an indicator of fecal contamination (organic), and COD as an indicator of dissolved toxins (inorganic).

[32] USAID's "Environmental Health Project" (EHP) has computer software, WAWTTAR, to help choose wastewater alternatives (e.g., environmental factors, human resources and materiel) for developing countries. For information contact EHP, Suite 300; 1611 N. Kent St., Arlington, Va. 22209-2111, USA; Fax: [703] 243-9004; Internet: EHP@ACCESS.DIGEX.COM

contractual arrangements should contain clauses dealing with environmental considerations. Because sewage treatment technology is so varied, the choice of technology should explicitly describe pathogen removal, or some equivalent health analysis, in setting of effluent standards. This needs to be stressed because health criteria are often neglected, or presumed covered under ecological criteria such as BOD. Engineers would not mix the two notions of biochemical water quality and pathogenicity, but many others involved with managing water quality do. Similarly, even with public health as an objective of sewage treatment, toxic chemicals are most important to the engineer running the plant because they can compromise biochemical processes, corrode machinery, or even force a shutdown of the plant, not because the untreated water could poison people or cause an epidemic. It may also be necessary to include a special covenant in the loan/credit to cover these factors. (See paras. 51-67 for description of pertinent diseases.)

141. Possible interventions: The most important intervention is to see that excreta disposal is considered as a dimension of water supply projects. Precise components could be straightforward excreta removal and safe disposal, with explicit mention of health criteria, and the choice of technology adapted to local conditions and consumer demand. In periurban areas, a component could deal with the special requirements of animal excreta, an element often neglected. Any of the above should consider community education and worker protection. Because technology choice is so important, TA may be appropriate as a separate component to help match local conditions with feasible options, or as a workshop during project preparation.

142. **Solid Waste Management.** Solid waste management can be a significant part of any infrastructure sector project, even if not formally identified as a component, e.g., deposition of construction materials in any sector. Solid waste management is broken into municipal/domestic, hospital, and industrial waste, since their technical requirements for its safe handling and disposal will vary, especially if they contain toxic, hazardous, or radioactive components. In addition, recycling, scavenging, accidents/safety are also important factors in each of the above.

143. **Solid Waste Management: Municipal/Domestic.** Typical water/sanitation subsector projects will probably always include domestic/municipal waste. It might also include hospital, industrial, and other specialized waste mixed in; these would vary as it would for the other infrastructure subsectors. The main problem encountered in waste disposal projects from normal domestic and municipal waste is groundwater and surface water pollution from leachate (accumulation of liquid seeping through the waste) and run-off. Leachate should always be considered as potentially toxic and treated accordingly. Because it is toxic, most pathogens will have been destroyed (see also "...industrial waste" paras. 150-152).

144. Those responsible for getting the waste from households to collection points and scavengers (see paras. 155-157) are at high risk because they require appropriate protective gear to prevent direct contact with the waste since it could contain fecal and toxic material. These are consistent weak links in the chain of personal hygiene and public health. Projects could help make a difference through community participation components to help study and design activities to be done outside the project, e.g., access paths to facilitate carrying waste from within the neighborhood, where trucks often cannot pass, to collection site; or wheelbarrows and other transport containers that are more hygienic than open baskets. This type of activity tends to be highly labor intensive for the Bank or local groups, hence the emphasis on technical assistance from the Bank to help solve the problem outside the project.

145. Transfer stations might not receive the same degree of managerial attention as the disposal site itself. The volume of waste transferred and vehicle traffic will vary, but the potential lack of supervision can lead to sufficiently large amounts of waste strewn about, contributing to water pollution, noxious odors, and vector breeding.

146. Traffic and dust can pose a major problem to nearby populations during construction or rehabilitation of landfill sites. Standard best practice occupational health and safety procedures already exist and should be implemented. After construction, traffic and dust can continue to be a problem along the access roads. Dust can be a major irritant causing or predisposing individuals to a full range of infectious and non-infectious respiratory disease. Scheduling truck deliveries to off-peak traffic hours can sometimes help. Outside the project area's access roads, it is difficult to design remedial measures. If the access route happens to be near/through a poor residential area where high levels of respiratory disease already exist, it might be advisable to work with the MOH or community groups to design some road upgrading program, such as tree planting, to help filter the dust. In general, as part of the site, access roads could be dealt with under the project.

147. Air pollution from the waste itself is often overlooked as a health hazard. Frequently, dust is considered a nuisance rather than a health hazard, but can be if it contains residues from industrial waste. The use of tarps to cover the waste in transport, as well as covering the waste with soil at the disposal site can also help curtail the problem. Fires are often intentionally set to reduce waste volumes, and spontaneous fires are a regular problem; both contribute to air pollution.

148. Site development and extension can pose recurrent health hazards throughout the operation of the landfill site where new areas must be dug out to accommodate additional waste until the site completely fills up and is definitively closed. Two factors are extremely important. First, the soil removed from within the site might already be saturated with potentially hazardous waste from underground water movement, surface saturation or leachate, and should be treated as potentially contaminated. Second, the digging holes and the deposition of soils can contribute to spreading mosquito habitat. (See "... human excreta," para. 137, and "Vector-related diseases," Section III, paras. 41-50 for diseases.)

149. Possible interventions: Project components could address water and air pollution, neglect of health considerations at and around transfer stations and disposal sites, traffic and access roads to waste disposal sites, and long-term site management as new sections are opened and old ones closed, and sometimes returned to public use. In all of the above, worker protection as well as the access of children to work sites should be considered. Community participation components can help with basic logistical support to community organizations, religious groups, and NGOs. A TA component might be necessary in the selection of technology most suitable to local conditions.

150. **Solid Waste Management: Industrial Waste.** The most hazardous sources of industrial waste are: wood preservation, paints, chemicals and pharmaceuticals, agrochemicals (fertilizers and pesticides), explosives, petroleum refining, iron and steel, textiles and dyeing, tanning, electroplating, smelting, cement, and /paper mills. Food processing sources which are important include dairies, slaughterhouses, and feed lots. The waste from granaries, silos, and grain storage can be contaminated with fumigant used to prevent spoilage. The waste of industrial parks or export processing zones is harder to characterize but should be considered dangerous, although often they are not, e.g., large-scale garment manufacturing. By comparison, specialized markets, such as those dealing with the sale of animals or vehicle repair, could generate enough waste which becomes hazardous because of its volume, e.g., animal feces, used motor oil, or battery acid. Similarly, vehicle graveyards and mounds of used tires can furnish an excellent site for mosquito breeding. Tinkering, artisan and specialized markets can sometimes generate large enough quantities of waste to require special attention. Of particular importance -- and often neglected as a realistic health hazard -- is exposure to lead in processing brass, copper, silver, and gold.

151. Epidemiologically, the most important factors concerning industrial waste entail: acute intoxications after which the body could bounce back; acute poisonings which can do permanent harm or kill; chronic low-dose exposures which can accumulate to a toxic dose and fat-solubility wherein toxins are retained by the body; or whether low-dose chronic exposures can lead to more serious effects such as cancers or birth defects.

152. Possible interventions: Whereas tackling the full gamut of these waste sources might be too ambitions for anything but a full-scale waste management project, if appropriate, a modest TA component could undertake a waste inventory, determine potential health risks, and make recommendations on how the different sources can be most effectively managed.

153. **Solid Waste Management: Hospital Waste.** Hospital waste is often not managed separately, with the adverse consequences ranging from polluting water to exposing scavengers at waste facilities. Hospital waste contains: human tissue, blood, and other infectious waste (e.g. from operating rooms); "sharps" (needles, glass, etc.); disposable medical equipment (gloves, aprons, urine/blood containers, etc.); pharmaceutical wastes; solid/liquid radioactive wastes; and domestic garbage. With the probable exception of radioactive material, hospital wastes are either flushed into toilets or mixed with domestic waste, even though they might be collected and stored separately. Sometimes they are burned on-site, and the residue containing unburned material is then mixed with municipal waste. Incineration poses a high risk of spreading disease because of the potential for incomplete combustion of toxic/contaminated waste to settle in the immediate area. Hospital waste, like leachate, should always be considered extremely toxic, but its actual importance as a public hazard can be overstated to generate hysteria rather than concern, based on an unnecessary fear of unleashing an Ebola-like epidemic. Pathogens in this waste, like the Ebola virus, are fragile outside the human body, readily die off, and require interpersonal contact for transmission. A cholera epidemic is far more significant epidemiologically.

154. Possible interventions: If a specific hospital waste component is not affordable or technically feasible within a project, a feasible objective could be technical assistance to design a waste management program with two foci: a) in-house, developing a system of collection, destruction (of infectious waste), and storage methods, and education of hospital staff; and b) at the disposal site, focussing on a system of segregation, collection, disposal, and destruction (of infectious waste) in a separate inaccessible area of the sanitary landfill, with provisions to cover it immediately; and education of scavengers and local residents about dangers and avoiding contact or incineration at the designated site, including hospital incinerators. The disposal site might require some construction to prevent scavengers or children from access to the landfill and could be incorporated into the project. A local NGO or development agency could assist with implementation of the program.

155. **Solid Waste Management: Scavenging.** The main environmental health risks come from exposing workers to toxic and other hazardous materials which have not been separated from waste being delivered to the site, and from accidents (see "... Recycling," para. 158). Scavengers also risk contracting the full range of excreta-related diseases (see "... human excreta" para. 137) of which leptospirosis (Weil's disease) is a particular occupational hazard.

156. Reuse and resale of contaminated material not treated as recyclables poses an additional public health risk, e.g., cast-off food, bottles, and tin drums that contained poisons, or newspaper and cardboard that has become saturated with toxic runoff and residue. In some instances this could include discarded hospital waste, such as syringes and reusable containers, although hospitals in developing countries tend to do a much greater amount of sterilization and reuse. If food-processing waste or food storage wastes, e.g., grains from packaging, storage, or shipping, is delivered to the waste site, special care should be taken to determine if the food has been exposed to pesticides or fumigants used to prevent mold or spoilage. Sometimes large or industrial producers throw out food on the verge of spoiling or approaching its sale expiration date.

157. Possible interventions: Several realistic measures can be undertaken in projects, based on the government policy on scavengers. All these would depend on how waste is currently being dealt with by scavengers. It would be appropriate to conduct a study on the type of risks scavengers could be exposed to, and the type of remedial measures practical under local conditions. Provisions should be made to segregate toxic and hospital waste if possible (see paras. 153-154). A first-aid station could be

made available to scavengers for dealing with routine wounds, or transportation provided to a clinic/hospital for more serious accidents. The conditions for sorting could be upgraded to increase productivity and reduce accidents. These could include equipment like conveyor belts and sorting screens, tools, protective clothing, such as gloves, boots, glasses, aprons, and washing facilities. It might also include a basic shelter to protect from sun and rain. A community participation or NGO type component could request the cooperation of the producers.

158. **Solid Waste Management: Recycling.** The most common health hazard stems from routine accidents in handling glass and sharp metal, which could lead to serious infections from otherwise unsanitary working conditions. Two other factors present potentially serious problems. First, glass and metal containers could have contained toxic materials, which could also have saturated paper and cardboard. Recycling spreads the hazard. Second, the literature review indicated that recently toxic material has been intentionally "disguised" as recyclables.

159. Possible interventions: A component could be designed following the same norms as those for scavenging (see para. 157) in making provisions for first aid and for upgraded sorting facilities.

160. **Drainage:** Clogged storm drains often become open sewers. The health dimensions of drainage range from nuisances, especially odors, to more serious problems like filariasis. All forms of wastewater and stormwater can transmit excreta-related diseases (see "... human excreta" para. 137). In addition, inappropriate drainage allows for accumulation of water that is not contaminated but can spread the vector habitats for malaria and schistosomiasis. (See also, "Vector-related diseases," Section III, paras. 41-50.)

161. Possible interventions: Projects can help resolve the problem through a range of straightforward measures such as cement slabs to cover storm drains and sturdy metal grates to block solid waste which can later cause blockage of the drains when there is insufficient water flow to keep them clean. The efficacy of these physical measures, however, is compromised if the local populations do not keep the drains clean. This would require some form of community participation managed by user groups or local NGOs.

162. **Water supply:** Surface water is susceptible to a wide range of urban and rural pollution. In some cities, air pollution is a major source of water pollution, though this is generally not the problem in Africa. Besides the key industrial sources ("... industrial waste," see paras. 150-152), mining runoff and processing wastes can contain highly toxic materials such as lead, mercury, and solvents. Heated water emitted by power plants can sometimes indirectly affect health by increasing the reproduction rate of pathogens to unsafe concentrations. In addition, chlorination byproducts which remain in drinking water have been shown to be carcinogenic, but relative risks of cancer, even in industrialized countries, are insignificant when compared with the risks of not chlorinating water. Dams, barrages, weirs, storage reservoirs, and other water impoundments[33] can spread habitats for mosquitos which can spread malaria and filariasis, and of aquatic snails which spread schistosomiasis (see "Vector-related diseases," paras. Section III, paras. 41-50). In addition, onchocerciasis (river blindness) can be spread by certain flies that breed in fast-running, oxygen-rich water.

163. Groundwater tends to be pathogen-free but might contain toxic levels of naturally occurring chemicals, such as arsenic, manganese, and iron, and salt intrusion. In general, these chemicals do not pose major widespread public health problems and can be handled in water treatment, although they can increase treatment costs. Areas with heavy agricultural activity might also be contaminated with nitrates,

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[33] Technical distinctions: "dam" generally means the structure holding back the water, high dams are over 10 m. in height; barrages allow water to spill over; weirs divert water flow; a reservoir is a water body designated to hold for water, irrigation, or power.

which occur naturally or come from fertilizers or animal wastes. Nitrates can cause blue-baby syndrome (methemoglobinemia, which can also affect animals). In high-density or industrial areas with poor sanitation, groundwater can of course become contaminated with fecal and industrial waste, and leachate from landfills and dumps.

164. Rainwater, as provided by Mother Nature, is pure, but can easily become contaminated by particulate matter[34] in air pollution and dust, both of which can be concentrated to hazardous levels in runoff of the collection system. Ambient air pollution is generally not a problem for the SSA Region as a whole, but it can be in large areas. Agricultural dust can contain pesticide and fertilizer residues. Airsheds of industries and power activity and solid waste facilities can contain a wide array of toxic pollutants. Areas with high motor vehicle emissions can contain lead. Power plants and industries are the main culprits producing acid rain.

165. Water delivery and storage typically opens the door to several health problems. Standpipes generally deliver potable water. Contamination frequently occurs when water pressure falls, drawing in surrounding liquid in holes, cracks, and loose connections, particularly severe in areas with illegal connections or pipes running through storm drains and even open sewers. Similarly, water storage in drinking pots or rainwater catchment systems can become contaminated with pathogens, all of which can lead to the excreta-related diseases (see Section III, paras. 51-56). At distribution points, such as communal standpipes or catchment systems, lack of drainage can contribute to breeding mosquitoes, which can spread yellow fever, dengue, and filariasis (see "Vector-related diseases," Section III, paras. 41-50). These problems can be reduced through construction of concrete platforms with adequate drainage or soakage pits, plus hygiene education.

166. Piped water can contain lead, emanating in old systems from the lead pipes once commonly used, or in newer systems from the lead in solder. Lead can also come from air pollution in areas with heavy vehicle pollution where unleaded gasoline is still used. There are often many other sources of lead which may be more important than pollutants in either air or water. Hence, dealing with lead requires, at a minimum, an indication of the relative importance locally, so as not to overestimate the potential role of water and air pollution abatement in projects. In Africa, lead pollution is *probably* not significant; therefore, it may be appropriate to seek additional information about lead sources since lead reduction is regularly included in pollution abatement proposals.

167. Women and children can spend hours daily fetching water, leading to physical stress which can impair their health, a situation exacerbated in rural areas if they must also find fuel and fodder. Often they must walk miles and wait for extended periods for the arrival of the water truck, adequate water pressure, or simply a place in line. Some of this stress can be alleviated by a small component to build an area protected from the sun and rain. How large or sturdy (just a foundation without a roof) would depend on local needs and the ability of the community to keep it up, e.g., replacing palm fronds.

168. Possible interventions: A variety of components are possible under straightforward water supply projects, e.g., water pollution control, vector control, rainwater catchment, and hygiene education. The greatest contribution that TMs can make is to ensure that provisions for sanitation and drainage which are included at project preparation are not cut later for budgetary reasons. If traffic injuries are a problem for children fetching water, a component could include protective measures like crosswalks, fences, etc.

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[34] Particulate matter is referred to as: TSP, Total Suspended Particulates; SPM, Suspended Particulate Matter; or PM_{10}, Particulate Matter smaller than 10 (or sometimes 5) microns in diameter, i.e., small enough to penetrate deep into the lungs.

169. **Industrial Wastewater:** Industrial wastewater should always be considered at least potentially dangerous to human health, though often it is not. (See "... industrial waste," paras. 150-152, for considerations of most harmful wastes.) Potential diseases transmitted in industrial wastewater are too numerous to mention in a checklist, largely a compendium of toxic compounds and heavy metals that result in poisonings. Where industrial wastewater treatment facilities *per se* are not part of the project, but industries exist in the project area, it may be appropriate to determine the biochemical composition of the wastewater through a modest technical assistance component and assess potential risk. If treatment is unaffordable, other options include provisions foı communal treatment facilities in industrial areas, or for safe transport to a suitable treatment facility or disposal site. If industrial wastewater contains domestic waste, it can also spread the excreta-related diseases (see "... human excreta" paras. 137-141).

170. Possible interventions: A modest TA component could include an inventory of waste sources, determine their potential risks, and evaluate the potential solutions. If the wastewater is deemed hazardous, provisions could be made for treatment.

171. **Accidents and safety.** The risk of accidents is enormous in the water/sanitation subsector because so many activities are still very labor intensive and potential exposures in waste management are exceptionally high. They include:

a) Workers in waste disposal are probably at highest risk because of the type of material they handle.
b) Scavengers, where they exist, would be at an even greater risk because they might not have access to protective gear or be aware of the toxic content of material once it is mixed together in the trucks. After-hours access of children and scavengers exacerbates the above.
c) Gas (methane) is naturally formed in the process of anaerobic (i.e., without oxygen) decomposition of wastes. Unless the gas is vented or the waste is aerated, the accumulation of gas can migrate under the waste to surrounding areas, where it can dissipate naturally or accumulate in structures along its path. This gas contains a high concentration of methane, which is combustible, and might also contain other toxic gases from other materials. Fires are a constant hazard at waste disposal sites, whether igniting from spontaneous combustion from methane (above), combustibles, or set intentionally.
d) Recycling exposes workers to contaminated material and cuts that can develop into more serious infections.

172. Possible interventions: Accidents and safety components dealing with any or each of the four issues noted above can be included in any water, sanitation, or drainage project.

173. **Special Mention for Guinea Worm Disease.** Guinea worm disease (dracunculiasis, dracontiasis) is the only disease spread exclusively through water. It deserves special mention because it is close to eradication in Africa — even by 2000, if programs continue their success. Consequently, any rural water supply project in an endemic or formerly endemic area should inquire about control measures, or, if already designated "Guinea-worm free," appropriate monitoring and follow-up to prevent a reintroduction.

174. Possible interventions: Remedial measures are straightforward, i.e., filtering the water, or protecting shallow wells and water holes, either with covers or stepping stones, that prevent humans from putting their feet and legs directly into the water. The MOH can provide TA concerning monitoring.

175. **Special Mention of Epidemic Cholera.** In general, Bank projects are not designed for epidemics or emergency relief measures except on an *ad hoc* basis for technical assistance or rehabilitation and reconstruction. Cholera could be such a case; it is important because it strikes the victim rapidly, spreads throughout a community rapidly, and can have a high mortality rate when untreated. Furthermore, if an

epidemic lasts long enough to become endemic, based on history, it may take up to 50 years to eradicate. With cholera epidemics, there are a number of feasible interventions that can be rapidly implemented through existing water/sanitation projects.

176. Possible interventions: Six project or component activities are practicable, in coordination with the water agency and MOH:

a) chlorination of water supply in key areas;
b) provision of water trucks to key areas;
c) purchase of vehicles and equipment (for trucking in or chlorinating water) by appropriate budget alterations/schedules, or linkages with other projects;
d) provision of transportation and logistical support to health personnel to help administer care and medications (primarily oral rehydration therapy (ORT) to the victims;
e) public education campaigns in newspapers, TV/radio spots and fliers, with special attention accorded to reaching areas not effectively addressed by the above, e.g., through NGOs or religious groups; and
f) changing the geographic distribution of project works as appropriate to prevent the spread of the epidemic in the future.

A word of caution is in order since governments are often reluctant to declare a cholera epidemic because of potential negative repercussions to trade and tourism.

177. **Institutional Problems.** Rural water supply projects sometimes fall under the aegis of the health or agriculture, which do not necessarily have the in-house competence to deal effectively with the engineering and maintenance of drinking water supply and sanitation services. Conversely, peri-urban water supply under the water supply and sanitation agency might not have the in-house competence to deal with essentially rural conditions. Both types of projects could benefit from a component to deal with the institutional weaknesses in engineering-maintenance, hygiene education, or health risk assessment. Many of these activities (or components) have been introduced into water/sanitation sector projects successfully. Many peri-urban settlements around African cities resemble rural villages with certain characteristics that have important health repercussions. Even high-density areas contain zones which require a rural approach to an urban problem.

178. **High Risk Groups.** The main high risk groups are the poor, of which women and children probably bear the greatest share of the burden.

Table VIII.2: Main Cross-sectoral Linkages with Water and Sanitation

Sector/Ministry	Linkages
Agriculture & Rural Development	competition between urban drinking water and irrigation; with feedlots, fertilizers/pesticides and their packaging, slaughterhouses, food processing plants, food markets contribute to water pollution and probably require special waste treatment; peri-urban conditions often require approaches similar to rural areas; a large amount of food is now produced through urban agriculture requiring water and waste management; irrigation and spread of vector habitats; competition for drinking, industrial, and irrigation uses can cause water shortage and therefore cost increase, leading to cut costs mostly for drainage and O&M
Energy	power plants, SO_2 contribution of fuel source to water pollution; dams and spread of vector habitats; risk of flooding
Industry	siting of settlements near industrial areas: risk of large scale accidents, exposure to toxic pollution; special requirements for provision of industrial: "process water," solid and liquid wastes; contributions of industrial air pollution to water pollution; see water competition under "agriculture" above
Infrastructure: Housing & Urban Development	provision of basic services: water, waste removal, drainage
Infrastructure: Telecommunications	better communications can help warn/prepare for "extreme events" (e.g., floods, storms) that can damage infrastructure and facilitate emergency responses to these
Infrastructure: Transportation	NO_2, contribution of fuel source to water pollution; special needs for waste disposal; water pollution from port/river vessels

179. Table VIII.3 gives a summary of the major health-related issues and appropriate remedial measures that should be considered in typical components for each of the Infrastructure subsectors. More detailed reference material is available in the annotated bibliography of outside literature and Bank publications, the Environmental Assessment Sourcebook, and Operations Manual.

TABLE VIII.3: WATER SUPPLY AND SANITATION CHECKLIST

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Construction/Works: General comment	the construction stage of water and waste management components can pose general hazards in excavations, deposition and temporary storage of construction and excavation debris, etc.:	
	a) pools of standing water and flooding can lead to an increase in malaria and other mosquito-borne diseases, especially during rainy season; workers and local residents at risk	a) preparation TORs should ensure that proper measures are taken during construction and afterward to eliminate breeding and feeding grounds, and to accommodate proper drainage in flood-prone areas, esp. in rainy seasons; may also be appropriate to include TA for residents in community education type component
	b) accidents are important: i) during construction, when workers and nearby residents are at risk of flooding, erosion, and mudslides; children are also at risk when playing after hours at construction sites; ii) in housing near/over water, infants/children are also at risk of drowning	b) preparation TORs should ensure that proper occupational health and safety measures are provided for workers and to limit access of children after hours; the latter might be pertinent in a community education type component
Low-cost Sanitation, On-site Sanitation: construction & disposal of latrines & septic tanks	a) poor maintenance of latrines can lead to full range of excreta-related diseases and also create odors which discourage their use	a) implementation TORs should include procedures for hygiene education; community participation component might be appropriate for maintenance and cost recovery, as appropriate
	b) when latrines or septic tanks are emptied, ground and surface water can become polluted and create vector breeding habitats, leading to full range of excreta- and vector-related diseases; if there is no proper treatment of solids (nightsoil, septage, nonstabilized sludge (note: some latrines are designed to treat waste)	b) preparation TORs should include provisions for proper treatment and disposal of septage sludge; community participation/education; design of appropriate treatment facilities,
	c) see also Public Facilities: washing/bathing and toilets (below)	c) see also Public Facilities: washing/bathing & toilets
Public facilities: washing/bathing & toilets	public facilities require adequate maintenance to prevent clogging of toilets, and of drains for drinking and grey water run-off; they can pollute ground and surface water and create vector breeding habitats, leading to full range of excreta- and vector-related diseases	implementation TORs should include procedures for adequate maintenance, including cost recovery scheme; public education component might also be appropriate

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Waste Stabilization Ponds	a) periods of low sunshine or temperature can lengthen holding time needed for good pathogen removal b) improperly managed facilities can attract flies and mosquitoes that spread disease	a) design should account for effects of weather in retention time; depending on population at risk of poor quality effluent, operation might require emergency disinfection back-up b) implementation TORs should reflect need for vector-control as appropriate; community participation/education may also be appropriate if community is nearby
Conventional Treatment Plants: activated sludge, trickling filters	skilled labor required to control flow of influent through various steps, prone to shock loading (surge in influent), results in high pathogen content in effluent	preparation TORs and designs need to assure proper O&M (or discourage use of conventional treatment); TORs need also to determine receiving water of effluent is destined for drinking or domestic uses, and consider tertiary treatment or other alternatives
Rural Water Supply	a) final stages of Guinea worm eradication feasible over next decade b) water supply and sanitation often the responsibility of MOH or MOAg which might not have engineering-type competence necessary for installation, O&M, etc.	a) preparation TORs for rural water supply and sanitation projects should determine if disease is/has been endemic; if so, project could contain monitoring; if still endemic, project should include provisions for protection of water source and education as appropriate b) implementation TORs should provide for proper O&M, outside MOH/MOAg if appropriate; community participation component might be needed for O&M and cost-recovery
Peri-urban Water Supply	peri-urban areas are often similar to rural areas with different needs for water and waste management to accommodate water, waste and drainage; range of diseases might include malaria	preparation TORs should reflect low-density living conditions and accommodate agricultural and animal waste; anti-malaria considerations might need special attention
Urban Water Supply	a) lack of drainage, especially in areas of communal water supply, breeds mosquitos and flies which can be a nuisance (and spread disease); b) water lines flow next to storm drains which become open sewers (over time, water lines can sag directly into storm drains from neighborhood activity and illegal connections); low water pressure causes intake of pathogens into water lines; especially problematic in areas with illegal connections	a) designs should account for proper drainage, soakaways, and runoff; may require community participation component for proper maintenance b) designs should take into account risk of illegal connections, poor O&M; may require community participation component

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Public facilities: Markets	a) markets can generate special waste needs, e.g., slaughterhouse, vehicle maintenance (battery acid, oils)	a) preparation TORs should include waste generation inventory, type of scavenging/recycling; designs should reflect special waste collection and disposal needs, and, if appropriate, provisions for scavengers and recycling;
	b) clogged drains can lead to spread of vector-related diseases	b) preparation TORs should include description of market business/user groups; community participation type component might be appropriate to help with O&M and cost recovery
	c) poor community organization can lead to a and b above	c) preparation TORs should examine appropriate use of user charges
	d) lack of water and excreta disposal facilities can spread diarrheal diseases through food in addition to poor personal hygiene	d) preparation TORs should design for sanitation and drainage in new markets, and appropriate renovations in upgraded markets; implementation TORs should address sound management practices with cost recovery
	e) — see also "Public Facilities: markets," Housing & Urban Development Subsector —	e) — see also "Public Facilities: markets," Housing & Urban Development Subsector —
Solid Waste Management: Municipal/domestic	a) — see also "Construction/Works: General comment" (above) —	a) — see also "Construction/Works: General comment" (above) —
	b) — see also "Solid Waste Management: Sanitary Landfills (below) —	b) — see also "Solid Waste Management: Sanitary Landfills (below) —
	c) — see also "Public Facilities: markets," Housing & Urban Development Subsector (above) —	c) — see also "Public Facilities: markets," Housing & Urban Development Subsector (above) —
Solid Waste Management: Hazardous commercial & industrial	hazardous and commercial waste can cause a wide range of public health problems which might require separate treatment	preparation TORs should include provisions, as appropriate, for inventory of sources and volumes of waste, and make recommendations for special handling/treatment as appropriate; designs should reflect these accordingly; monitoring program and user charges may be appropriate

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Solid Waste Management: Hospitals	a) non-segregated waste can expose hospital and waste disposal staff (and scavengers) to hazardous waste	a) designs should provide for separate collection and storage of non-domestic waste within hospital and separate disposal with immediate covering (and no-access to scavengers); may require physical barriers
	b) incineration can expose local workers and residents to un-burned hazardous waste	b) preparation TORs should determine if incineration is appropriate, if so, designs should provide for safe incineration and disposal
	c) radioactive waste is a special hazard to workers and local residents, needs long-term, high-tech special attention	c) prepaiation TORs should determine use of radioactive wastes, and design handling measures as appropriate
Solid Waste Management: Sanitary Landfills	a) improperly designed landfills can lead to water/air pollution	a) designs should include provisions for appropriate disposal of leachate, air pollution from dried waste and soil covering
	b) controlled and spontaneous fires can lead to air pollution and burns	b) designs should include provisions to control fires and accidents from burns
	c) traffic during construction and operation can cause road dust and accidents; dried waste can cause dust	c) preparation TORs should include: a description of possible road accidents and inventory of schools and workplaces along the traffic routes; include assessment of health data that indicate high-risk areas for respiratory disease along the access roads and site itself; make appropriate recommendations for design modifications
Solid Waste Management: Scavengers	a) scavengers are exposed to excreta- and vector-related diseases, accidents, and hazardous waste	a) implementation TORs should plan for safe handling of wastes, and, as appropriate, protective clothing and first aid; designs should provide for sorting areas with appropriate construction/barriers, etc., and, if appropriate, areas protected from sun/rain, benches, screening for sporting (or conveyor belts)
	b) scavengers sometimes consume or resell food that is contaminated, spoiled, or near expiration date; waste from peri-urban food processing and storage can be contaminated with fumigants and pesticides	b) implementation TORs should determine if reuse/resale of food is common; if so, describe basic sources and make appropriate provisions to reduce risk; community participation type component might be useful to educate scavengers and solicit help of food producers

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Solid Waste Management: Recycling	a) recycling can cause accidents, in particular cuts that can lead to serious illness in unhygienic conditions; paper and cardboard taken from disposal sites can be saturated with toxic materials; recycled bottles and containers from pesticides and industrial chemicals can lead to acute and chronic poisoning	a) preparation TORs should inventory main types of recyclables locally, indicate potential health hazards, and provide for first aid as appropriate; TORs should determine potential sources of hazardous/caustic materials and make provisions excluding/processing them from the waste stream; might require community participation type component for worker education or to solicit assistance from industries
	b) hazardous materials can be intentionally disguised as recyclables to reduce disposal costs, e.g., of manufacturers, and sent illicitly to developing countries	b) implementation TORs should determine if recyclables include imported materials and, if so, contain provisions to ascertain that exporters are legitimate companies and, if necessary, to examine waste to ensure it contains no hazardous materials
	c) collections of tires, bottles/cans and other containers that hold water can spread mosquito habitat and spread vector-related diseases	c) preparation TORs should determine basic health risks from mosquito-related diseases, and provide appropriate education to reduce risks
Hygiene Education	health education appropriate at almost every level; problems frequently encountered are training materials, translations into local languages	preparation TORs should include, as appropriate, multidisciplinary team, and design programs at least in personal hygiene, food preparation, waste disposal
Pollution Control: General comment	pollution control covers a broad spectrum and could be a part of any project; health aspects to humans might be relatively neglected or subsumed by standards to meet engineering or ecological criteria, which might also omit role of community participation in resolving or monitoring the pollution	preparation TORs and design standards should include: explicit references to pathogen removal, vector control; as appropriate, identification of the population at risk or pollution inventory; might be appropriate to include pollution monitoring and community involvement
Drainage	a) blockage of stormdrains *per se* plus inadequate drainage of general area can cause flooding which can contaminate water supply and cause accidents;	a) implementation TORs should include provision for regular maintenance of stormdrains, which may require component for community education/participation; designs should include provisions for proper drainage of project zone and contiguous areas as appropriate
	b) blockage of stormdrains around markets and public facilities can spread vector habitat for filariasis	b) designs should include soakaways, runoff, spillways, etc.
	c) general inadequate drainage can spread habitat of vectors that spread malaria	c) preparation TORs should allow for proper geographic planning area (neighborhood/town) and appropriate regulatory needs
	d) "solving" drainage problem of one area may merely shift it to another	d) designs should verify if they need to extend drainage provisions beyond the immediate project area

TYPICAL COMPONENT	MAJOR HEALTH-RELATED ISSUES	MAIN REMEDIAL MEASURES & COMMENTS
Sewage Treatment Plants	a) poor quality effluent can promote excreta-related diseases	a) designs should include adequate consideration of BOD and pathogen removal
	b) improper sludge disposal can lead to i) water pollution which can promote excreta-related diseases and ii) provide habitat for mosquitoes and flies	b) designs should include provisions for proper sludge disposal, and incorporate measures to reduce mosquito and fly breeding
	c) it is not always possible to know in advance the technology to be used and therefore design in advance for potential health or occupational risks	c) preparation TORs should ensure that environmental health considerations are considered in bidding documents or Environmental Assessments
Emergency Cholera Response	contaminated water and interpersonal contact are considered the main route of transmission in epidemics; epidemic spread can be very rapid, so quick response is necessary, i.e., diarrheas cause dehydration and shock in hours and with fatality up to 60 percent if untreated (medication and rehydration); MOHs are not well equipped to provide clean water or chlorination of local water supply and could use help from water agency	preparation TOR's could address: i) chlorination, ii) water delivery (trucks), iii) logistical support, e.g., labs, staff; iv) loan of vehicles and equipment to MOH, e.g., water testing, chlorination etc.; iv) public education campaigns; v) as a preventive measure, reordering geographic distribution of future project water and sanitation works

ANALYSIS OF INFRASTRUCTURE OPERATIONS

1. The review of SSA 1984-1994 infrastructure sector documents showed that health has been most integrated into the water and sanitation subsector. Health benefits are perceived to be most significant when projects have integrated water and sanitation in an overall plan with input from the community about preferences and affordability. However, health benefits *per se* have not been systematically tracked for before and after results. In the transport subsector, environmental health has focused on ambient air pollution which is generally not severe in African cities, but has not yet examined hot spots or high risk groups, e.g., vendors near bus/taxi stations and traffic police with high pollution levels. In transport projects, road safety, and accident prevention, by comparison, are very serious in Africa and have been integrated as a public health issue for some time. Environmental health in the housing and urban development subsector has been limited to past work on indoor pollution through the Energy Sector Management Assistance Program in studies aimed at increasing stove efficiency to reduce pollution and accidents (mainly burns in children). In the telecommunications projects, six environmental assessments (EA) mentioned that "improvements were likely to speed up health interventions and thus could be cost-effective."

2. The review of 203 SARs also revealed that environmental health regularly got passing reference, but seldom received detailed scrutiny. Of the 62 PCRs (53 excluding telecommunications), one project, Ghana: Accra District Rehabilitation, listed a health specialist on two missions. Out of the 203 SARs, two projects listed a health specialist as part of the appraisal team: Accra (above) and Zimbabwe: Emergency Drought Recovery. Forty-two projects mentioned health in the project description, and 38 mentioned it in the economic analysis as a project benefit, but one project contained an actual health component, Sudan: Flood Reconstruction; none contained any detailed economic analysis. The first port project to contain an environmental health analysis was approved in June 1995 (Mauritius); of the 24 projects reviewed, none mentioned health risks from water pollution or handling dangerous cargo.

3. **Component Type.** Components of the 203 projects are listed in Table A.1; multisectoral projects have been distributed in the appropriate subsector. This breakdown was used in devising the environmental health checklist for use in project preparation and implementation (Sections IV-VIII).

Table A.1: SSA Infrastructure Component Distribution, 1984-1994

Housing & Urban Devt.		Telecommunications		Transportation		Water & Sanitation	
Type	#	Type	#	Type	#	Type	#
Urban General	24	Telecommunications	18	Railways	19	Water Supply	50
Housing	24			Ports	24	Sanitation	27
Drainage	23			Airport	6	Waste Management	20
Sites & Services	10			River	4	Drainage	13
Public Markets	8			Road Construction	14		
Urban Transport	4			Road Rehab. & Maint.	177		
Public Buildings	2						
Motor Parks	1						
Cap./Inst. Building	90	Cap./Inst. Building	16	Cap./Inst. Building	129	Cap./Inst. Building	39

4. **Analysis of Health.** Economic analyses frequently referred to environmental health factors, but no project actually presented an economic analysis of health benefits. Many projects also state that there are no health impacts. A breakdown of projects mentioning health in passing, compared with those actually containing a health-related analysis is shown in Table A.2. In the transport sector, health issues focussed mainly on road safety, and to a lesser extent on drainage, air pollution abatement, and control of vehicle emissions and dust. Thirty-one of the 89 projects had a general objective of accident prevention, 26 roads, 3 aviation (runway safety), and two maritime. One project contained provisions for immunizations of construction workers, health services for workers and their families, and waste disposal from camps, shops, and work sites (Tanzania: Integrated Roads I). However, these provisions were not implemented in the project and workers were recruited locally. Occupational health was mentioned in two railway projects, and one included a description of safety provisions. Housing and urban projects considered basic shelter as a health benefit, one project addressed accidents/safety as a specific issue. Eleven of 47 projects mentioned health. In water supply and sanitation projects health aspects dealt mainly with protection of water quality, the provision of appropriate drainage and low-cost sanitation methods, pollution control, and the promotion of personal hygiene; and one dealt with emergency drought rehabilitation. Of the 16 multisectoral projects, two dealt with natural disaster rehabilitation and two with accidents/safety. Project supervision, reflected in form 590s, for 62 projects (i.e., those with a PCR or still under supervision) shows that no projects identified health dimensions as an issue during supervision. No Impact Evaluation Reports were produced for the 203 projects.

Table A.2: Number of Projects Mentioning Health

Sub-sector	No. Projects	No. Mentions in SAR text	No. Mentions in EAs	No. Mentions in Econ. Anal.	No. with calculations
Transport	89	-	6	-	-
Housing & Urban Dev.	47	11	7	18	-
Water & Sanitation	35	10	8	17	-
Multi-sectoral	16	3	4	3	-
Telecommunications	16	-	6	-	-
TOTALS	203	25	31	38	0

5. **Staff Health Input.** The breakdown of staff input in SARs showed that the majority of staff were economists, financial analysts, engineers (transport, communications, water, sanitary, and municipal), and in the housing and urban development sector, urban planners. Nine projects specified the kind of specialist, including health specialists, water engineers, environmental specialists, and sociologists; 17 mentioned specialists/consultants without designating the sort. These are listed in Table A.3.

Table A.3: Number of Health or Similar Specialists

Sub-sector	No. Projs.	No. PCRs	No. Health	No. Water	No. Engrs.	No. Sociol.	N.A.
Transport	89	30	-	-	-	-	-
Housing & Urban Dev.	47	10	1	2	1	1	9
Water & Sanitation	35	18	1	-	-	1	4
Multi-sectoral	16	-	-	-	-	-	4
Telecommunications	16	4	-	-	-	-	-
TOTALS	203	62	2	2	1	2	17

6. **Environmental Assessments.** The analysis was inconclusive for the 124 (of the 203) projects which were subjected to environmental reviews, some of which included EAs.[1] None went into depth on cross-sectoral environmental health linkages. Since EA procedures do not require environmental health analyses, it was not possible to distinguish whether routine analysis included issues beyond water pollution in deciding that they were not problems or whether they were not analyzed. In the case of malaria, this would mean that Bank projects in an endemic area would be required to analyze project repercussions only if they would worsen the situation, but not if Bank activity would merely contribute to an already bad situation. (25 NEAPs were produced for SSA, 7 with Bank support; see Annex B, paras. 6-8, and Table B.1.)

7. **Transport and Environmental Health.** Since environmental health has been well integrated into the water/sanitation subsector, transport was selected for closer examination because data are available about transport accidents, as a public health problem, and air pollution as an environmental health problem. In general, SSA urban air pollution from transport is very low because person/vehicle density is low, i.e., 46/1, but the figures are skewed because Nigeria and South Africa contain nearly half the vehicles. In Lagos, Johannesburg, and Capetown, vehicle densities are similar to other developing country capital cities, i.e., 6/1 and 2/1 respectively for the two countries. Otherwise, figures for urban areas are 19/1, but decrease to 13/1 in the 13 cities with populations over 1 million (excluding Lagos, Johannesburg, and Capetown). Even with these generally low person/vehicle ratios, urban air pollution can be very high in pockets in the cities with populations over one million,[2] plus some of the smaller cities because of the concentrations of vehicles in city centers and overall poor maintenance.

8. Thus far, of the 89 transport projects, six have addressed air pollution abatement; four through regulating faulty vehicular emissions (Malawi, Mauritius, Tanzania, Uganda); two through reducing road dust (Guinea, Sudan); but none in Nigeria, with 13 percent of SSA vehicles. Nigeria is, however, considering the use of unleaded fuel. Despite the importance of respiratory disease, no infrastructure projects have been aimed at reducing indoor air pollution. By comparison, some energy and multisectoral projects have been indirectly involved in reducing household air pollution. Twelve energy and

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[1] Composition by environmental category: A, 4; B, 70; C, 36; D, 3; to be determined, 11.

[2] The remaining 13 cities are: Abidjan, Accra, Addis Ababa, Conakry, Dakar, Dar-es-Salaam, Khartoum, Kinshasa, Lusaka, Luanda, Maputo, Nairobi, and Yaounde.

multisectoral projects[3/] included energy conservation (fuelwood, charcoal) or improved stoves, although health improvement was not mentioned as an objective. Total spending of these components amounted to $28 million (one half of which went to Malawi: Energy I), representing 1.3 percent of energy lending from 1984-1994. These projects dealt with cooking efficiency programs, TA for training blacksmiths, improved cooking stoves, smallholder woodlots. By comparison, this review estimated as a thumbnail calculation that it would take an equal amount, about $30.0 billion in investments outside the health sector, to have a major impact toward eliminating respiratory infections as a major burden of disease by reducing the majority of predisposing factors due to indoor and outdoor air pollution[4/]. This would leave primarily the childhood cluster and poor personal hygiene as the remaining important factors under the aegis of the health sector.

9. Based on data from the 1993 World Development Report, *Investing in Health*, it appears possible to reduce four times the amount of respiratory burden of disease, as measured in disability-adjusted life years (DALY), with one half the investment that it would take to reduce traffic injuries. That is, reducing respiratory disease would have to concentrate on indoor air pollution and focus interventions largely at three points, i.e, the household, health care services, and ambient air pollution abatement. This would be equivalent to 1.8 million DALYs and could be achieved at a cost of $85.6 million. By comparison, reducing traffic injuries would require interventions focussed on a multipronged road safety interventions, i.e., legislation., financial incentives, programs of road safety, education, insurance, and liability systems. This would be equivalent to 460,000 DALYs and would cost $172 million.

3/ Burundi: Power Transmission and Distribution (US$0.17 millions, FY1985), and Energy Sector Rehabilitation ($1.1, 91); Côte d'Ivoire: Pilot Women in Development (est. $0.2, 91); Ethiopia: Energy ($1.6, 86); Malawi: Wood Energy II ($0.7, 86), and Energy I ($16, 89); Mauritania: Power & Energy Sector Institutional Development ($0.27, 90); Mozambique: Household Energy ($3.2, 89); Niger: Energy ($1.7, 88); Somalia: Power Rehabilitation ($0.33, 88); Tanzania: Power Rehabilitation ($2.0, 86); Togo: SAL IV (est. $0.2, 91). Total lending: $28.0 (with contingencies).

4/ Calculation based on achievable reduction of respiratory infections and chronic respiratory disease through partially feasible intervention: a combination of median $50 and $375/DALY reduced for the first 5 percent of the burden of disease, and $1000+/DALY reduced for the remaining 95 percent, e.g., air pollution reduction, stove improvement, etc.; the basic difference in costs stems from the ability to get a significant reduction from low-cost interventions such as education, low-capital-cost improvement stoves etc., as opposed to higher cost items such as pollution abatement, traffic regulation, etc.

ANALYSIS OF BANK DOCUMENTATION AND SSA NEAPs.

1. Most project-related work done thus far on environmental health in the Bank has been done in the Europe and Central Asia (ECA) and the Middle East and North Africa (MNA) Regions, where environmental health has played a role in determining overall environmental strategies for the area, essentially emphasizing pollution control.[1] The East Asia and Pacific (EAP) and the Latin American and the Caribbean (LAC) Regions have been involved with the economic evaluation of the human health damages from pollution.[2] Numerous other projects have been approved dealing with pollution control and waste management, wherein there are important positive environmental health repercussions, but these are not necessarily separated into components or other disaggregated activities. Only one pollution control project in Europe and Central Asia was designed based on a health criteria rather than the reverse, which is more common.[3]

2. **General.** Environmental health in Bank documentation has received uneven attention; it tends to be subsumed by other related topics. Many of the traditional health concerns such as indoor household pollution or vector-related diseases like malaria have been treated as health sector, not environmental issues. As with SSA infrastructure projects, the bulk of the work on environmental health has been under the stewardship of engineers and economists. A literature search of Bank documentation found only one peer review by health professionals, i.e., presented at a workshop on the methodologies used in evaluating the economic costs of pollution on human health.[4] Apart from that observation, it is hard to draw conclusions because there is no Bank-wide definition of environmental health.

3. Guidance for staff to deal competently with environmental health issues is lacking, when compared with the broad range of documentation of environmental management. Within the Staff Operations Manual, only one OP/BP (Operations Policy/Best Practice) deals directly with environmental health; i.e., Operational Directive (OD) 4.03 "Guidelines for Use, Selection and Specification of Pesticides in Public Health Programs" deals with spraying to reduce vectors, but does not deal with general pesticide use in agriculture sector. OD 4.30, "Involuntary Resettlement" contains one footnote on health; GP 4.37 "The Safety of Dams" refers to public health in general; OD 4.01 "Environmental Assessments", Annex A lists "Occupational Health and Safety" in a checklist; OP 4.02 "Environmental Action Plans" mentions a public health specialist as part of the EA team, and lists public health and safety

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[1] *Middle East and North Africa Environmental Strategy: Towards Sustainable Development*, Report No. 13601-MNA, 1995; and *Environment and Health in Central and Eastern Europe*, Report No. 12270-ECA, February 1994.

[2] *Thailand — Mitigating Pollution and Congestion: Impacts on a High-growth Economy*, Country Economic Report No. 11770-TH, February 1994; *Chile — Managing Environmental Problems: Economic Analysis of Selected Issues*, Report No. 13061-CH, December 1994; *Estimating the Health Benefits of Air Pollutants: A Method with an Application to Jakarta*, Policy Research Working Paper 1301, May, 1994; *Argentina — Managing Environmental Pollution: Issues and Options*, Report No. 14070-AR, October, 1995; *Valuing Environmental Costs in Pakistan: The Economy-Wide Impact of Environmental Degradation*; Country Economic Memorandum for Pakistan, FY95; Asia Technical Department, Environment Division; draft, April 4, 1995.

[3] *Kyrgyz Republic: National Environmental Action Plan*; Infrastructure, Energy and Environment Division; Environment Division, Country Department 3, Europe and Central Asia Region, No. 13990; (draft) March 13, 1995.

[4] Reviewers from the London School of Hygiene & Tropical Medicine, St. George's Hospital Medical School (London), and the Centers for Disease Control (Atlanta) were asked to participate in a workshop June 1-2, 1995, to comment on "Estimating the Health Effects of Air Pollutants: A Method with an Application to Jakarta", Policy Research Working Paper No. 1301, 1994.

as general objectives; GP 4.03 "Agricultural Pest Management" refers to proper disposal of pesticide containers; and OP 4.76 "Tobacco" refers to the dangers of tobacco smoking.[5]

4. The literature search of non-project documents showed an emphasis primarily on pollution control, i.e., "brown issues," followed by development of techniques to evaluate the health costs of environmental degradation. One finds frequent reference to environmental health, but little actual health analyses. Typical is *Making Development Sustainable: From Concepts to Action* which presents the approaches of sociologists, ecologists, and economists in separate chapters, explicitly mentions gender and poverty in separate sections, cites the urban-pollution issues, and features diagrams of pollution indicators.[6] By comparison, an annotated bibliography, "Sociology, Anthropology and Development," covering Bank publications from 1975-1993, lists two entries on health out of 390 citations. The annual sustainable development conferences of 1994 and 1995, however, have included many presentations on health.

5. SSA Departmental and Divisional publications were reviewed in a bibliography covering 1988-94.[7] Of the 227 publications reviewed, 115 dealt with health, and included 41 on malaria, 29 on tse-tse fly, 25 on schistosomiasis, 17 on pesticides, 12 on the food chain, 10 on food security, 6 on respiratory infections, 4 on transport accidents, 3 on diarrhea, 2 on heavy metals, and 1 on preventative measures.

6. **National Environmental Action Plans (NEAPs).** "Taking Stock of National Environmental Strategies" reviewed 33 NEAPs, 14 of which were from Africa.[8] Pollution was a frequent concern, and human health was mentioned as a criteria, but not necessarily with explicit data or recommendations. Twenty five NEAPs have been completed for SSA, of which 7 received Bank assistance (indicated by "WB" beside country name in Table B.1). All the NEAPS contained similar themes of sustainable development based on considerations of flora and fauna, biodiversity, and ecosystems. Of the 23, four mentioned specific health issues (Rwanda, Sao Tome & Principe, Sierra Leone, Uganda); three identified occupational health problems (Malawi, Seychelles, Zimbabwe); four included passing references to improvements in quality of life (Burkina Faso, Burundi, Guinea Bissau, Kenya); and two assessed health issues in detail (Ghana and Tanzania).

7. None, however, included a comprehensive overview or analysis nor an action plan or recommendations for remedial actions. The closest comes from the Gambia and Eritrea. The Gambian NEAP contains three programs: natural resources management (US$26,805,000), energy (US$1,634,500), environmental health (US$6,507,900), and "cross-programme support" (US$1,736,500). The latter, however, focuses on peri-urban and urban waste management, pollution control with an emphasis on hazardous chemicals, and community involvement in rural areas. The NEAP from Eritrea was most comprehensive, mentioning even nutrition-deficiency diseases related to population distribution, and lists 8 priorities, and a "Pollution Control and Environmental Health Programme." The NEAP was organized

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[5] The ODs above are to reissued as OPs.

[6] Others are "National Environmental Strategies: Learning from Experience" (March 1995), "Monitoring Environmental Progress: A Report on Work in Progress" (draft March 1995), "Taking Stock of National Environmental Strategies" (March 1995), and the Bank's Annual Reports on the Environment.

[7] P. C. Mohan; Bibliography of Publications, World Bank Technical Paper 255; Technical Department, Africa Region; 1994.

[8] The remainder: South Asia, 5; East Asia & Pacific, 4; Middle East and North Africa, 2; Latin America and the Caribbean, 1; Eastern and Central Europe, 7.

in three main thematic areas: "Human Health and Environmental Issues", "Natural Resource and Management Issues," " Socio-economic, Institutional, and International Affairs."

8. Health considerations within the passing references were typically set in the context of ecological issues, e.g., soil erosion includes mention of chemical pollution from pesticides and fertilizers, but not of human exposures; forest depletion considers phalloid depletion and energy conservation, but not the consequences of indoor air pollution; ambient air pollution examines the role of cars in urban areas, power plants, industries and phalloid, but not respiratory disease; marine pollution considers the impact on fishing, but not of contamination of the food chain or recreational exposures to water pollution. When water supply, sanitation, and waste management were cited as important issues, by comparison, they generally/always considered the health dimensions of water-related diseases. The Ghana NEAP addressed the issue of monitoring urban air pollution and mentioned indoor air pollution.

Table B.1: Environmental Health in SSA NEAPs

COUNTRY	DATE	THEMES MENTIONED
Benin	1994	emissions (car, dust, industry)
Botswana	1991	urban water pollution
Burkina Faso	1993	water-borne diseases
Burundi	1993	—
Congo	1994	urban air pollution
Ethiopia	1994	—
Eritrea	1995	human health and environmental issues: sanitation, vector-borne diseases (malaria, schistosomiasis, leishmaniasis, onchocerciasis), diarrheas, nutrition-deficiency diseases, and the working environment
Gambia	1992	environmental health program (budgeted activities: urban waste management, community participation, and livestock vector control)
Ghana	1992	indoor pollution, environmental health program (fuelwood)
Guinea	1994	water supply, sanitation & waste management
Guinea Bissau (WB)	1993	potential for lead in motor fuel
Kenya	1994	adverse effect from motor fuels
Lesotho	1989	—
Madagascar (WB)	1989	—
Malawi	1994	water supply & waste management; occupational hazards & chemicals
Mauritius	1990	—
Mozambique	1994	urban (Maputo-Matola) sanitation and waste management, potable water, infectious/parasitic diseases
Nigeria (WB)	1990	pollution in general (no mention of vehicles)
Rwanda	1991	health & quality of life, water supply & sanitation
Sao Tome & Principe (WB)	1993	malaria
Seychelles	1990	occupational health
Sierra Leone (WB)	1994	causes of death in Freetown: schistosomiasis, malaria, diarrheas, etc.
Tanzania	1994	pollution
Uganda (WB)	1994	water supply & sanitation, water-related diseases; malaria
Zimbabwe (WB)	1993	water supply, sanitation & wastes, air pollution, occupational health

GLOSSARY

African Sleeping Sickness: trypanosomiasis; spread by bite of the blood-sucking tse-tse fly (*Glossina*), which live and breed in woody vegetation along rivers and forests.

Amoebiasis: infection by amoebas, spread mainly hand-to-mouth; parasitic in humans, most commonly known for "amoebic dysentery," or bloody (rather than watery) diarrhea.

Bioaccumulation: biological accumulation; concentration of substances in living organisms from breathing, eating or drinking at a rate greater than the substances can be metabolized or excreted; can accumulate to toxic doses (however, sometimes used to refer to intake of toxic chemicals from environmental factors other than food and water); refers to the process within an organism, as opposed to "biomagnification" which emphasizes the overall process in the aquatic food chain, and "bioamplification" which emphasizes given impurities.

Bioamplification: biological amplification; concentration of a persistent substance by an organism in the food chain, e.g., 0.001 ppm in earthworms of a pesticide can be amplified to 1 ppm in birds; "bioamplification" emphasizes a given substance as opposed to "biomagnification" which emphasizes the overall process in the aquatic food chain, and "bioaccumulation" which emphasizes given organisms.

Biocide: general term for substances toxic to living organisms; pesticide, also used as general term to kill pests; herbicides attack weeds; fungicides attack fungi and molds.

Biodegradation: biological degradation; general term covering the process of breakdown by microorganisms as organic matter becomes less toxic/harmful to humans and the natural environment; sometimes misused in that biodegradation is not necessarily total, materials remain harmful nonetheless; should not be confused with disintegration in which physical form changes but not biochemical content, e.g., many "biodegradable" plastics with additives cause the plastic simply to dissolve or fragment to be less unsightly.

Biomagnification: biological magnification; concentration of impurities in water as they pass through the food chain; concentrations occur in tissues or organs which are consumed by larger organisms and humans as they go up the food chain, e.g., 0.001 micrograms of mercury in water can magnify to 50 micrograms in fish; as opposed to "bioaccumulation" which emphasizes the overall process in the aquatic food chain, and "bioamplification" which emphasizes given impurities.

BOD: Biological oxygen demand; a common water quality standard, measures the amount of dissolved oxygen "demanded" by organic material in biological degradation over 5-days; an indicator of degree of organic pollution; does not indicate pathogenicity of organic material; used primarily as an indicator of the healthiness of water bodies to support flora and fauna, or conversely, the propensity to stagnate/eutrophy due to lack of oxygen; see also "chemical oxygen demand (COD)" which, by comparison, emphasizes inorganic chemical pollution levels.

Carbon monoxide: *CO*; odorless, colorless gas, the product of incomplete combustion; CO reacts with blood in the lungs and reduces overall capacity of blood to carry oxygen; at moderate concentrations, can affect central nervous system, diminishing perception and performance of fine movements; CO also paralyzes the cilia (tiny hairs) of the respiratory tract, which predisposes to respiratory infection; main sources are vehicular traffic and tobacco smoke; major indoor sources are from heating, lighting and cooking fuels.

Carcinogen: substances that produce cancer; related terms: **metastasis**, cancer spreading to other organs; **mutagen**, change in DNA, which is passed on to other generations; **teratogen**, change *in utero*, or birth defect.

Carrier: an infected individual that can spread a disease without necessarily becoming sick or showing symptoms.

Chagas' Disease: American trypanosomiasis or "sleeping sickness" spread by a bite of nocturnal blood-sucking cone-nosed bug that lives in cracks/crevices of walls/roofing in the day, hence sometimes called bedbugs; tends to be associated with poor housing, particularly in rural areas; see also "African Sleeping Sickness."

Cholera: diarrheal disease important because it frequently occurs in epidemics and can spread rapidly; due primarily to a combination of deficient sanitation and poor hygiene, with interpersonal contact a major means of transmission, thus, considerations of crowding, even in rural areas, are important; also important because once introduced, can be very difficult to eliminate in areas of poor sanitation, e.g., historically up to 50 years to eliminate; can be fatal if untreated because it strikes rapidly, i.e., major consequences are due to rapid dehydration and subsequent depletion of essential body chemicals from the water loss; can be effectively treated by oral rehydration therapy (ORT) which replace lost fluids and essential chemicals.

CO: see "Carbon monoxide."

COD: chemical oxygen demand; a common water quality standard which measures the amount of dissolved oxygen "demanded" by inorganic material in chemical breakdown over 5-days; an indicator of degree of inorganic pollution; does not indicate toxicity of inorganic material; see also "biological oxygen demand (BOD)" which, by comparison, emphasizes capacity of water body to support life, rather than pollution which can jeopardize it.

Coliforms: groups of bacteria that live in human and animal intestines, commonly used as an indicator of fecal contamination of water supply; "coliform count" is a common standard of water quality.

DALY: "Disability-adjusted life years", a socioeconomic measure of human suffering that weights morbidity against mortality by combining years lived with a disability/disease/injury together with the death rate from the same conditions.

Dengue: dengue fever, breakbone fever, dengue hemorraghic fever; febrile illness spread by the *Aedes* mosquito, which breeds in clean water; appears to be on the increase, with epidemics noted in Latin America; causes for epidemic spread not yet fully understood but might involve habitat change from global warming or urbanization.

Diarrheas, diarrheal diseases: broad category of diseases symptomatic of many illnesses; main effect is loss of body fluids, which can include essential chemicals and blood (e.g., in dysentery).

Dose-response: relationship indicating degree of exposure, e.g., of a pathogen, radiation or pollutant, to evoke a physiological response; sometimes considered controversial since it can overstate relationships for which exposure has been measured, but understate potential risks because of inadequate data.

Filariasis: parasitic worm infection spread by *Culex* mosquito which tends to breed in organically polluted water, thus a direct risk in dealing with sanitation and drainage.

Giardiasis: intestinal infection by *Giardia*, spread mainly hand-to-mouth, important in water management because chlorine concentrations sufficient to kill most pathogens do not kill giardia cysts; can also be passed on to humans from some animals.

Global burden of disease: concept developed to convey various socioeconomic factors beyond traditional morbidity and mortality rates; consists of a combination of years lived with disability and death rates.

Guinea worm: worm infection of the lower extremities, causing an ulcer from which the female, 60-100 cm long (2-3 ft.) discharges eggs; the eggs develop into tiny "water fleas" that people drink; spread when infected individuals immerse feet/legs fetching water from ponds, etc. (or to relieve the itching from the sore); the only disease spread exclusively by drinking water; on the verge of eradication in Africa; primarily rural.

H_2SO_4: sulfuric acid; see "Sulfur oxides."

Helminths, helminthic worms: see "Intestinal worms."

Hepatitis: general term for several forms of live infection commonly designated viral hepatitis and differentiated by main mode of transmission: ingestion of feces for Hepatitis A & E, or contaminated blood or exchange of body fluids for Hepatitis B, C, & D; debilitating illness causing sever fatigue lasting up to several months; improved sanitation is important for A & E.

Herbicides: See "Biocides."

Host: human or animal that harbors an infectious agent; the host does not always get the infection or even show symptoms; sometimes also called "reservoir."

Infective Dose: level of infection from a pathogen to cause sickness; see also "Dose-response."

Insecticides: See "Biocides."

Intestinal worms: helminths, parasitic worms (nematodes or trematodes) spread essentially by deficient sanitation; most commonly known from intestinal infections like hookworm or ascariasis which are epidemiologically very important; the worms can cause a wide array of problems and infect body organs, e.g. with tapeworm, liver fluke.

Lead: *Pb*; lead poisoning can cause a wide array of problems even in low doses; most common are irreversible neurological damage and stunted mental grown (to which aggressive behavior has also been linked), stomach pain, colic, high blood pressure, kidney problems and bone loss; can adversely effect normal functions of other vital organs; lead can accumulate in the body, causing paralysis, blindness and death; major sources are lead smelting, lead in gasoline; important sources not related to commerce and industry are cosmetics, household remedies for diarrhea and stomach ailments, poultices for sealing umbilical cord; other sources that could be important hotspots include: battery manufacturing, brass foundries, lead glazed pottery and cloisonné, radiator repair, art restoration; exposure standards vary, e.g., US OSHA (Occupational Safety and Health Administration) from 50μg/8hrs permissible exposure for workers to USEPA 1.5μ/m^3 for ambient air, 30μg-or-more/30days/year maximum atmospheric exposure, to 0.15mg/m^3 threshold limit value for fumes and dust; generally, about 40% lead deposited in the lungs is absorbed into the bloodstream; despite the general importance of lead, the role of vehicular emissions is sometimes overstated relative to other issues because lead in ambient air is commonly measured and thus data are available for analysis and discussion, whereas other sources are only irregularly measured.

Malaria: common parasitic infection spread by the *Anopheles* mosquito, which breeds in pure, slow-moving salt or fresh water; malaria has been staging a comeback because of resistance to prophylactic drug measures (spraying and medication), as well as prolongation of breeding season through year-round cropping, and extension of habitat through water supply and irrigation; in addition to water management, control strategies need also to consider drainage since breeding occurs in natural marshes and backwaters; there are four basic form of malaria characterized by symptoms and relative seriousness; once on the decline because of vigorous combative programs, malaria appears to be staging a comeback because of resistance to pesticides and medications.

Micron: μ; 1/1,000,000nth of a meter; approx. 1/25,000th of an inch.

Nightsoil: human (or animal) excreta (feces and urine); used normally in context of its collection, e.g., in latrines using buckets, or its being carted away or reused.

Nitrates: class of chemicals that are commonly discussed as water pollutants of groundwater plus rural surface water, coming mainly from fertilizers and human/livestock waste (nitrates are also a derivative of nitric acid, which is discussed under "Nitrogen oxides" as an air pollutant); nitrites and *N-nitroso* compounds (nitrosamines) are frequently cited derivatives of nitrates transformed in the digestive tract; nitrates and nitrites contain antimicrobial, and are thus used in food processing, but an excess can be toxic to humans; from a health perspective, nitrosamines are important as a group because they can cause blue baby syndrome (methemoglobinemia, in humans and animals), and possibly gastric cancer (drinking water standards are based on risk of methemoglobinemia); methemoglobinemia is normally a temporary condition occurring in the first six months until the infant's digestive system develops; can also come from nitrites used in meat/fish curing and food preservation, storage of certain green vegetables, e.g., spinach, which form nitrite and *N-nitroso* compounds; the latter occur also in tanneries, cosmetics, rubber/iron foundries; wells over 30 m. deep are likely to be safe; USEPA standards for drinking water are 10ppm.

Nitric acid: HNO_3; corrosive, colorless acid, toxic to humans when inhaled, caustic to skin and mucous membranes; public health importance stems from the possibility of the virtually ubiquitous NO_x reacting with water vapor and other chemicals in the air to form acid aerosol of nitric acid; very commonly used in industry, e.g., in the manufacture of fertilizers, herbicides, insecticides, explosives, etching glass and steel, wood pulping, reprocessing nuclear fuel, meat processing, ceramics, pharmaceuticals, chemicals, dyes, and as a common laboratory reagent; OSHA limit is 232 ppm in air, or 30 mg/m^3.

Nitrites: See "nitrates."

***N*-nitroso compounds**: See "nitrates."

Nitrogen dioxide: NO_2; see "Nitrogen oxides."

NO_2: nitrogen dioxide; see "Nitrogen oxides."

Nitrogen oxides: NO_x; a general term for compounds containing nitrogen and oxygen, the most common of which is nitrogen dioxide (NO_2); NO_x can compromise the body's ability to kill bacteria in the respiratory tract and reduce the body's resistance to fight disease; is not very soluble in water, and thus does not get readily filtered out in the upper respiratory tract, causing difficulty in breathing or asphyxiation, and penetrates into the lungs causing other problems, including respiratory and cardiovascular diseases; because of the high nitrogen content of the air, NO_x is an important general and occupational health problem; principal sources of NO_2 are combustion of coal, oil, natural gas, and motor vehicle fuel from: transportation, energy, industry, solid waste disposal, and miscellaneous activities such as fires; also used in manufacture of chemicals, fertilizers, paints, and propellants; because transportation and industrial activity are concentrated in urban areas, NO_2 tends to be more significant as an urban pollutant, but can be important in rural or peri-urban pockets; NO_2 is an ingredient of tobacco smoke, and is believed to be particularly harmful in the presence of automobile exhaust; when nitrogen in the air reacts with a burning flame in a furnace or combustion engine, it forms nitric oxide (NO), a relatively harmless pollutant; combustion and cooling temperatures are important; when this involves venting and rapid cooling, it becomes significant to public health; thus, idling cars produce less of a health hazard than rapidly moving ones; can react with water vapor forming acid rain, acid aerosol (nitric acid), and poor visibility.

NO_x: see "Nitrogen oxides."

O_3: see "Ozone."

Onchocerciasis: "river blindness," spread through bite of the blackfly (*Simulium*), which need highly oxygenated water for breeding, i.e., fast moving streams or other water, predominantly rural; on the decline from effective programs in Onchocerciasis Control Programme of Western Africa.

Organochlorides: group of chemicals characterized by their solubility in fat, epidemiologically important because they can be absorbed and accumulate in the body to toxic doses (as opposed to water-soluble chemicals which, generally, are either metabolized or flushed) and because they are very common in the food chain since they are widely used in pesticides; PCBs (see below, are also organochlorides); see also "Pesticides."

Organophosphates: class of insecticides highly toxic to nervous system of humans and mammals but non-persistent in the environment.

Oxides of nitrogen: *NO_x*; see "Nitrogen oxides"

Oxides of sulfur: *SO_x*; see "Sulfur oxides"

Ozone: *O_3*; a secondary pollutant, caused by the reaction with carbon monoxide or unburned oxygen from vehicle fuels, the main component of smog; economic activity that generates ozone includes: high voltage electrical equipment, e.g., x-rays machines, electrical insulators, motor brushes, and some ultra-violet lights, and also used to purify water, sugar and industrial waste, and help extend the shelf life of produce in cold storage by controlling the growth of bacteria and fungi; irritant to eyes and respiratory tract; can compromise the body's ability to kill bacteria in the respiratory tract and reduce the body's resistance to fight disease. Like SO2, O_3 reacts mainly with the respiratory tract itself, thus, generally does not get absorbed by the blood; portion of O_3 not destroyed in the upper respiratory tract can cause thickening of the respiratory arteries, leading to chronic lung disease, emphysema and sometimes heart failure. It can also react with nerve endings, interfering with normal oxygen/carbon dioxide exchange in breathing; OSHA ceiling is 0.1 ppm in air, or 0.2 mg/m^3.

PAH: polycyclic or polynuclear aromatic hydrocarbons; class of chemicals significant as air pollutants, produced by incomplete combustion of coal, oil, gas, garbage and hazardous waste; toxic to humans and can cause lung cancer; OSHA permissible exposure limit, 0.2 mg/m^3.

Pathogen: organisms, mostly microscopic in size, which causes disease; in this book, pathogen refers to bacteria, viruses, and parasites collectively.

Pb: lead; see "Lead."

PCB: polychlorinated biphenyl; class of industrial chemicals once widely used in transformers, vacuum pumps, (liquid) insulators, adhesives, and plastifiers, with one of their most important uses as fire retardants; now discontinued in many countries because of toxicity, negative effects, and persistence in the environment; see also "Organochlorides."

Pesticides: general term that covers killing, preventing, or repelling pests (i.e., fungicides, rodenticides, herbicides, insecticides), including defoliants, desiccants; see also "Biocides."

Phenols: toxic organic chemicals contained in oil-based compounds; important because of the predominance of oil-based compounds (e.g., gasoline, motor oil, coal, etc.) currently used in the transportation, energy and infrastructure sectors which release phenols in their chemical breakdown.

PM_{10}, PM_5: particulate matter less than 10 or 5μ (microns) in diameter (less than 1/1,000,000 m., or 1/250,000 in.); see "Suspended particulate matter."

Polyaromatic hydrocarbons: *PAH*; polycyclic or polynuclear aromatic hydrocarbons; class of chemicals significant as air pollutants, produced by incomplete combustion of coal, oil, gas, garbage and hazardous waste; common constituents cigarette smoke, coal tar; toxic to humans and can cause lung cancer; OSHA permissible exposure limit, 0.2 mg/m^3.

ppb: parts per billion.

ppm: parts per million.

Respirable fraction: refers to that fraction of air pollutants not filtered out in the nasal passage, and are small enough in particle size (generally less than 10 microns in diameter) to penetrate into the lungs where oxygen exchange occurs.

Roundworms: See "Intestinal helminths."

Salmonelloses: common, acute gastrointestinal infections with salmonella, causing sudden onset of diarrhea, headache pain and nausea, frequently associated with food poisoning; spread mainly through animal feces, hence food preparation a major preventive measure; spread also by deficient sanitation; typhoid and parathypohoid are also classified as salmonelloses, but are not spread through animal feces, and are characterized mostly by fever.

Sanitation: general term covering waste management, used irregularly to refer to sewers and other water-conveyance systems, e.g., high- and medium-tech sewerage; on-site systems, e.g., latrines and other low-tech systems; and solid waste removal.

Septage: human waste that does not pass through a sewage system; see "Sanitation."

Sewage: contents of the sewers.

Sewerage: general term referring to the system of conveyance of wastewater containing human (and animal) excreta, consisting of: a) sewers, i.e., network of pipes; b) treatment plants, which produce water and sludge; and c) means of final disposal, e.g., sewage outfalls discharging treated or untreated wastewater into rivers or oceans, or a sanitary landfill which accepts the sludge. Technically speaking, the sewerage system is different from the "drainage system" which conveys stormwater not requiring treatment for pathogen removal; some systems carry a combination of sewage and storm water; "sewerage" and "sewerage system" are inconsistently used and defined, even in technical dictionaries; the important point is to distinguish among component parts (collection, transmission, disposal), drainage systems, and the institutions which manage the system.

Sludge: residue from sewage treatment plant, consisting of the accumulation of settled solids and other material that results from different treatment stages; eventually needs proper disposal and, depending of the thoroughness of treatment and the type of effluent coming into the system, can be biologically pathogenic and chemically toxic.

SO_2: sulfur dioxide; see "Sulfur oxides."

SO_x: see "Sulfur oxides."

SPM: see "Suspended particulate matter."

Sulfur dioxide: SO_2; see "Sulfur oxides."

Sulfuric acid: (H_2SO_4); mainly a secondary pollutant caused by reactions with sulfur dioxide; see "Sulfur oxides."

Sulfur oxides (SO_x): general term used to refer to compounds containing sulfur and oxygen, the most common of which are sulfur dioxide (SO_2) and sulfuric acid (H_2SO_4). Most SO_2 is generated in the combustion of coal, petroleum products and wood, byproducts primarily of space heating and cooking and in the production of electricity. SO_x is also generated in refineries, smelters (e.g., copper, lead, zinc), manufacturing of paper and incineration of refuse;. Most SO_x consists of particles less than 2μ, making it a contributor to poor visibility, and also small enough to penetrate into the lungs. By and large, SO_2 is a mild respiratory irritant, most of which is absorbed in the upper respiratory tract because it is soluble in water but can be converted to sulfuric acid, a more serious pollutant to the lungs. SO_2 is implicated in chronic bronchitis, asthma, eye and nasal irritations. SO_x are a major component of tobacco smoke, which probably constitutes a more serious health problem than does respiration of SO_x in ambient air.

Sullage: wastewater that does not contain fecal material, also called "greywater"; see "Sanitation."

Suspended particulate matter (*SPM*): a reference to small particles of solids or liquids suspended in air; when used in measuring air pollution, figures also include PM_{10} or PM_5 to refer to particles less than 10 or 5μ (microns) in diameter; important because they can penetrate deep into the lung cavity where the blood is oxygenated; TSP, total suspended particulates, refers to the aggregate of pollutants, regardless of particle size, as opposed to the "respirable fraction," which refers to PM_{10} or smaller.

Tetanus: an infection of the musculature causing painful contractions, hence the name lockjaw. Tetanus is commonly spread through puncture wounds contaminated with human or animal feces in soil, street dust; it is an important occupational disease for agriculture and animal husbandry because of frequent handling of animal feces.

Trachoma: a leading cause of preventible blindness, transmitted from person-to-person contact of discharges from the eye of infected individuals; more common in dry areas,hence a seasonal variation; main preventive measure is adequate water for personal hygiene.

Trypanosomiasis: see "African Sleeping Sickness" and "Chagas' Disease."

TSP: total suspended particulates; see "Suspended particulate matter".

Tuberculosis: disease of the lungs (though it can infect other body organs), spread mainly by inter-personal contact through air-borne droplets, hence crowded living conditions are a factor (can also be spread through consumption of unpasteurized dairy products; common complication of HIV infection; staging a comeback even in developed countries, where it was considered a scourge of humanity at the turn of the century. TB bacillus is resistant to drying, but susceptible to sunlight; hence dark, dusty housing is conducive to its spread.

Typhoid: see "Salmonelloses."

Vector: an intermediate agent, such as a fly, mosquito or rodent, capable of transmitting a disease from one organism to another, or the susceptible **host**; infections can be transmitted from a bite or skin penetration (inoculation), e.g., mosquitoes transmitting malaria or by rats carrying plague, by mechanical deposition, e.g., flies carrying bacteria that cause diarrheas, or by ingestion, e.g., humans drink "water fleas" that carry Guinea worm disease.

Intermediate vector indicates a complicated life cycle with more than one stage, e.g., in schistosomiasis, humans excrete worm eggs that develop into larvae which infect snails, which, in turn excrete eggs that develop into larvae that penetrate human skin.

Virulence: degree of severity of an infection capable of withstanding body defenses or medical treatment, often measured by case fatality rates.

Volatile organic compounds: *VOC*, organic compounds that readily evaporate and exist as gases in the atmosphere; term commonly used when referring to air pollutants, e.g., benzene.