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Minimizing the Negative Environmental and Health Impacts of Agricultural Water Resources Development in Sub-Saharan Africa

M. P. McCartney, E. Boelee, O. Cofie and C. M. Mutero

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Acronyms

ADB	African Development Bank
AIDS	Acquired Immunodeficiency Syndrome
CIDA	Canadian International Development Agency
DANIDA	Danish International Development Agency
DDT	Dichloro-Diphenyl-Trichloroethane
DFID	Department for International Development
DRIFT	Downstream Response to Imposed Flow Transformation
EA	Environmental Assessment
EAA's	Environmental Audits and Appraisals
ECZ	Environmental Council of Zambia
EIA	Environmental Impact Assessment
EHIA	Environmental Health Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (German development agency)
HIA	Health Impact Assessment
HIV	Human Immunodeficiency Virus
ICID	International Commission on Irrigation and Drainage
IFAD	International Fund for Agricultural Development
InWEnt	Internationale Weiterbildung und Entwicklung gGmbH (Capacity Building International, Germany)
IUCN	The World Conservation Union
IWMI	International Water Management Institute
NGO	Non-Governmental Organization
PEEM	Joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control
SEA	Strategic Environmental Assessment
SA	Social Assessment
UNCHS	United Nations Centre for Human Settlements - Habitat
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WHO	World Health Organization

Summary

This paper provides a synopsis of environmental and health impacts arising from agricultural water development in sub-Saharan Africa and recommends ways to increase the sustainability of investments in irrigation by giving greater prominence to health and environmental concerns. In many places in the region, irrigation is a key means of enhancing agricultural productivity that can reduce poverty and improve livelihoods. However, failure to adequately foresee, plan and manage the negative environmental and health impacts arising from irrigation undermines the sustainability of many schemes and can worsen poverty. To improve sustainability, environmental and health issues must be at the core of future irrigation development with much greater emphasis on the planning and management of potentially negative impacts. This paper presents a conceptual framework for considering environmental and health issues in tandem; reviews current environmental and health assessment tools; describes national and donor policies; and analyzes current constraints to successful environmental and health planning and management. On the basis of findings, it makes recommendations to improve planning and management across a range of scales. The recommendations are of relevance to both water and agricultural planners and are timely, in the light of recent calls for significant increases in irrigation investment as a contribution to achieving the Millennium Development Goals.

INTRODUCTION

Food insecurity and overall inadequacy of food supplies remain a major problem throughout sub-Saharan Africa. This is despite the fact that typically 70-80 percent of the population in the region is involved in agricultural production: an indicator of the degree to which land and labor productivity is still extremely low by international standards (FAO 2004a). Furthermore, there is little evidence that existing policies are effective in reducing hunger. Malnutrition and poverty remain persistent and widespread problems despite the fact that the need for improved agricultural productivity has been highlighted as a priority for many years (Eicher 2004). Throughout sub-Saharan Africa, agricultural development is a precondition for greater economic development (Commission for Africa 2005).

Dependence on rain-fed agriculture, coupled with high rainfall variability, is one of the main causes of food insecurity across the continent. For example, during the drought of 2002-2003 in southern Africa, some 15.2 million people (i.e., 26% of the population of the countries affected) were dependent on food aid (Drimie 2004). Although the impact of the drought was greatly affected by a range of factors, including the generally poor macroeconomic situation in the region, inappropriate government policies and the HIV/AIDS pandemic, the extensive failure of rain-fed crops was the immediate cause of the food crisis (Drimie 2004).

In sub-Saharan Africa, substantial new investments in agriculture are needed to meet targets for poverty alleviation and food security. The Food and Agriculture Organization of the United Nations (FAO) estimates that about 75 percent of the growth in crop production required by 2030 will have to come from intensification in the form of yield increases (62%) and higher cropping intensities (13%) (FAO 2002).¹ At least some of this intensification will require development of water resources.

It is widely acknowledged that irrigation can play a major role in improving productivity, reducing poverty and sustaining rural livelihoods (Hussain and Hanjra 2004; Smith 2004). However, over the past two decades, investments in irrigation in sub-Saharan Africa have declined significantly (Kikuchi et al. 2005). There are a number of reasons for this decline, but the poor performance of irrigation, especially with respect to capital-intensive schemes, has undoubtedly contributed. Although not the sole reason, factors of an environmental nature and adverse health impacts have been a prominent cause for the disappointing performance of many schemes (Oomen et al. 1990). Inadequate consideration of environmental and health issues in the planning and implementation of projects is widely perceived as a key cause of project failure (Morardet et al. 2005).

Agricultural and irrigation potential in Africa is huge. It is estimated that currently only 24 percent (i.e., 2,820 million hectares [ha]) of arable land is under cultivation. Of this, it is estimated that just 0.5 percent (i.e., 13 million ha) is under formal irrigation. Furthermore, for sub-Saharan Africa as a whole, annually renewable water resources are abundant though not evenly distributed. Currently, total human abstractions amount to 73,620 million cubic meters (Mm³), which equate to just 2 percent of the annual renewable resource of 3,941,000 Mm³ (FAO AQUASTAT 2005). Annual averages do not tell the whole story because in many places there is considerable spatial and temporal variation in river flows and in some countries abstractions are considerably higher. For example, in South Africa, Somalia and Sudan total abstractions, primarily for agriculture, exceed 20 percent of the annual renewable resource (FAO AQUASTAT 2005). Nevertheless, overall there is sufficient water to make the regions' food supply secure, if water could be stored and/or transferred for irrigation.

¹The remaining 25 percent will have to come from expansion of arable land.

It is now widely recognized that if sub-Saharan Africa is to meet the poverty reduction and food security targets of the Millennium Development Goals, the decline in investment in agriculture must be reversed. The New Partnership for Africa's Development (NEPAD) has called for \$37 billion (in this paper, \$ means US\$) of new investment in the agriculture sector by 2015 (NEPAD 2003) and the paper of the Commission for Africa proposed a doubling of the area of arable land under irrigation by 2015, with an estimated cost of \$2 billion per year (Commission for Africa 2005). The World Water Development Paper calls for "substantial increases in investment in rural areas, where water management plays a central role in raising the productivity of agriculture" (United Nations 2006). Recent World Bank corporate strategies identify the need for a "reengagement in agricultural water management," particularly in sub-Saharan Africa (World Bank 2006).

The leaders of the G8 summit in Gleneagles, through the launch of the Infrastructure Consortium for Africa, committed a significant amount of aid assistance to infrastructural development. In addition, the European Union has pledged to increase aid to developing countries with a significant part of the increase going towards infrastructural development in Africa. It is therefore to be expected that investments in agricultural water projects will increase substantially in the near future. However, if such investments are to be more successful than those of the past, there is great need for significantly improved returns and greater sustainability.

Against this background, this paper presents key findings on environmental and health impacts arising from agricultural water development in sub-Saharan Africa. Information has been obtained from a wide variety of published and unpublished sources and from case studies conducted in Burkina Faso, Ghana and Zambia. In this paper, agricultural water development encompasses both formal and informal irrigation across a range of scales from individual and community-based interventions to huge (i.e., many thousands of hectares) irrigation systems.

This paper is not intended as a compendium of data, which can be found elsewhere (e.g., Dougherty and Hall 1995; Kay 1999), but rather as an overview for understanding policy and programming issues and requirements. The overall aim is to provide ideas for improving the planning of agricultural water development projects in the region by enhancing the management of environmental and health risks associated with it. Specifically the paper presents:

- a brief summary of environmental and health issues of particular relevance to agricultural water development in sub-Saharan Africa
- a conceptual framework for considering environmental and health issues in tandem
- a review of environmental and health-assessment tools
- an overview of environmental and health-impact assessment policies
- an inventory of measures to increase the benefits and mitigate the negative impacts associated with water development
- an analysis of the constraints to the successful implementation of these approaches in sub-Saharan Africa
- pragmatic recommendations to improve planning and management, which recognize that small- and large-scale projects have to be treated differently

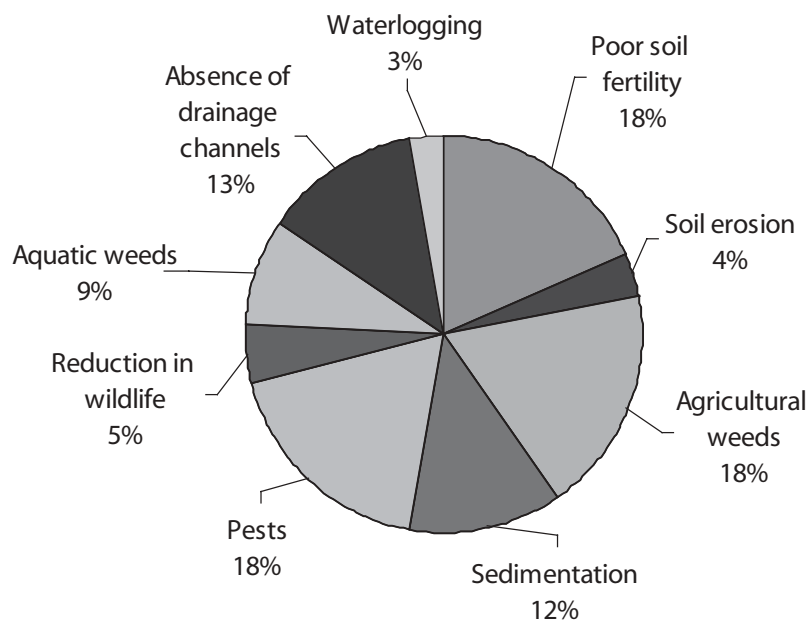
OVERVIEW OF ENVIRONMENTAL AND HEALTH ISSUES

Environmental Impacts

The potential negative environmental impacts of large capital-intensive irrigation schemes are extensively documented (e.g., Adams 1992; Dougherty and Hall 1995; Petermann 1996). Modification of river flow regimes, depletion of groundwater, sedimentation effects, soil salinization, waterlogging, water contamination and biological effects,² have all been responsible for undermining the sustainability of schemes. In some cases, environmental impacts that undermine sustainability occur not as a direct result of the development, but as a consequence of changes elsewhere in the catchment. For example, sedimentation in irrigation channels may be caused by erosion upstream.

Often, these environmental problems are not adequately foreseen at the project design stage. Although in some instances the problems may initially go undetected, in many cases, farmers recognize the problems impacting directly on a scheme. For example, farmers on irrigation schemes in Ghana are fully aware of many environmental problems (figure 1), but either because they lack resources or because small incremental changes can take a long time to significantly impact productivity, often nothing is done until it is too late. When the impacts threaten the livelihoods of the poor, and rehabilitation is not technically or economically viable, far from catalyzing poverty alleviation, food security and economic growth, irrigation may actually represent an economic and social liability (box 1).

Figure 1. Environmental problems reported on formal irrigation schemes in Ghana (presented as the percentage of farmers identifying the problem).



Total number of farmers interviewed = 388

Source: Kranjac-Berisavljevic and Cofie 2004.

²Examples include agricultural pests and weeds and the establishment of aquatic vegetation in the water storage, distribution and drainage systems.

Box 1. Examples of reduced productivity resulting from environmental impacts.

Kenya: The 350-hectare Gem-Rae smallholder rice scheme developed in 1985, ceased to function in 1997, because, following high El Niño rainfall, the clogging of the intake and main canal became a weekly event. As a result, farmers were clearing as much as 200 cubic meters (m³) of sediment each week at the expense of farming. After 1997, sediment-clearing ceased and the scheme is now largely abandoned; most of the irrigation infrastructure is clogged with sediment or overgrown with vegetation. Formerly well-demarcated rice fields were overgrown with weeds. Driven by hunger, now prevalent in the area, several farmers are attempting to clear small areas and use residual water to grow rice. Approximately 30 hectares are being used in this way, but yields are less than 0.5 t ha⁻¹ compared to 3.5 t ha⁻¹ obtained when the scheme functioned (Ong and Orego 2002).

Mozambique: At the Chokwe irrigation scheme it is estimated that some 4,000 to 5,000 hectares (out of approximately 30,000 ha) experience soil salinization to the point where rehabilitation is no longer possible. Furthermore, weed and silt accumulation in irrigation channels has created serious and costly problems in operation and maintenance (Sogreah and Hidrogest 1993).

Somalia: The Jowhar offstream reservoir commissioned in 1980 to collect flood flows on the Shabelle river in order to provide dry-season irrigation water is currently non-operational because of silting up of both the supply and outlet channels. This has contributed to the virtual collapse of large-scale irrigation schemes in southern Somalia (Houghton-Carr and Fry 2002). It is possible that this could have been foreseen and mitigation measures introduced if better environmental assessments had been undertaken.

Ghana: Aquatic weeds (i.e., *Pistia stratiotes*, *Vallisneria sp.*, *Nymphaea lotus*) growing in the drains are reducing the performance of the Lamboya irrigation scheme (Kranjac-Berisavljevic and Cofie 2004).

Health Impacts

Agricultural water development can adversely impact health through the extension of water-related vector-borne diseases (such as malaria, schistosomiasis, liver flukes, filariasis, onchocerciasis, dengue fever, yellow fever, Rift Valley fever and encephalitis) (Oomen et al. 1990). Recent reviews added to the understanding of the impacts of water resources development, specifically dams, on health (Jobin 1999) and particularly malaria (Keiser et al. 2005a).

A number of complex interlinked factors determine the severity of potential adverse impacts. For example, increasing mosquito-breeding habitats, especially in rice fields, does not necessarily result in increased prevalence of malaria or other mosquito-borne diseases such as lymphatic filariasis (Erlanger et al. 2005) and Japanese encephalitis (Keiser et al. 2005b). Case studies show that malaria transmission may increase, decrease or remain largely unchanged as a consequence of irrigation. In studies in Tanzania, lower malaria prevalence in villages with irrigation, compared to those without, has been attributed to a better socioeconomic status (Ijumba and Lindsay 2001). In West Africa, intensified rice cultivation in the semiarid savanna has led to an increase in *Anopheles* mosquitoes, but because mosquito abundance is high, it has created a demand for bednets, which farmers can afford through their improved income (Parent et al. 2002). Similar studies in Mwea, Kenya, have suggested that an improved socioeconomic status does not entirely

explain the relatively low malaria prevalence in irrigated villages, since poverty and social problems are rampant in both irrigated and non-irrigated villages. The most compelling explanation of low prevalence in the irrigated villages appears to be the tendency by the vector mosquitoes to feed more on cattle than on people (Mutero et al. 2004).

The prevalence of schistosomiasis in irrigated areas is governed by a range of complex and interacting factors that influence snail habitats, the disease transmission cycle and people's behavior (Boelee and Madsen 2006). A recent review of 35 data sets showed that large reservoirs increase the relative risk for schistosomiasis by a factor of 2.5, though for irrigation this was less clear (Steinmann et al. 2006).

Contrary to widespread belief, community-based and small-scale agricultural interventions also have environmental and health impacts (Konradsen et al. 2000; McCartney et al. 2004; Mutero et al. 2004). Currently, these impacts are usually disregarded and, in many instances, there is almost no knowledge of the cumulative environmental and health impacts arising as a consequence of up-scaling. For example, small earth dams are being widely promoted, particularly in Sahelian countries, for multiple uses of water including irrigation and livestock watering. In many places, the creation of small reservoirs has resulted in increased household income through productive agricultural activities upstream and downstream of the dam. However, the potential environmental (e.g., on hydrology) and health consequences (e.g., on malaria and schistosomiasis) are rarely considered and the impacts of many thousands of dams are unclear (Hunter et al. 1993). In Cameroon, the development of hundreds of small agro-pastoral dams has led to a rapid spread of schistosomiasis (Ripert and Raccurt 1987). Similar results have been reported from Côte d'Ivoire (Le Guen 2000; Cecchi n.d.), Ghana (Hunter 2003) and Burkina Faso (Poda and Traoré 2000; Poda et al. 2003; Boelee and Koné n.d.). In Ethiopia, the construction of small dams in the semiarid northern region of Tigray has led to increased spread of malaria. Seasonal transmission changed to year-round transmission because of the continuous availability of surface water, and children living near small dams had a 7-14 times higher risk of being infected than those living further away (Ghebreyesus et al. 1999). The main health-related costs to households relate to increases in time spent sick and not working, as well as time spent caring for the sick. Disease incidence has also led to reduction in labor allocation to off-farm activities and a decline in non-farm income share, thus adversely affecting the households' ability to cope with risk (Senzanje et al. 2002). Nonetheless, because agricultural yield and farm profit significantly increased in villages close to small dams, even after accounting for health costs, the marginal benefits of investment in water outweighed the costs (Ersado 2005).

As Africa's urban population rises another increasingly common practice is the use of varying combinations of domestic sewage, industrial effluent and storm water, for irrigation in urban and peri-urban environments. This use of wastewater is associated with environmental and health risks (Scott et al. 2004; Obuobie et al. 2006; Drechsel et al. 2006), such as salinization, eutrophication and pollution of soils and receiving drainage water with heavy metals and other toxic substances. A study in Dakar, Senegal showed that 60 percent of the farmers utilizing wastewater from irrigation were infected with intestinal parasites (i.e., roundworm, threadworm and whipworm) (Faruqui et al. 2004). Studies in Pakistan showed that farmers using wastewater for irrigation had a higher prevalence of infection with hookworm and other helminths than those who used conventional canal water (Feenstra et al. 2000; van der Hoek et al. 2002b). Both environmental and health risks of wastewater irrigation can be much reduced by mixing wastewater with freshwater (Ensink et al. 2002) and by the use of protective shoes and clothing. At the same time, wastewater can be an important water and nutrient resource that may bring about improvements in health by improving socioeconomic conditions of farmers and their families (Obuobie et al. 2006). For example, in Ghana,

irrigated urban and peri-urban vegetable farming using polluted water was found to generate incomes for farmers ranging from \$500-700 per year, depending on farm size, crop type and cropping intensity (Danso et al. 2002). In this instance, the primary benefit arose from farmers having access to water in the dry season, not from the fact that the water contained nutrients. Nonetheless, the income generated enabled some farmers to jump the poverty line (Danso et al. 2002), which usually benefits health.

CONCEPTUAL FRAMEWORK

The environmental and human health aspects of irrigation schemes are strongly linked because it is changes in the environment (in conjunction with socioeconomic change) that result in changes in the health of local populations (figure 2). Health impacts of agricultural water resources development can be both positive and negative (Lebel 2003).

Environmental and health impacts of agricultural water resources development are generally site-specific and are multiple, varied and complex. They depend on a range of factors such as the scale of water resources development, biophysical conditions, management, operation and actual use of water resources, and on the extent to which safeguards are introduced. Agricultural water development can improve health directly, through improvement in food security, and improved economic status may ensure greater purchasing power for drugs and health services (table 1).

Figure 2. Influence of agricultural water development on health. The different dimensions of environmental and social change mutually influence each other and are impacted in turn by health outcomes.

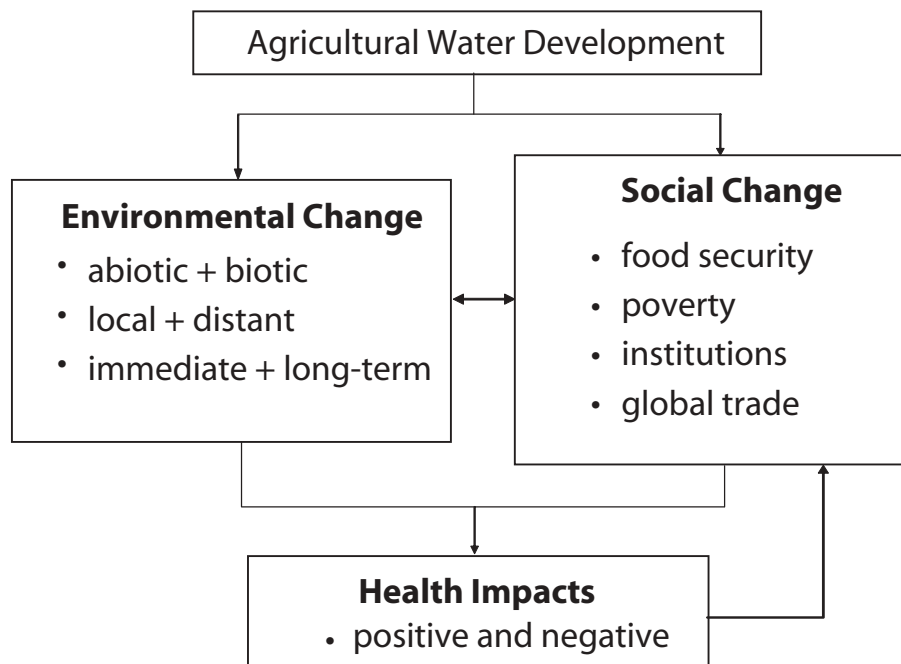


Table 1. Examples of positive and negative health impacts of agricultural water resources development.

Positive health impacts	
Direct	Indirect
<ul style="list-style-type: none"> • Improved food security, nutritional status • Improved economic status and access to health care • Improved domestic water supply, hygiene • More productive labor • Increased life expectancy 	<ul style="list-style-type: none"> • Empowerment of individuals and communities • Strengthening of institutions • Better lives
Negative health impacts	
Direct	Indirect
<ul style="list-style-type: none"> • Increase in vector-borne diseases • Contamination of water supplies by biological agents and toxic chemicals • Occupational exposure to toxic agrochemicals • Reduced labor productivity • Shorter life span 	<ul style="list-style-type: none"> • Loss of ecosystem functions and natural resources that benefit people • Social changes that introduce infectious and non-communicable diseases • Violent conflicts between agriculturalists and pastoralists, and between upstream and downstream communities

Direct positive impacts. People may gain access to more varied and higher-quality nutrition through increased income from cash crops, though this effect is not always very clear. Food security is recognized as being key to helping people fight HIV/AIDS-related infections. Research has shown that diets rich in protein, energy and nutrients help develop resistance to opportunistic infections in AIDS patients. Furthermore, people who have adequate food are less desperate and so improved food security may have a role in reducing prostitution-related transmission. Consequently, food security, enhanced through agricultural water development, can make an important contribution to alleviating the impacts of HIV/AIDS (FAO 2004b; Gillespie and Kadiyala 2005). Irrigated crops can also contribute valuable micronutrients. Even a single irrigated papaya tree per family could cater to all vitamin A needs and thereby prevent blindness. Other direct benefits accrue through the multiple uses of irrigation water by communities. Obvious health benefits of multiple uses occur when irrigation water is used for personal hygiene or when irrigation water recharges shallow wells for drinking (van der Hoek et al. 2002a; Shortt et al. 2003). Without adequate sanitation or when water quality is very poor, this same domestic use of water could create a health hazard (van der Hoek et al. 2001). Additional benefits are less obvious as often the multipurpose use of irrigation water is not formally recognized. However, these include the use of irrigation water for livestock watering, home gardens and small-scale local economic activities (Boelee and Laamrani 2004a; Peden et al. 2005; Molle and Renwick 2005). These benefits can be enhanced when facilities for multiple use of water have been incorporated in the planning and design of irrigation systems (van Koppen et al. 2006).

Indirect positive impacts. Through the empowerment of individuals and communities, and the strengthening of institutions associated with the implementation of agricultural water development, overall well-being can increase too (Birley 1995). If local agriculture or health institutions are strengthened, these will be better able to voice their opinion and influence planning processes. More often than not the direct and indirect benefits of irrigation reinforce each other and are especially visible when additional investments for (rural) development have been made (box 2).

Box 2. Examples of positive impacts of irrigation on health.

Zimbabwe: On average, farmers in the EU-funded Maunganidze groundwater irrigation scheme spend nearly 40 percent of their incremental income on food, shelter, water, sanitation (i.e., VIP latrines) and education of their children. All these measures are likely to improve people's health (Esrey et al. 1990). Certainly, the farmers themselves believe that the scheme has substantially improved their lives and in a recent survey stated that "what the EU did was very wonderful." Non-irrigators are also believed to enjoy positive health impacts through improved access to food (from wage labor and donations) (Peacock 2004).

Ghana: Studies of formal irrigation schemes have shown that irrigation has increased absolute incomes as well as food supply and nutrition. For example, average annual post-project farm income at Tono, Weija and Dawhenya irrigation projects was 3, 7 and 13 times higher, respectively, than the average annual farm income before the irrigation projects (Sam 1993). In a case study of irrigation schemes conducted for this study, health officials reported reduced cases of malnutrition (Kranjac-Berisavljevic and Cofie 2004).

Zanzibar: Less-poor households (average annual cash income of \$3,312) in an irrigation scheme on average spent 17 percent of their income on health compared to 9 percent spent by poor households (average annual cash income of \$698) (Shaaban et al. 2004). Although not all the difference in income is attributable to irrigation, this confirms that, at least in some circumstances, when households have higher income they spend a larger proportion on health care. However, it is not clear whether the higher expenditure on health care was also necessary because of the increased health risk associated with irrigation.

Direct negative impacts. Most of the health impacts reported in the previous section fall in this category. Some of the direct health impacts appear only after long periods of exposure and may have hidden implications such as reduced productivity. Moreover, while irrigation can add value to labor and increase its productivity, if this is not balanced by increased food intake and higher income, the final impact will be negative. In Côte d'Ivoire, women spent so much time on their new plots irrigated from a small dam that they had less time to spend on child care (De Plaen et al. 2004). In the previous section, many examples have been given of water-related diseases that increased with water resources development. Other effects are smaller-scale and less documented, but could be locally very significant, such as the impact of toxic cyanobacteria (Chorus and Bartram 1999).

Indirect negative impacts. Especially with large-scale construction works for irrigation systems and dams, migrant laborers may be hired who can bring pathogens and who can also contribute to sharp increases in sexually transmitted diseases. Accidents, alcohol abuse and stress related to crowding conditions have also been reported as indirect impacts of water resources development (Birley 1995). Livestock may either be displaced or attracted by new agricultural water facilities. The animals may bring with them various infections that can be pathogenic to people, such as fascioliasis (liver fluke) and cryptosporidiosis. The latter can be a life-threatening disease in immunocompromised people such as children, the elderly and those suffering from HIV/AIDS.

Overall impacts. Investments in irrigation are supposed to bring health benefits to all (although these are rarely specified at the planning stage), regardless of their socioeconomic standing within a community. In reality, the economic and social impacts of irrigation are diverse and widespread, and neither costs nor benefits are evenly distributed amongst community members. For example, farmers who own land may benefit directly from increased yields and some landless laborers may benefit from both on- and off-farm employment opportunities generated by irrigation. However, other disadvantaged people on site or downstream may suffer from negative health impacts without being able to improve their well-being. Positive health impacts do not cancel out the negative ones if they affect different groups of people (Boelee 1999). Internal factors such as genetics, immune status, health-seeking behavior and the socioeconomic situation will determine the final outcome for human health (De Plaen et al. 2004). Factors like these have to be included at the planning stage in order to avoid or mitigate negative environmental and health impacts and enhance benefits.

ENVIRONMENTAL AND HEALTH ASSESSMENT TOOLS

A principal cause of failure of irrigation schemes in the past was the fact that initial project selection and planning gave insufficient priority to the sustainability of development. The need to take environmental and health considerations into account as part of ensuring sustainable development is now widely recognized. For a project to be sustainable it is essential that environmental and health issues are considered in all phases of the project life cycle (Morardet et al. 2005).

The term “Environmental Assessment (EA)” covers a variety of tools including project-level Environmental Impact Assessments (EIAs), Strategic and Sectoral Environmental Assessments (SEAs), Health Impact Assessments (HIAs) and Environmental Audits and Appraisals (EAAs) (box 3). There is considerable diversity among donors and other institutions in their mandates and approaches to dealing with social issues (including health) in the EA. Most institutions routinely consider social impacts that are mediated by the environment, such as the health impacts of water pollution, and many also consider a range of physical/biological impacts on directly affected groups (e.g., displacement of, or adverse impacts on, local communities or vulnerable groups). Some agencies, through comprehensive Environmental and Social Impact Assessments (ESIAs) or through separate social assessments (SAs) identify adverse social impacts and promote other social goals such as social inclusion or poverty reduction.

Currently, the coverage of human health aspects within environmental and social assessments is usually inadequate (Birley et al. 1997). Public health agencies are often not involved or only marginally involved. Environmental Health Impact Assessments (EHIA) are generally underutilized as tools for health protection (Fehr 1999). Practical approaches to EHIA have been advocated by the World Health Organization and the Asian Development Bank. The WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM), jointly with the Danish Bilharziasis Laboratory, developed a training course on rapid health impact assessments, later further refined and disseminated by the Liverpool School of Tropical Medicine (Birley 1995; Furu et al. 1999; Bos et al. 2003). In addition, some good textbooks are available now (e.g., Kemm et al. 2004). However, for the most part, EHIA development has occurred in parallel, but is not integrated with EIA methodologies. There is a need for much better integration. A policy shift is required so that institutions promote EHIA rather than EIA (Amerasinghe and Boelee 2004). In addition, given the typically high degree of livestock interaction within irrigation schemes, it is important that environmental and health issues relating to livestock and pastoralists are explicitly considered (Peden et al. 2005).

Box 3. EA tools.

Environmental Impact Assessment (EIA) is a process for examining the environmental and human consequences, both beneficial and adverse, of a proposed development activity, and for incorporating appropriate measures to address them into project design and implementation. In many instances, EIA is defined broadly to include social dimensions such as health (e.g., Dougherty and Hall 1995). However, in some instances, where the situation warrants and greater emphasis is required, health impact assessments (HIAs), which are intended to focus on the health implications of a project, and/or social assessments (SAs), which are intended to analyze, manage and monitor both the intended and unintended social consequences of a development, may be conducted in addition to an EIA.

Strategic Environmental Assessment (SEA) is a process to assess the environmental and social implications of strategic decision making. SEA differs from EIA in that it is applied to policies, plans and programs rather than to projects. It addresses a number of shortcomings of EIA in that it is capable of addressing the cumulative impacts of projects (i.e., where one project stimulates other development); it can address synergistic impacts (i.e., where the impact of several projects exceeds the sum of the individual project impacts); and it can address global impacts such as biodiversity loss.

Environmental Management Plans (EMPs) are strategies for ongoing activities to avoid, mitigate or compensate for adverse impacts. They should include specific quantifiable aims and objectives and assign responsibilities and budgets for the environmental and social- (including health) impact management measures.

Environmental Audits and Appraisals (EAAs) determine the effectiveness of mitigation measures conducted and, where appropriate, propose remedial measures.

Many small-scale community and NGO development projects do not warrant full EA. For example, many community-driven development projects do not justify heavy investment in site-specific studies. In Zambia, several NGOs are promoting small-scale irrigation, using treadle pumps, in seasonal wetlands and the cost of full EIA is prohibitive in relation to the cost of individual projects. However, in such cases, consideration should be given to long-term impacts and the consequences of scaling-up activities. In such situations, SEAs conducted with the objective of identifying ways to maximize benefits and simultaneously mitigate potential adverse impacts that may arise from the whole program are often an appropriate tool, if undertaken by government or donor agencies. For individual projects, methods of rapid field assessment and checklists, such as that developed by the International Commission on Irrigation and Drainage (ICID) should be used to evaluate project-specific risks (Mock and Bolton 1993; Field and Collier 1998). Community involvement can also enable implementation of environmental and health impact assessment at the grass-root level, as was shown in three African countries (Spaling 2003).

For all agricultural water development projects, in addition to short-term measures to mitigate immediate negative impacts associated with establishing the project, there is a need for effective long-term, flexible (i.e., adaptive) management to deal with ongoing potential environmental and health impacts (Corvalán et al. 1999). If Environmental Management Plans (EMPs) are not implemented, mitigation measures may become ineffective as conditions change.

A prerequisite for adaptive management is long-term monitoring. However, in sub-Saharan Africa such monitoring is rarely undertaken in large formal schemes and is virtually nonexistent for small-scale and informal schemes. Furthermore, for the planning and management of all environmental and health impacts to improve, there must be analyses of the impacts that have occurred as a result of past activities. Often, the negative environmental and health impacts of agricultural water development projects are simply attributed to “irrigation.” However, for a balanced assessment of impacts a much broader and more rigorous evaluation is required that also recognizes indirect environmental and health hazards and benefits. To assess the “true” environmental and health consequences of a particular agricultural water development project, it is necessary to conduct comprehensive environmental and social audits to determine the causality of environmental and human impacts³ and the relative magnitude of impacts at the basin or regional level in comparison to alternative development scenarios.⁴

POLICIES AND THEIR IMPLEMENTATION

Coherent policies by governments and international agencies are critical if sustainable development is to be achieved. The integration of environmental and social considerations into the planning and operation of development projects is now a condition of funding from most donor agencies. Many international financing institutions (e.g., The World Bank, ADB and IFAD) as well as many bilateral donors (e.g., CIDA, Danida, DFID, GTZ and USAID) and international development agencies (e.g., FAO) have environmental policies that mainstream environmental issues at operational levels (Bos 1999). Commercial organizations (e.g., banks) are also increasingly environmentally aware (box 4).

In recent years, the World Bank has reviewed the effectiveness of its EA procedures. The lack of a definitive Environmental Management Plan (EMP) with time-bound actions and responsibilities, the absence of environmental monitoring indicators, a lack of reporting requirements for project performance indicators (including environmental and health indicators) and the absence of legal commitments by borrowers to undertake environmental actions were all reported as specific limitations for projects for which EA was not deemed to have been performed effectively (World Bank 1997).

A recent review of ADB projects (not limited to agricultural projects) concluded that there was considerable variation in the degree to which environmental considerations were taken into account for different projects. The review found that some projects were “under-classified” and proposed that some types of project should always be classified as category I projects (i.e., those for which most stringent EAs are required). This included dams, but irrigation schemes per se were not specifically included. The review also found that there were both considerable variations in the quality of EMPs and no after-construction monitoring of projects. The review recommended that social analyses should be improved (Intercontinental Consultants and Technocrats 2004).

³Specifically whether it is poor design and construction or poor operation and maintenance, rather than irrigation per se that result in negative impacts.

⁴For example, what would the impacts have been if there had been no irrigation development; perhaps in terms of more extensive rain-fed farming and possibly increased rural-urban migration.

Box 4. Policies of international agencies.

The World Bank policies and guidelines relating to the environment are published in the World Bank's operational manual (<http://wbln0018.worldbank.org/Institutional/Manuals/OpManual.nsf>). This contains both Operational Policies (OPs) that are mandatory policy and Bank Procedures (BPs) that are mandatory instructions for carrying out the policy. The World Bank Operational Policy 4.01 (one of a number of "safeguard policies") requires environmental assessment of all projects proposed for Bank financing, and Bank Procedure 4.01 contains details of how EAs should be conducted. The Bank requires environmental screening of all proposed projects to determine the appropriate extent and type of EA. Proposed projects are classified into one of four categories, depending on the type, location, sensitivity and scale of the project. On the basis of the World Bank classification, all agricultural water development projects (including rehabilitation of existing schemes) will be classified as A (i.e., likely to have significant adverse impacts that are sensitive, diverse or unprecedented) or B (i.e., potential adverse environmental impacts but few if any of them are irreversible and, in most cases, mitigation measures can be relatively easily designed). The size of the scheme, and the ecological sensitivity of the area in which the scheme is located, are key criteria determining into which class it falls. However, unlike some other sectors (e.g., mining) there are no sector-specific guidelines for EA of irrigation projects. The World Bank has also produced reviews of guidance on HIA with particular reference to infrastructural projects (Mercier 2003). This guidance includes the integration of health aspects in EA.

The ADB adopted an environmental policy in 1990 and Environmental Assessment guidelines in 1991. Environmental and Social Assessment procedures were released in 2001. In these, category I projects (i.e., likely to have a significant environmental impact) are required to undertake a full environmental and social impact assessment and also a full audit to ensure compliance. Category II projects (i.e., likely to have a lower environmental impact than category I) require full environmental and social management plans and must undergo a desk audit, but a full audit is not required.

IFAD has formal administrative procedures for environmental assessment that are comparable to those of the World Bank and ADB. All development projects are categorized according to their urgency and screened for potential adverse effects on the environment and local populations. In common with the World Bank and the ADB, the stringency of the EA varies depending on the potential harmful impacts of the proposed development. The IFAD operational statement (OS) 5.1 provides broad guidance on potential mitigation measures of negative impacts during the siting, design, construction and operation of irrigation schemes. Similarly, OS 6.1 and OS 8.1 include descriptions of the environmental issues and potential mitigation measures associated with development in rangelands and wetlands (IFAD 1994).

The FAO series of Irrigation and Drainage Papers cover a wide range of topics pertinent to environmental aspects of irrigation and, in particular, Paper No. 53, entitled "Environmental impact assessment of irrigation and drainage projects" (Dougherty and Hall 1995) is a useful compendium of environmental and social (including health) issues that should be considered in an environmental impact assessment.

The Equator Principles were adopted by a number of financial institutions (e.g., Barclays Bank of America, Credit Suisse Group, HSBC group, the Royal Bank of Scotland, WestLB AG, Westpac Banking Corporation and others) in April 2004. They are intended to serve as a common framework to manage environmental and social issues in the financing of projects with a total capital cost of \$50 million. The principles require EA to have been conducted and an Environmental Management Plan (EMP) to have been developed for all category A and category B projects (i.e., as defined by the World Bank) before loans are approved (<http://www.equator-principles.com/principles.shtml>).

Box 5. Examples of application of Environmental Assessment in selected countries.

South Africa: The National Environment Management Act (1998) requires environmental authorization for any development projects that may impact negatively on the environment, including diversions from rivers. Two “schedules” of activities are defined, based on the nature and associated risk of the activity. Those in schedule one (e.g., simple canals and channels within 32 m of a river or stream) are subject to only a Basic Assessment process, whilst those in schedule two (e.g. dams higher than 5 m) must conduct an EIA. It is a requirement that EIAs include public participation.

Zambia: The Environmental Protection and Pollution Control Act (1990) established the Environmental Council of Zambia (ECZ) as the institution responsible for the coordination of environmental management in Zambia. EIA regulations, developed in 1997, stipulate that a “project brief” must be presented to ECZ prior to the implementation of all development projects. On the basis of the project brief, ECZ determines if there is a need for an EIA. With respect to agriculture, an EIA is always required for “large-scale” land clearance and all irrigation projects of more than 50 hectares in extent. The ECZ is responsible for ensuring that any mitigation measures, derived through the EIA process, are implemented.

Tanzania: The National Environment Management Council (NEMC) is the institution responsible for enforcing the provisions of the Environmental Management Act of 2004. Part VI of the Act provides for EIA and makes provision for projects that will require EIA. All applicants for water use permits are required to make a statement on the likely impact on the environment of the use of the water requested. NEMC undertakes environmental enforcement, compliance, review and monitoring of environmental impact statements.

Ghana: The Environmental Protection Agency (EPA) Act of 1994 mandates the EPA to ensure compliance in planning and execution of all development activities with the EIA procedures in order to promote environmentally sound and sustainable development in Ghana. General EIA procedures were adopted in 1995 and specific sector guidelines for forest and wood industries as well as for environment were adopted in 1999. Specific guidelines for eight other sectors are currently under preparation. Environmental Assessment regulations adopted in 1999 provide for public participation at all stages of the EIA process. There is no specific legislation for SEA. However, the environmental assessment regulations cover plans and programs in its definition of undertakings to be subject to EIA.

Ethiopia: The Environmental Protection Authority (EPA) of Ethiopia, established by a proclamation of 1995, is the main administrative body for EIA in Ethiopia. The enabling legislation for EIA in the country is the EIA proclamation of 2002. EIA procedures and framework guidelines were finalized in 2000 and sectoral guidelines in nine sectors are at various stages of development. The EIA proclamation provides for public participation and also provides for SEA. However, procedures and guidelines on SEA are yet to be prepared.

Uganda: The National Environment Act of 1995 is the enabling legislation for EIA in the country. The Act established the National Environment Management Agency (NEMA) which is the main administrative body for EIA in Uganda. The Act also provides for the establishment of a Technical Committee on EIA to provide advisory services to NEMA on critical aspects of EIA implementation. NEMA prepared guidelines for EIA in 1997, and the EIA regulations were adopted in 1998. The regulations provide a detailed elaboration of the Act and present the details of the EIA process and the roles of various stakeholders. The National Environment Regulations of 2003 provide for a uniform system of certification and registration of EIA practitioners and set minimum standards and criteria for qualification as an EIA practitioner. The Act provides for public participation and it is a central policy of the Uganda EIA process that opportunity is provided for public involvement and participation. There are no formal requirements for SEA. *Source:* Adapted from Economic Commission for Africa (2005).

A limitation of current donor agencies' procedures for environmental assessment is that, although broadly similar in approach, they all differ in detail. Governments in sub-Saharan Africa cite differences in donor-operational policies as a major impediment to the effectiveness of external development assistance (Morardet et al. 2005). It is believed that consistent administrative, procedural and technical requirements for environmental assessments would strengthen institutional capacity to conduct effective EAs.

Many countries in sub-Saharan Africa have national policies, strategies (e.g., National Environment Action Plans) and legislation that stipulate the need for appropriate environmental planning and management, including EA, of projects (box 5). These policies usually apply to both public- and private-sector investment in irrigation. However, many countries lack the resources and capacity to enforce policies and to ensure that recommended guidelines are followed. Consequently, despite current national policies, EIAs for the most part are restricted to large construction projects and are largely donor-driven. For example, the Environmental Council of Zambia (ECZ), the lead institution for overseeing EIAs in Zambia, has a total staff of just 75. Furthermore, it receives an annual grant from the government, that is equivalent to \$210,000, but its annual running costs are estimated to be \$1.25 to 1.70 million (McCartney et al. 2004). Some of the difference is made up from fees collected for conducting EIA and fines imposed for noncompliance of environmental safeguards. However, the effectiveness of the institution and, hence, implementation of the government policy are severely curtailed by the inadequate budget and limited human resources.

ENVIRONMENTAL AND HEALTH SAFEGUARDS

Attributing an economic value to implementing environmental and health safeguards in development projects is extremely difficult. Some work has been done on translating the environmental impacts of development projects into monetary values (Dixon et al. 1994) and there is increasing consensus on approaches to value ecosystem goods and services (e.g., Emerton and Bos 2004). However, relatively little is known about the benefits of incorporating health safeguards in irrigation planning and operation versus the cost of not taking potential negative impacts into account. This is because although the costs are relatively easy to assess, the benefits are much more difficult to quantify. A comprehensive study for the World Health Organization shows that it is extremely difficult to evaluate the total health benefits of interventions because, by their very nature, such interventions have multiple benefits on different sectors (Hutton 2000). The "willingness to pay method" can help to determine the total benefits as perceived by the "users" and may provide a sound basis for investing in health interventions as part of a wider irrigation or rural development program. However, only a better understanding of the linkages between environmental and health impacts within irrigation schemes will enable comprehensive cost-benefit analyses.

Successful environmental and health management, in the context of agricultural water development, requires an integrated approach that deals with the entire scope of the relationships between people and the diverse range of environmental functions that affect both the productivity and the sustainability of an irrigation scheme (figure 2). A number of both technical and nontechnical interventions have been devised to minimize the undesirable, and maximize the beneficial, impacts

of water development schemes. For environmental protection, a hierarchy of three basic types of measure has been identified (Bergkamp et al. 2000):

- those that avoid anticipated adverse effects
- those that mitigate or reduce the undesirable effects that cannot be completely avoided
- those that compensate for effects that can neither be avoided nor sufficiently mitigated

In relation to health, the distinction between avoidance and mitigation is far less clear than it is with the environment, because most interventions seek to “prevent” negative impacts. However, a distinction can be made between those interventions that: (a) avoid health risks by lessening the contact between people and sources of diseases, and enhance health, for example by providing ample and safe water for drinking and other domestic purposes, and (b) mitigate health risks by killing vectors or removing their habitat. The former could also be termed avoidance measures and the latter mitigation measures.

Avoidance Measures

The best way to manage negative environmental impacts is to avoid them from the outset. The adoption of avoidance measures generally results in no change to the environment and has no impact on the existing functioning of a particular ecosystem. The most obvious option for avoiding the environmental impacts arising from an agricultural water development project is not to proceed with it. An effective way to avoid widespread adverse effects to the environment at the national or regional level is to initiate a development strategy that commits specified river basins to development while limiting development in other river basins, in effect “setting aside” certain basins for the purpose of environmental protection. By adopting a strategy whereby multiple water resources development projects, including those for agricultural water, are concentrated in some basins, the ecological resources located in the other basins may be protected. This is an approach adopted for hydropower development in Scandinavia (Bergkamp et al. 2000). Such a strategy may be of significant value in areas where biological diversity is high and, in sub-Saharan Africa, it could be used to identify regions where large-scale irrigation schemes are not permitted. However, careful consideration also needs to be given to other factors (e.g., density of rural populations, location of markets and suitability of geological, topographic and soil conditions, etc.) that influence the location of irrigation development. Furthermore, the possible consequences of people migrating from “undeveloped” to “developed” areas also need to be taken into account.

In relation to adverse health impacts, avoidance measures are also envisaged after scheme development. Reducing the contact between people and vectors of disease can also be effective in minimizing disease transmission if taken into account during the project planning and design phase. For example, the flight range of several mosquito and fly species is known and households can be located beyond this distance to reduce people’s exposure to vectors. However, often people move closer to the water once a scheme is completed. Other options include the use of bednets, insect screens on doors and windows and the spraying of homes with insecticides (WHO 1982). Furthermore, water-borne and water-washed diseases can be avoided by providing communities with good sanitation and alternatives to the irrigation canals for domestic supply (e.g., boreholes). By involving the health sector at the planning stage, options like these can be incorporated into the design and the project is more likely to achieve multiple benefits (Bos 1999).

At the Mushandike scheme in Zimbabwe, environmental control measures, comprising structures to avoid standing water and to ensure flow velocities are high enough to dislodge snails, in conjunction with the construction of boreholes for water supply, have been successful in controlling schistosomiasis. Studies show that snail hosts remain present but apparently in sufficiently low populations to substantially reduce the transmission potential. Ten years after implementation of the project an evaluation showed that schistosomiasis infection rates were lower in intervention villages than in a control area (Chimbari et al. 2001).

Often, the best way to avoid negative health impacts of vector-transmitted diseases is to develop the public health infrastructure. Development projects should budget for this and health infrastructure should be developed in parallel with irrigation infrastructure, rather than months or years later, as often happen currently. If the disease transmission cycle can be broken by treating migrants from disease-infested areas before they infect vectors or intermediate hosts this prevents infection of others or even the establishment of local transmission in a newly irrigated area. In the case of schistosomiasis, medication has played a big role in control programs since the development of the very effective drug Praziquantel. Such an approach requires considerable long-term and well-targeted involvement so that everybody, and not just the better-off, obtains timely and effective treatment.

Mitigation Measures

Mitigation measures are modifications to the design or operation of an agricultural water development project to reduce negative environmental and health impacts. Ideally, mitigation measures are identified through SEA, EIA, SA and HIA. However, present levels of understanding mean that very often some negative impacts are not foreseen prior to project implementation. Consequently, there should be a constant reevaluation of the need for mitigation measures throughout the life of a project. This requires monitoring so that measures can be introduced retrospectively when necessary. Monitoring enables health authorities to target resources and treatment interventions at times and locations of greatest need.

A wide range of technical mitigation measures to prevent environmental damage has been developed for formal irrigation schemes. Measures that promote high water-use efficiency also tend to mitigate negative environmental and health impacts. For example, good water management and drainage are prerequisites to preventing waterlogging, and hence potentially increased habitats for mosquitoes, as well as salt accumulation in soils.

Over the last 20 years, considerable progress has been made in the development of methods to determine environmental flows downstream of dams and abstractions for irrigation. Increasingly, these techniques are taking a holistic approach that explicitly includes assessment of the whole ecosystem (i.e., different invertebrates, animals and plants) and also predicts the impacts of different flow regimes on the livelihoods of people using river resources (Dyson et al. 2003). For example, Downstream Response to Imposed Flow Transformation (DRIFT) is a scenario-based environmental flow assessment process designed specifically for use in negotiations over water resources. It is designed to quantify the link between changing river conditions and the social and economic impacts for riparian people who rely on the river for their livelihoods (Brown and King 2000). Hydrology-based environmental flow assessment methods are being developed for use in areas where there are insufficient ecological data for full analyses (Smakhtin and Shilpakar 2005). Such approaches help define environmental targets and so facilitate the design of mitigation measures by specifying desired environmental conditions.

For mitigation of health risks, a wide range of options is available. WHO proposed the following broad classification in a report to the World Commission on Dams (WHO 1999):

- Appropriate health regulations and enforcement
- Modifications to project plans and operations
- Improved management and maintenance
- Supportive infrastructure such as domestic water supply
- Timely provision of accessible health care including diagnosis and treatment

Table 2. Measures to mitigate and avoid negative health impacts and enhance health benefits of irrigation.

Health issue	Target	Measures
Mosquito and snail breeding	Reduce stagnant and slow-flowing water	Repair leaking canals and bunds; drain or fill seepage pools, and burrow pits near agricultural fields; stock permanent ponds with fish; redesign hydraulic structures into free-draining ones; cement line canals; clear canals, structures and drains of vegetation and silt; avoid (night) storage reservoirs; promote rotational flows; use alternative irrigation techniques (sprinkler, drip).
Mosquito biting, transmission of vector-borne diseases	Reduce people-mosquito contact	Site villages away from (potential) breeding sites; screen houses; use bednets; stables for livestock; ensuring that health centers are equipped and functional before construction of the irrigation system and that health staff are available and trained in water-related diseases; treatment of in-migrating staff from high-transmission areas.
Schistosomiasis	Reduce water contact	Crossings for canals and drains; laundry and bathing sites; piped water supply; safe swimming pools for children; fences.
Contaminated water	Reduce pollution	Sewage system connected to drains, not canals; properly constructed and located latrines; health education; solid waste disposal system.
Zoonoses	Reduce animal fecal contamination of water	Separate animal troughs; protected crossings; fencing of water sources; buffer strips; alternative grazing areas; safe water supply; improved hygiene.
Hygiene	Increase access to water for all purposes*	Design for multiple uses include steps at canals; special laundry and bathing sites; health education; planning and construction of water supply and sanitation facilities simultaneous with the irrigation scheme.
Nutrition	Improve food intake	Allow free crop choice; educate on proper diet and food preparation.
General well-being	Increase socioeconomic status	Design for multiple uses, facilitate water use for other (productive) purposes such as livestock and pottery; provide support to farmers' by improving access to inputs and markets.
Introduction of diseases	Migrant workers	Systematically screen and treat newcomers for the most common infections; provide adequate living quarters and educate on sexually transmitted diseases.

*Provided there is no risk of schistosomiasis infection.

- Special disease-control operations
- Individual protective measures
- Redistribution of risk through insurance schemes

In relation to disease vectors, the primary approach is to design irrigation or pastoral water systems that do not provide habitats for vectors, combined with health education. Good design and construction of the canal and drainage system, as well as the correct laying out of fields, can ensure that water is fast-flowing and stagnant pools of water are avoided. Other options include direct vector control using either chemicals or biological methods. However, with chemical control, care is required in application to ensure that the vectors do not develop resistance. Physical removal of habitats, for example, through manual or mechanical cutting of weeds is also possible. Good cleaning and preventive maintenance of all infrastructures, including canals, cattle troughs, hydraulic structures and drains reduce the breeding of vectors and intermediate hosts, as well as improving irrigation performance. In several sub-Saharan African countries weed control in canals has been applied as an effective method of vector control. However, routine cleaning work can itself be a health hazard. In the Gezira scheme in Sudan, the canal cleaning personnel became the group most infected with schistosomiasis (Fenwick et al. 1982). In some places, attempts have been made to prevent this by adapting the time of cleaning activities to the cycle of the parasite or by providing alternative tools (Euroconsult 1993). A recent review of 40 largely pre-DDT interventions suggests that environmental modification can be a very effective malaria-control strategy (Keiser et al. 2005c).

Adapting water management to modify the vector habitat is another approach that has often been proposed in biomedical studies as an easy and cheap measure for vector control. However, there are very few examples where this type of environmental manipulation has been applied in practice (Matsuno et al. 1999; Laamrani and Boelee 2002; Boelee and Laamrani 2004b). This is because, in reality, it is neither simple nor cheap to change established water management patterns. Water management interacts not only with vector breeding or disease transmission, but also with the irrigation system itself. Changes to the water distribution often require modifications in the design, notably the sizing of canals and type of structures. For example, if continuous delivery is replaced by rotation of the water flow to disrupt breeding sites, the discharge in the canals alters from constant low flows to intermittent high flows, requiring larger canals. At the same time, the wider human environment is influenced. With water flowing in the canals continuously, farmers can use it to irrigate their crops whenever they want. With rotation, the flow has to be divided over time between users, demanding a higher level of organization. Water scheduling to meet crop water requirements is complicated, especially when conflicting interests between higher water use efficiencies and farmers demanding flexibility have to be taken into account. If disease control measures have to be observed as well, scheduling and management become very complicated (Boelee 1999). Adaptive water management in rice fields may result in reduced vector breeding and hence reduced transmission of Japanese encephalitis and malaria (van der Hoek et al. 2001; Keiser et al. 2005b). However, these studies mainly report from Asia. In an African context, with constraints on resources and capacity, it may be especially difficult to achieve the required water deliveries and level of water management (Mutero et al. 2000).

A summary of health mitigation and avoidance measures is presented in table 2. In reality, effective health interventions require an integrated approach that simultaneously implements avoidance and mitigation measures in collaboration between the water and health authorities.

Compensation Measures

Compensation can be viewed as a form of repayment for anticipated or realized negative environmental impacts that can neither be avoided nor mitigated to an acceptable level. Principal approaches include preservation of existing ecologically important areas and/or rehabilitation of previously disturbed land in the vicinity of irrigation schemes and dams. For example, after constructing the Gariiep and Vander kloof dams on the Orange River in South Africa, land acquired to accommodate flood levels was set aside for flora and fauna conservation. Five nature reserves, occupying a total of 56,000 hectares, were established. Jointly the five reserves provide economic benefit to the area through exploitation for recreation, including bird and game viewing, hunting and hiking (Skinner pers. comm.).

It is often stated that, through the provision of better and affordable food, irrigation improves nutrition and hence health (e.g., Hussain and Hanjra 2004). However, for sub-Saharan Africa there is little quantitative evidence to support this assumption. In a study in Ghana, health officials attributed improvements in health to irrigation, as a result of reduced malnutrition (Kranjac-Berisavljevic and Cofie 2004). Studies in Senegal showed that women cooperatives are able to apply and benefit from an integrated approach to irrigation and nutrition (Murray-Lee 1989). Conversely, a study in Kenya concluded that crowding and poor sanitation conditions in the new Mwea-Tebere rice irrigation scheme made the nutritional status of preschool children worse than outside the scheme (Mwadime et al. 1996). Overall, it is difficult to evaluate the extent to which improved nutrition, resulting from irrigation schemes, improves people's health. The degree to which an individual irrigation scheme "compensates" for negative health risks resulting from the scheme requires further research.

CONSTRAINTS TO SUCCESSFUL MANAGEMENT

In sub-Saharan Africa, as elsewhere in the world, people and governments generally understand that sustainability of systems requires the goals of socioeconomic development to be linked with those of ecological conservation. As a result, there is increasing recognition of the need to reduce the negative impact of development on ecosystems and people's health. However, approaches to reduce the negative impacts of water development schemes are successful in some circumstances but are not effective in others. Although a wide range of engineering and environmental control options have been developed to minimize the health hazards associated with irrigation, few have been widely applied in sub-Saharan Africa. Constraints to environmental and health management and the successful implementation of measures to ameliorate negative impacts, arise because of both technical reasons and limitations in human, financial and institutional capacity.

Failures of measures to ameliorate negative impacts often stem from a lack of sufficient information at the design stage in planning (Morardet et al. 2005). More often than not, thorough baseline information is not available for water resources development projects. Adverse environmental and health consequences often occur because schemes are planned and managed in isolation from other things occurring within the catchment. In many instances too little thought is given to the dynamics of catchment change and there is inadequate evaluation of the specific biophysical and socioeconomic context in which the scheme is located. Furthermore, available descriptions of effective avoidance and mitigation measures generally do not include the underlying assumptions or specifications that were used to design them. Without appropriate criteria and specifications for the design of measures, it is unusual for the measures to achieve the desired

Box 6. Factoring in HIV/AIDS.

It is widely acknowledged that in sub-Saharan Africa, the region of the world worst hit by HIV/AIDS, the epidemic has serious implications for agricultural productivity and food security (Dixon et al. 2002). However, while several studies have been done on the impact of HIV/AIDS on economic development, only a few considered the impact of HIV/AIDS on agricultural productivity and production. Most studies have focused on the impacts at the household and community levels and report on loss of labor, skills and, eventually, assets. Impacts of HIV/AIDS on irrigated agriculture and potential impacts of water resources development on transmission of HIV/AIDS are much less known.

In relation to irrigation development, an aspect of the pandemic that is of particular concern is through its impact on knowledge flows. The consequence of mortality on the transfer of knowledge from elders to youth is not clear and requires research. A recent study of the impact of HIV/AIDS in the Chokwe district of Mozambique concluded that HIV/AIDS was likely to accelerate loss of traditional knowledge, increase barriers to learning and increase dependence on outside interventions and handouts (Waterhouse et al. 2004). A study of HIV/AIDS in the Ministry of Agriculture in Malawi, found that “all occupational categories experienced excess mortality, with higher mortality rates among professional staff than among junior technical staff... death among Research Scientists and Agriculture Officers are (sic) double the average mortality rate in Malawi” (reported in Cohen 2002). Clearly such findings have important implications for the implementation of agricultural water development projects.

Many major donors have mainstreamed, or are in the process of mainstreaming, the implications of HIV/AIDS into their activities. For example, the IFAD strategy paper on HIV/AIDS for southern and eastern Africa advocates that predevelopment project assessments should include an analysis of the potential effects of HIV/AIDS on the proposed project (and vice versa). It also recommends that project logical frameworks include an analysis of vulnerability to HIV infection and the impact of AIDS with corresponding indicators and that, when appropriate, HIV/AIDS should feature among core project activities (IFAD 2004). However, many government agricultural ministries need to develop strategies to offset the ongoing and future loss of capacity.

goals. To develop the necessary criteria and specifications, sufficient information must be obtained. Very often, the environmental, ecological and socioeconomic monitoring required, for design both prior to the implementation of a scheme and afterwards to assess the effectiveness of protection measures, is inadequate. For example, in Ghana a data checklist sent to 22 irrigation schemes, provided limited information for just three schemes. This lack of data was attributed to poor data keeping and the fact that, for the majority of schemes, reviews of environmental and/or health impacts had never been undertaken (Kranjac-Berisavljevic and Cofie 2004). In relation to health, baseline information on the health and socioeconomic status of communities and, hence, their susceptibility to changes is often lacking (Fehr 1999).

To a large extent, the effectiveness of environmental and health management depends on the abilities of those people who plan and manage safeguard measures. In many parts of sub-Saharan Africa, the requisite professionals are unavailable or not proficient in the interdisciplinary working habits necessary for successful environmental and health planning and management. Furthermore, there is often a lack of coordination between relevant government departments. In a review of World Bank projects in Africa, the most frequently cited recommendation for corrective action for environmentally sensitive projects was improvement of capacity in responsible institutions (Green

and Raphael 2000). This lack of capacity is a constraint that, in the near future, will be exacerbated as a result of the HIV/AIDS epidemic (box 6). Training key mid-level managers in EHIA will make them aware of the various options for avoidance and mitigating measures. Moreover, if training courses are set up in the integrated way that is necessary for successful implementation of the impact assessments themselves, participants will meet with colleagues who can help them plan, develop, implement and monitor safeguard measures (Bos et al. 2003).

Another major limitation to formal EA procedures is that, often, there are no mechanisms to ensure adaptation in the design of the project. Usually, the people who demand the assessment are not the same as those who decide on changes in the project design or those who know whether or not the project will be carried out. There is little documentation of proposals and designs that have been adapted following environmental or health impact assessments. Very little is known about the proportion of assessments that lead to actual adaptations or implementation of mitigating measures. Donor agencies do not always provide funds to implement these measures, which are often seen as the responsibility of other sectors.

Most sub-Saharan African countries have neither the necessary framework to ensure legal compliance nor organized civil society to ensure that recommended environmental and health safeguards are implemented. In such situations, the contractual arrangement with the donor may be the major means for ensuring compliance. However, in the absence of a transparent accountable system this arrangement is rarely successful.

RECOMMENDATIONS

If water development is to make a significant contribution to realizing the potential of agriculture in sub-Saharan Africa, there is a need for much improved and integrated planning. Measures that promote sustainability by, among other things, capitalizing on the opportunities for enhancing human health should be at the core of agricultural water development. The key is to improve the decision-making process in such a way as to effectively bring development benefits, whilst simultaneously protecting the environment, local communities and the most vulnerable in society.

Planning and management of large-scale projects are necessarily different from those required for small-scale and community-based interventions. Existing donor and government procedures for environmental and health planning and management are most applicable to large-scale water development. The EA process, recommended by most donors and governments, is widely recognized as a useful instrument for identifying issues and developing plans to address them. However, within sub-Saharan Africa there are many constraints to the process, and subsequent follow-up is often weak. Furthermore, the process is inappropriate for many small-scale developments. Subjecting smallholder and community-led projects to full environmental and health assessment, and monitoring, although justifiable, is often neither economically feasible nor practical.

The following recommendations are a pragmatic attempt to address current limitations in environmental and health planning and management pertaining to agricultural water development. Focused on what governments and donors can do to improve planning and management of water

⁵The suggested value of 20 hectares is arbitrary but intended to make recommendations operationalizable. Governments could decide on a more appropriate figure, based on the specific agro-ecological conditions and development needs of their country.

resources for agriculture in a way that is not harmful to the environment and enhances human health, the recommendations are divided into three categories:

- strategic planning at national and regional level
- agricultural water development projects for which full environmental and health assessment should be mandatory (i.e., all government- and donor-funded projects, whatever their size, plus all other projects involved in commercial agricultural production and larger than 20 ha in extent⁵)
- agricultural water development projects that bypass current procedures and for which it is unrealistic to expect full environmental and health assessment to be conducted (i.e., private-community- and NGO-organized projects smaller than 20 ha in extent⁵)

Strategic Planning at National and Regional Level

The following recommendations are intended to improve assessment procedures throughout sub-Saharan Africa and potentially elsewhere too.

1. Implement strategic environmental assessment at regional and national level

Strategic environmental assessments (SEAs) can be used as a planning tool for agricultural water development at national level and for major international river basins (e.g., Zambezi, Limpopo, Volta). SEAs are most valuable if they integrate environmental, health and social concerns and attempt to reconcile development, environmental protection, community rights and human health. An important aspect of SEAs is to reduce uncertainties regarding potential agricultural water development by, for example, defining river reaches where agricultural water development is allowed and, conversely those reaches where it is not. Regional and national development goals, as well as issues such as climate change and loss of biodiversity, and commitments to international conventions (e.g., the Convention on Biological Diversity) ought to be considered. Improved structures like this at the national level, taking the whole approach to impact assessments much more seriously, will also facilitate the implementation of project alternatives and inclusion of safeguard measures.

2. Improve and promote EHIA

Currently, health impact assessments are often conducted in isolation from environmental assessments. It is mutually beneficial if they are integrated, since much of the information to be collected on environmental receptivity and community vulnerability is the same for both. However, political support may be required so that institutions promote EHIA rather than EIA and HIA separately. Including the long-term perspective will strengthen this approach. Certain impacts are only visible several years after the construction of a project and would benefit from adequate safeguard measures, or alternatively at least the provision to cater to them, supported by good monitoring practices. Where necessary, EHIA should specifically include the issues of migrants and livestock that have hitherto tended to receive very little attention.

3. Improve regional capacity for environmental and health assessment

All countries without compulsory environmental and health assessment processes should consider enacting laws that make these mandatory for large infrastructural projects, including large irrigation projects. In many countries, strengthened institutional arrangements would assist in the implementation of environmental and health assessment processes. For example, establishing environmental units within government ministries responsible for irrigation could be contemplated. The effectiveness of such units would be enhanced if they work closely with national environment agencies and appropriate health authorities, and would increase the likelihood of suggested measures being implemented. It could help make the health sector more proactive and less reactive to agricultural development. Capacity building measures that improve information-sharing throughout the region (e.g., through the establishment of data warehouses) and include the training of engineers and other professionals to incorporate environmental and health safeguards in irrigation projects, are critical to mitigate the attrition of skilled staff as a consequence of HIV/AIDS.

4. Adopt harmonized environmental and health procedures

The ability of governments to implement sound environmental and health practices would be improved if donor agencies harmonized procedures and developed a consistent framework for the evaluation, planning and management of environmental and health aspects of agricultural water development. Coherent EHIA instruments need to be developed for local use and promoted. Procedural requirements should conform to current international best practices and be clearly laid down in regulations and operational manuals. They ought to include realistic, but mandatory, deadlines (throughout the process) to limit uncertainty and unreasonable delays for all stakeholders.

5. Conduct regionally specific research

More research is needed on the benefits of incorporating environmental and health safeguards in irrigation planning and operation versus the cost of not taking potential negative impacts into account. This includes theoretical comparisons of no-project alternatives. Another researchable issue stems from the lack of monitoring, both for water resources development projects and in the health sector. With baseline data not available, proxies need to be developed to provide alternative ways to the same information. Furthermore, specific tools need to be developed to facilitate assessment of long-term health and environmental impacts. For example, for chronic diseases, with long-term effects on human health and well-being, long-term cohort studies are required that are not feasible within the context of individual EHIA.

Agricultural Water Projects for Which Full Environmental and Health Assessment Should Be Mandatory

The following recommendations are intended to improve environmental and health planning and management in all government- and donor-funded projects (whatever their size) plus all other projects that are involved in commercial production and are larger than 20 hectares in extent.

6. Implement a comprehensive options assessment

Comprehensive options assessments, undertaken during the scoping of irrigation projects, provide a means, early in the planning process, to eliminate unacceptable projects or project components. Comprehensive environmental and social audits can help determine the causality of environmental and human impacts and the relative magnitude of impacts at the basin or regional level, which can then be compared to alternative development scenarios. It is essential that environmental, health and social criteria, as well as technical, economic and financial factors are considered when comparing alternatives. Such assessments should: (a) be driven by a needs assessment that reflects local, national and regional goals, (b) include the full range of alternatives relevant to the articulated needs, including structural and nonstructural alternatives and conventional and nonconventional options, (c) be participatory, involving among others, intended beneficiaries, potentially affected communities and currently disadvantaged groups, as well as representatives of interested stakeholders at the strategic planning and policy levels, and (d) be time-bound and result in documented decisions.

7. Identify and quantify intended livelihood and health benefits

The environmental and health impacts of irrigation are diverse. As with any development process, trade-offs between social, environmental and economic goals are inevitable. As far as possible, these trade-offs need to be identified and made explicit. Often, it is assumed that, by improving food security and/or people's socioeconomic status, water development will inevitably result in health benefits and improved livelihoods. However, the intended livelihood and health benefits are rarely made explicit, and in reality, neither costs nor benefits are evenly distributed amongst stakeholders. Environmental and health assessments, as well as management plans, need to take into account the socioeconomic diversity of communities and ensure that the weakest and most vulnerable are not adversely affected. All assessment teams ought to include health specialists and the potential health risks to different sectors of communities should be identified. To facilitate project evaluation and adaptive management, the intended health and livelihood benefits of any agricultural water development project need to be identified and stated at the outset in a way that is unequivocal and measurable. Using an integrated holistic approach, avoiding and mitigating measures, as well as accompanying infrastructure such as health posts, can be included in the design. Indicators and means of verification should be clearly stated in the logical framework of any project.

8. Plan and manage using a catchment-wide perspective

Given the interlinkages between impacts and what occurs elsewhere in the catchment it is essential that projects are planned and managed within the specific socioeconomic and biophysical context in which they are located, according to the principles of Integrated Water Resources Management. Consideration must be given to potential environmental impacts on, as well as impacts caused by,

⁶Trust funds have been suggested as a possible mechanism for financing the mitigation of the environmental impacts caused by large dams (Bizer 2000). A project-specific trust could be established at the outset of a project (by the project financier) with the condition that funds are used specifically for environmental and health management, including monitoring. The approach could incorporate annual contributions from the scheme owners/beneficiaries as well as other organizations (e.g., governments or donors), with the environment and health program funded from the proceeds of the trust.

the development. Donors and governments can insist that project planning gives specific attention to the needs of communities both upstream and downstream of the project, including pastoralists. Assessments of impacts on the catchment water balance and sediment fluxes, including evaluation of possible future development (particularly relating to land-use change) are essential. The potential cumulative effect of small-scale interventions has to be specifically included in the assessments.

9. Improve data generation and analysis related to environmental and health impacts

A major constraint to the sustainability of agricultural water development is the lack of site-specific data and long-term monitoring; a prerequisite for informed decision making. For this reason, measures to significantly improve data generation and analysis related to environmental and health impacts should be encouraged (e.g., coordination of existing data collection efforts between sectors and/or establishment of meta-databases). Ideally, monitoring strategies would be mandatory in all projects, and governments and donors must provide adequate funding to enable this. Mechanisms for evaluating the effectiveness of safeguard measures should be presented in the logical frameworks of projects and assessed against verifiable indicators.

10. Develop innovative ways for financing environmental and health measures

The cost of effective environmental and health measures is often very high and must usually be borne by the organization responsible for the water development. The most common mechanism for financing these measures is to incorporate the costs into the capital financial package of the project. The costs that are most readily incorporated into the capital costs are those that occur once (e.g., construction of fish ladders in dams). Financing ongoing obligations, such as environmental and health monitoring, is more difficult. Whilst it is sometimes appropriate for beneficiaries to cover these, in many cases it is not. For this reason, donors and governments ought to investigate innovative ways of financing recurring costs, such as trust funds.⁶ As a starting point, donor agencies could fund a comprehensive review of options for financing environmental and health measures. Governments can also set up or enhance the existing legal mechanisms to deal with noncompliance and resolve conflicts.

11. Develop innovative approaches to ensure compliance with environmental and health requirements

Incorporating environmental protection and health measures into irrigation projects is made difficult by the failure of many project operators to fulfill voluntary and mandatory obligations and the failure of civil society and governments to enforce compliance. Improving compliance requires incentives as well as sanctions. Innovative approaches to encourage compliance ought to be investigated. Options could include: (a) the use of performance bonds, supported by financial guarantees and expressed in well-being-related outcomes and not just agricultural yields and water use efficiency, (b) implementation of a sector-specific environmental management system, perhaps constructed around that developed by the International Standards Organization (ISO), and (c) development of an ethical code for large-scale irrigation projects to ensure that environmental and health concerns are adequately addressed. As a first step, donors could fund a study to evaluate the potential effectiveness of different alternatives for encouraging compliance.

Agricultural Water Projects for Which It Is Impractical to Conduct a Full Environmental and Health Assessment

The following recommendations are intended to improve consideration of environmental and health planning and management in agricultural water projects, which currently bypass procedures and for which it is unrealistic to expect full environmental and health assessments to be conducted (i.e., private-, community- and NGO-organized projects smaller than 20 ha in extent).

12. Increase local-level awareness of environmental and health issues

With the intention of encouraging self-regulating and self-enforcing incentives for improved environmental and health management, governments and donor agencies ought to develop strategic approaches that build local-level awareness of the environmental and health issues associated with agricultural water development. Specifically, they should support campaigns of health awareness carried out by community health teams and training programs that, in collaboration with community groups (e.g., farmer associations, agricultural water user associations, water committees and women groups), increase awareness of potential environmental hazards and approaches to mitigation. Information on practical ways to maximize health benefits should be provided, as well as outlining potential hazards and approaches to ameliorate potential negative impacts, whenever these are available.

13. Develop “user-friendly” methods of rapid appraisal for evaluating small-scale projects

Donor- and government-funded programs that promote small-scale development (e.g., the community-driven development program of the World Bank) should conduct program-specific environmental and social (including health) assessments. These would assess the potential impacts of the micro-projects to be financed under the program, and the possible cumulative impacts of scaling-up. They will set the context for lower-level assessments and, based on the priorities for attention, simple checklists, similar to those of ICID, can then be developed to evaluate the impacts for individual micro-projects. These checklists have to be designed, made readily available and promoted in such a way that they can be easily utilized by small local organizations and communities in their development interventions.

14. Ensure programs that promote small-scale agricultural water development projects are embedded within rural development programs

Governments and donors should ensure that programs promoting small-scale agricultural water development are undertaken in conjunction with broader rural development programs that include water and sanitation, as well as health components. Care must be taken that these projects are designed so that the main beneficiaries are clearly identified and the objective of improving livelihoods through agricultural water development remains the primary focus.

CONCLUSION

Untimely availability of water is one of the key constraints to agricultural production in many parts of sub-Saharan Africa. Agricultural water development that improves food security and reduces poverty can translate into health benefits. People, who are well-fed, and sufficiently well-off to access health-care services, tend to be healthier, and their overall well-being increases. However, with a few exceptions, irrigation schemes have a poor track record in the region. There are a large number of reasons for this, but failure to plan and manage adverse environmental and health impacts is key amongst them. In many instances, it is the poorest and most vulnerable in society who suffer most when irrigation schemes fail. The need to move towards more sustainable agriculture is a key message of the World Water Development Report (United Nations 2006). This paper has made a case for better planning and management of the environmental and health impacts associated with agricultural water development. Addressing environmental and health impacts are crucial for the sustainability of future projects. The recommendations presented above focus on ways to improve the policies and practices pertaining to impact assessment and planning for both large and small developments. To be effective the recommendations require a coordinated effort and long-term commitment from both governments and donors. If implemented they will contribute to better awareness of the linkages between environmental and health impacts and improve the sustainability of agricultural water development in sub-Saharan Africa.

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