Assessing the impact of irrigation development on the environment and human health

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Introduction. Irrigated agriculture has been the backbone of increased food production and improved quality of life for millions over the past 50 years. However, irrigated agricultural development also has had negative environmental impacts, and there is, today, an increasing trend to make it accountable for its impacts on the environment, as well as to improve its environmental performance so as to ensure long term sustainability (Stockle 2001). "Environment" in the broad context irrigation development also includes the factors that affect public health, and there is now increased awareness of, and willingness to remedy, adverse human health impacts that may result from irrigation development.

Environmental and Human Health Impacts. Modern irrigated agricultural development impacts on the environment and on human health through changes in landscape ecology, as water is provided to pre-existing natural resource areas (be they desert, grassland or forest) that are now modified to make way for crops and livestock. Both qualitative and quantitative changes related to aspects such as infrastructure development (dams, reservoirs, canals, drainage ditches), human settlement, crops, livestock, agrochemicals, and mechanization are manifested in this process. Some of the typical environmental issues surrounding irrigated agricultural development include human resettlement; watershed degradation; encroachment of unique ecosystems and historical /cultural sites; biodiversity loss/change (including wildlife and fishery resources); proliferation of invertebrate and vertebrate pests and disease carriers; soil erosion; soil fertility; sedimentation; surface water hydrology (quantity, quality); groundwater hydrology (level, quantity, quality); seepage; waterlogging; and eutrophication.

This diverse array of environmental impacts can be classified as derived from:

- *The physical construction of irrigation systems.* This involves issues such as human resettlement; watershed degradation; encroachment of unique ecosystems and historical and cultural sites; biodiversity loss and change (including wildlife and fishery resources); proliferation of invertebrate and vertebrate pests and disease carriers; soil erosion and sedimentation).
- *The management of irrigation systems*. This depends on the nature of the water source (surface or ground water or both), quality of the water, and its delivery to the irrigated land. The withdrawal of ground water can lead to land subsidence, salinization, and increased pollution by other chemical contaminants. Withdrawal of surface water leads to changes in river hydrology (e.g., water quantity, flow regime and quality) that can affect these and other associated aquatic ecosystems. Water delivery to the irrigated land and agricultural run-off can lead to soil erosion, impacts on aquifers, waterlogging, and salinization of soil and water.

- *Agricultural management practices*. These may contribute to the pollution of groundwater and downstream surface water through inputs of salts, agrochemicals, and toxic leachates.

Water resources development has major impacts on human health. Positive health impacts arise from higher incomes, better diet and nutrition, and improved assess to health case systems, all of which can translate to better overall health status. Foremost among the negative impacts are illnesses resulting from water-related diseases. Generally, four groups of water-associated diseases are distinguished based on their method of transmission (Cairncross & Feachem 1993):

- Water-borne or faecal-orally transmitted diseases, such as cholera, typhoid and diarrhoea;
- Water-washed diseases, such as louse-borne infections and infectious eye and skin diseases;
- Water-based diseases with an intermediate host living in water, such as guinea worm and schistosomiasis;
- Water-related insect-borne parasitic diseases such as malaria, river blindness, and filariasis.

Water-washed diseases may be reduced dramatically in irrigation systems as better water availability, regardless of quality, enhances personal hygiene practices especially in arid and semi-arid regions. The use of irrigation water for cooking and consumption, despite its often questionable quality, may even diminish hygiene-related diarrhoeal diseases, as water quantity is believed to be more important than quality (Van der Hoek *et al.* 2002). Unfortunately, water-related diseases transmitted through vectors or intermediate hosts sometimes increase with irrigation development. In Ethiopia, for instance, the construction of small dams in Tigray has led to increased spread of malaria, even at higher altitudes (Ghebreyesus *et al.* 1999).

In order to prevent adverse impacts of water resources development projects on the environment and on human health, impact assessments can be done before implementation of the project to estimate the risk of negative impacts and identify mitigation measures. Many donors officially require that such assessments are carried out before funding is approved. Unfortunately, the same donors not always make funds available for the implementation of mitigating measures or for the monitoring of impacts. Hardly any project proposal has been rejected because of the impacts on environmental or health (Biswas 1994). As a result, predicted negative impacts often do happen and the opportunity is missed to enhance positive benefits of the project for health and the environment. The World Bank, for instance, now attempts to change this trend and has set up a project to address malaria through infrastructure projects (Anonymous 1999, Listorti 2002).

Environmental and Health Impact Assessment.

Some of the definitions of Environmental Impact Assessment (EIA) are:

"An environmental impact assessment determines the potential or actual impact(s) of an activity on the environment." (www.wra-ja.org/glossary/)

"The assessment of the environmental impacts likely to arise from a major action (i.e. legislation, a policy, a programme or project) significantly affecting the environment." (www.soton.ac.uk/~engenvir/glossary.htm)

"An evaluation designed to identify and predict the impact of an action or a project on the environment and human health and well-being. Can include risk assessment as a component, along with economic and land use assessment." (www.gdrc.org/uem/waste/swm-glossary.html)

The last definition includes human health and wellbeing within the scope of environmental impact, but in general, the coverage of human health aspects in EIA assessments is usually inadequate and public health agencies often uninvolved 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, among others. It is a fact, however, that for the most part Health Impact Assessment (HIA) development has occurred in parallel but not integrated with, EIA methodological approaches. HIA has built on the understanding that human health and wellbeing relate to economic, environmental, social, psychological and constitutional (e.g., age, sex and genetic constitution) influences. All but the last are likely to be influenced by irrigation development (Birley 1995).

UNEP (2003) promotes EIA to identify environmental and social impacts of a project prior to decision-making, i.e., as a prospective tool. The purpose is to predict environmental impacts at an early stage in project planning and design, find ways to reduce adverse impacts, mould projects to suit local conditions, and present options to decision-makers. Both environmental and economic benefits purportedly can be achieved by using EIA, for instance, reduced costs and project design and implementation time, avoided treatment/clean-up costs, and impacts of laws and regulations. However, EIA also can be used as a retrospective tool, to identify and sometimes quantify impacts after implementation. Ideally, EIA should examine environmental implications during all project phases under both normal conditions and defined worst-case scenarios, and should assess the overall environmental risks associated with the project.

Key elements of EIA are:

- *Scoping,* to identify key issues and concerns of interested parties;
- *Screening*, decide whether an EIA is required based on information collected;
- *Identifying and evaluating project alternatives*, by listing alternative sites and techniques and the impacts of each;
- *Mitigating measures,* reviewing the proposed actions to prevent or minimise the potential adverse effects of the project.

The environmental parameters to be evaluated may include biophysical, social and economic parameters. Major categories within a broad environmental checklist would include Air, Water, Geology, Soils, Natural vegetation, Wildlife and fisheries resources, Heritage resources, Land use on adjoining property, Community conditions with the potential to be affected by the environmental aspects of the project (Govt. of Saskatchewan 2000).

The types of baseline data and procedures used in their collection are generally parameter-, site- and project-specific. The quality and quantity of data on a particular parameter should be proportional to the anticipated degree of impact on that parameter. All existing information should be collected, and there will often be a need to collect additional data for certain parameters. Information often exists simply as an inventory of available data, but it is desirable that data be collected and analyzed using methodologies that yield results of a quality and level of detail that will be of practical use in predicting and evaluating impacts, so as to form a good basis for post-EIA studies. Additional baseline information needs to be collected where there are data gaps on key parameters. Importantly, the extent to which data gaps bias the impact assessment need to be evaluated and limitations placed on the reliability of predictions.

There are many methodologies for EIA. *Checklists* (e.g., World Bank [1991]; ICID [Mock and Bolton 1993]) are the simplest method to identify impacts but do not provide a measure for rating different project alternatives. The more advanced *Scaling Checklists* (e.g., Dee et al. 1973) do allow the relative rating of each impact, and are thus useful to compare "project vs. no-project" options or different project alternatives options. *Interaction Matrices* (e.g., the Leopold Matrix [Leopold et al. 1971], allow rating and weighting of impacts, and so can assist in decision making, but are complex and often do not provide guidance to objectively assigning impact scores, and thus the overall results can be biased. *Networks and System Diagrams* techniques attempt to link main impacts with subsequent indirect impacts, and often include mitigation measures in the planning stages of projects, but are complex and expensive to use. The *Overlay Mapping* technique using GIS allows modeling and analysis of environmental impacts and interactions spatially and temporally, and is a powerful tool, albeit complicated to use because of its hardware, software and training requirements. At the highest level of complexity are *specially designed tools* such as EIAxpert[1], and EIADSS[2] that combine several of the previous tools and integrate GIS, simulation modeling, expert systems and multi-criterion evaluation techniques in one package (Abu-Zeid et al. 1999).

In relation to water resources development projects, Health Impact Assessment (HIA) may be prospective, concurrent or retrospective. In order for it to be effective, it is best carried out as integral part of the project's feasibility study (Konradsen et al. 1997), though input on health aspects in all stages of the planning process are required if health safeguards are to be included into irrigation projects (Tiffen 1991). The HIA framework, too, consists of several steps that parallel those of EIA: Screening (should HIA be done?), Scoping (how best to do it), Appraisal (identifying/examining the best available evidence) and Formulating Recommendations (Taylor and Blair-Stevens 2002). These may be followed by further engagement with decision-makers on the implementation of recommendations, and monitoring and evaluation of the HIA process, impact and outcome. Details of the HIA methodological process are provided in works such as Scott-Samuel et al. (2001), and Taylor and Blair-Stevens (2002). A detailed framework and methodologies to assess specific health indicators is available from the World Health Organization (WHO 1999). Rapid HIA strategies for short duration assessments also are available (e.g., Adams 1983; Scrimshaw and Gleason 1992; Harris 2002), as well as specific approaches for irrigation (Tiffen 1991) and water resources development (Birley 1991).

The basic steps of implementing EIA and HIA are similar, but EIA by its very nature tends to focus to a greater extent on biophysical parameter monitoring than HIA, which tends to focus

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[1] EIAxpert: rule-based screening-level EIA. Environmental Software & Services. (www.ess.co.at/EIA)
[2] Center for Environment and Development for the Arab Region and Europe – Environment Impact Assessment Decision Support System. (www.dams.org/kbase/submissions/showsub.php?rec=opt081)

more on people and community profiling. EIA and HIA need to be considered as important tools in efforts to protect the two aspects of paramount importance in irrigation development: long term agricultural sustainability and stakeholder health.

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