Nile Basin Capacity Building Network 'NBCBN'

Environmental Aspects of River Engineering Research Cluster

GROUP II

BEST EIA PRACTICES AND GUIDELINES
EIA GUIDELINES AND SUPPORT TOOLS

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EXECUTIVE SUMMARY

This report was compiled as a result of research work undertake by a team of professionals from a total of five Nile Basin countries; Uganda, Sudan, Egypt, Kenya, and Rwanda under the NBCBN_RE Uganda Research Cluster, during a period July 2003-June 2004. The Uganda research cluster was inaugurated in June 2003, and assigned a research theme "Environmental Aspects of River Engineering". The research theme was further subdivided into two groups: 1) EIA Processes (procedures, legal and institutional aspects); and 2) Best EIA Practices, Methodologies and Guidelines.

This report "Best EIA Practices and Guidelines" is a product of Group 2 which is aimed at improving EIA process for River Engineering projects through critical review of EIA practices in the Nile Basin countries, development of tools of analysis and Unified Guidelines for the Nile Basin. The major concerns were lack of suitable tools in EIA practice to objectively and scientifically quantify environmental quality parameters.

The objectives of the research are:

- To enhance the best practices in Integrated Water Resources Management in the Nile Basin through improving the EIA process
- To contribute to the knowledge base in River Engineering
- To build capacity of human resources in the Nilotic Countries

Research was carried out through; literature review, data collection, review of country experiences as well as international guidelines, review of existing tools as well as development of tools. From the critical review of the EIA practices in the Nile Basin countries and Literature the following were realized.

- The EIA process for the five NB countries all follow the same EIA process involving four major steps(Screening, scoping, EI Study, and EI Review), though Egypt has sectoral EIA guidelines in addition to the steps above.
- The EIA Guidelines of the NB countries do not adequately address the practical methods of assessing the impact at every stage of the EIA process and as such leave a lot of discretion to the developer.
- Professionals in the Nile Basin region carry out EIA using subjective and adhoc methods. There is no evidence of analytical tools used to scientifically and objectively evaluate environmental impacts from the implemented projects.
- The tools currently used to quantify environmental impacts still use a high level of subjectivity in normalizing and weighting environmental quality parameters
- The present tools can adequately be used for screening and scoping. These two stages can be facilitated by use of computer software like DR. EIA.

Efforts were made to address the above problems, and the results were:

- A unified EIA process, addressing all the weaknesses in the Nile Basin EIA process was proposed with a concept of its integration in the NB EIA practice.
- Mathematical models or equations describing bio-geophysical processes can be developed to enable assessors to objective quantify the environmental parameters. The development of such models is ongoing are and preliminary results are given in this report. This research focused on analytical and empirical formulations.
- Converting the environmental quality parameters into comparable units can be done through economic evaluation of the impacts.
- The existing tools, used to assign significance to impacts have been improved through use of Boolean method based on cross impact Analysis.
- The EIA process has been elaborated to ensure that all relevant steps are included to ensure a comprehensive analysis and yield of un-disputable results.

It was noted though that environmental processes are so complex that the development of mathematical models is a hard task that has to be done. For parameters that can not be expressed mathematically, economic values should be assigned or may be evaluated subjectively. Nevertheless, the overall objective of this research is to minimize the subjective and judgmental assessment of environment and must be pursued.

It was concluded that;

- The Nile Basin EIA Country Guidelines need revision in order to upgrade current EIA practice in the Nile Basin, and DR.EIA as a support tool needs to be introduced as a basis for EIA integration in the Nile Basin.
- Comprehensive EIA requires scientific and objective evaluations to be carried using analytical tools.
- Cost Benefit analysis remains a vital component of environmental analysis
- The current initiatives should be promoted to improve on EIA process
- Practicing professionals require training is environmental aspects of EIA.

The following recommendations are proposed;

- Continuation of the development of tools of analysis
- Development of Unified EIA Guidelines for Nile Basin countries that address above mentioned weaknesses in the EIA process.
- Improvement for current initiatives like DR. EIA to facilitate a uniform process of screening and scoping in EIA practice in the Nile Basin.
- Conduct refresher trainings for professionals in the Nile Basin countries
- Develop Data Bases for monitoring and evaluation of environment in the Nile Basin countries

Future activities will be based on the above recommendations.

TABLE OF CONTENTS

ACRONYMS

EIA	Environmental Impact Assessment
EIR	Environmental Impact Review
EIS	Environmental Impact Statement
EI Study	Environmental Impact Study
EU	European Union
FAO	Food Agricultural Organization
GIS	Geographical Information System
IEM	Integrated Environment Management
IWRM	Integrated Water Resources Management
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
NBCBN-RE	Nile Basin Capacity Building Network-for River Engineering
SA	South Africa
TOR	Terms of Reference

1 INTRODUCTION

1.1 GENERAL

This report has been prepared by a team of professionals as a result of the ongoing research work on the Environmental Impact Assessment Practices in the Nile Basin countries to address the emerging concerns regarding water resources management in relation to river engineering projects in a regional context. The Uganda Research Cluster was assigned a research topic "Environmental aspects of River Engineering" assigned under the Nile Basin Capacity Building Network for River (NBCBN-RE)

1.2 BACKGROUND

At the 1st Regional Workshop organized by Makerere University, Uganda and Nile Basin Capacity Building Network for River Engineering (NBCBN-RE), held during the period 16-18 June 2003, at Hotel Africana, Kampala, the Uganda Country Node for the Regional Research Cluster was launched.

NBCBN-RE is a project aimed at establishment of a Network for capacity building in River Engineering within the broader scope of Capacity Building Network for Integrated Water Resources Management (IWRM) for the Nile Basin. The Network is linked to UNESCO's Friend Nile program and CAPNET and has four components through which it will address its mission of capacity building; Education and training, Research, Provision of information and Coordination.

Funding is obtained from; Fellowship fund, Node strengthening fund, Staff development fund, Staff exchange fund and Research fund.

NBCBN-RE is focusing on strengthening the human resources development capacity and research capacity in a specific field of IWRM, namely River Engineering.
A total of five research clusters have been launched in different countries, each with a specialized research topic as follows; River Morphology (Sudan), Hydropower (Tanzania), River Structures (Ethiopia), GIS and Modeling (Egypt), and Environmental Aspects of River Engineering (Uganda). Therefore, the Uganda Node was assigned to carry out research work under the field of "Environmental Aspects of River Engineering".

1.3 PROBLEM STATEMENT

Countries pay varying attention to the environment, resulting in significant disparity in the Environmental Impact Assessment guidelines used at regional level. On the other hand, there are several International EIA guidelines applied to different projects depending on the source of funding or project implementing agency.
Arising out of this scenario is:

- Lack of unified and appropriate EIA guidelines to objectively assess the impacts of water development projects in the Nile Basin
- Lack of suitable tools for EIA to objectively and scientifically quantify the environmental quality parameters.

The presence of a wide range of professionals in the water sector with relevant expertise together with the enormous amount of information available on environment will provide an opportunity to comprehensively study and develop solutions to address the problems.

1.4 OBJECTIVES

The main objectives of this research activity are;

- To enhance the best practices in Integrated Water Resources Management in the Nile Basin through improving the EIA process
- To contribute to the knowledge base in River Engineering
- To build capacity of human resources in the Nilotic Countries

1.5 SIGNIFICANCE

This output of this research work will contribute tremendously towards building and strengthening capacity in the Nile riparian countries for an environmentally sound development and management of the River Nile Basin. The outcome of this research will enhance Regional Corporation in River Engineering projects and probably reduce regional conflicts related to management of shared waters.

1.6 SCOPE OF WORK

1.6.1 EIA Guidelines:

- Critical Review of Sectoral EIA Guidelines in the Nile Basin countries.
- Critical Review of EIA guidelines elaborated out by International Organizations in the field of interest.
- Identifying main sectoral projects of interest in the NB countries.
- Elaboration of tentative proposal for EIA guidelines.

1.6.2 Development of EIA Tools;

- Critical assessment of EIA studies conducted in the NB countries; lessons learned, achievements and gaps.
- Elaboration of a set of sectoral checklist based on review of and integration of existing guidelines in the region and those of the international organizations.
- Elaboration of support tools for quantifying the impacts (use of environmental quality parameters as indicators of impact).
- Development of a DSS for weighting/scaling system for application of EIA.

1.6.3 Proposed Activities for the second phase:

- Improvement of DR EIA software based on the output of the first phase.

1.6.4 Approach and Methodology

The method adopted will include the following tasks;

- Literature review
  - Data Collection
  - Data Analysis
- Compiling Country Report
- Critical review of sectoral EIA guidelines
  - Final review and analysis
  - Preparation of Final Report

The detailed methodology is given in the research proposal a copy of which is in Annex 1 for reference.

2 METHODOLOGY

2.1 GENERAL APPROACH

The research is aimed at providing improved and unified EIA Guidelines and Tools for EIA for use in the Nile Basin.

The work was divided into two major elements; *review of the EIA Guidelines and Development of EIA Tools,* which allows a wide spectrum of professionals with various expertise to effectively contribute to the activity. Participants from various countries in the Nile Basin; Uganda, Sudan, Eritrea, Egypt, and Rwanda, have already confirmed their participation. This will accelerate the collection/acquisition, analysis of information and experiences from individual countries in areas relevant to the study. Delays which may arise out of having many participants working at a distance shall be minimized by improved communication methods and motivation.

Each participating country will be required to select and engage a minimum of two professionals in this exercise to ensure prompt and effective execution of the tasks assigned. One of the two said persons shall be identified and work as a lead person and hence a focal point for all communications unless otherwise he delegates to the other. The two professionals in a given country will collect data/information, make consultations with relevant agencies and authorities, analyze data and prepare reports for forwarding to the research coordinator in Uganda.

2.2 DETAILED METHODOLOGY

2.2.1 Main Tasks

The method to be adopted will include the following tasks;

- Literature review
    - Data Collection
    - Data Analysis
- Compiling Country Report
- Critical review of sectoral EIA guidelines
    - Final review and analysis
    - Preparation of Final Report

Literature Review

Each country research team will review literature related to environmental impact assessment for water resources development projects (WRDP) in their countries. The major focus will be on guidelines, procedures, methods of evaluation, for Environmental Impact Assessments, not forgetting the Environmental Laws and Regulations in the Nilotic countries. This will reveal a stock of information, experiences and documentation available in the Nile Basin and will form the knowledge base upon which our research activities will build on. Summary of the findings will form part of the country reports.

a) Data Collection

Each country research team will collect available data which will include but not limited to:

- List all water sector projects executed and proposed in the country, including; achievements, lessons learned, gaps, proposed future actions, and any relevant information.
- Collect documents related to environmental impact assessment (local and international guidelines on EIA, including study reports for various projects).
- Use questionnaires as well as interviews to collect information on the guidelines, procedures, methods of evaluation used in EIA in each country. The target sources of this information will be the Consulting firms and Environmental Agencies.

b) Data analysis

Each country research team will read the documents collected, internalize and come up with the following;

- A summary of deficiencies and disparities if any, between the local and EIA guidelines.
- List of environmental parameters recommended and used
- List of methods of evaluation recommended and used
- List of special environmental factors (Social, Biological, Physical) that may need special attention at country level
- All references used must be quoted

c) Compile Country Report

- Compile a country report on all the above findings which may be discussed with the Environmental Authorities at country level.
- The draft country report will then be forwarded to the research coordinator Uganda Node.

Critical Review of Sectoral EIA Guidelines

a) Final Review and Analysis

The coordination unit will use the information provided in the country reports to execute their tasks, which are grouped into two;

i) EIA Guidelines:

  - Study and analyze the country reports to identify the significant gaps, conflicts in guidelines for EIA.
  - Compare guidelines from the NB countries with the international guidelines.
  - Identify solutions to peculiar/special environmental problems in various countries.
  - Develop a proposal for the "Unified EIA Guidelines for the Nile Basin".

ii) Development of EIA Tools:

  - Develop a set of sectoral checklist based on the analysis of existing local and international guidelines as well as addressing issues of integration.
  - Develop a comprehensive list of environmental quality parameters (EQP) for the projects of interest in the Nile Basin.
  - Develop scientific functions for each EQP; i.e. Models describing the physical environmental parameter and the effects of the project on the parameter. In the past this has been done through mere weighting and qualitative/judgmental form of evaluating the significance. The basis of this idea is that all physical processes can be defined by deterministic/stochastic models or functions. At present value is lost by using judgmental methods to evaluate physical processes, hence a major part of the EIA process carries no value. If the parameters are defined by mathematical models, then simulation of various scenarios can be effected and hence the effects of any proposed project on the environment can be studied easily and decisions taken.
  - Define an appropriate environmental impact unit (EIU) which has the same unit of measure to allow effective comparison of EQP's.
  - Develop a transformation function to transform the changes in EQP into EIU
  - Develop a Decision Support System (DSS) for application in EIA.

b) Preparation of Final Report

A final report will be prepared by the coordination unit and submitted to NBI for approval. The key researchers will bring together their reports , which will then be integrated into one final report by the coordination unit. Prior to submission to NBI, the draft report will be discussed by a seven-member panel consisting of five researchers and two advisors from IHE-UNESCO.

2.2.2 Means of Verification

The new EQP functions and DSS developed will be tested by applying them on successfully executed projects in various NB countries and comparing with the results of the EIA's of such projects.
If any significant deviation is observed during verification, it will be dealt with separately.

3 EIA GUIDELINES

3.1 EIA PROCESS

3.1.1 Background

An EIA may be defined as a formal process to predict the environmental consequences of human development activities and to plan appropriate measures to eliminate or reduce adverse effects and to augment positive effects. EIA thus has three main functions:

- to predict problems,
- to find ways to avoid them, and
- to enhance positive effects.

Environmental Impact Assessment is a relatively new concept aimed at assessing the overall impact of a proposed development project on the environment and enhance sound environmental management practices. EIA arose from the numerous concerns about the increasing negative effects of development projects which lead to significant environmental degradation.

The concept was fully developed by the late 60's; however, implementation of EIA process took root in early 1970, in the developed countries, mainly in; United States of America and Europe. Environmental Policies were formulated and Laws were enacted for purposes of implementation of environmental procedures, regulation and control. While the concept remains the same all over the world, there are differences in EIA procedures from place to place due to the differing political and institutional frameworks in various countries.

In the Nile Basin countries, EIA process has been carried since mid-eighties, on mainly large projects funded by Foreign Funding agencies like; World Bank, European Union, USAID etc. Nevertheless, various countries formulated environmental policies and enacted environmental laws with the assistance from the funding agencies. The acts promulgated in various Nile Basin countries are;

- Egypt: Environment Protection, Law No.4, of 1994,
- Uganda: Environmental Management Act in 1995,
- Sudan: Environmental Management Act in 1998,
- Kenya: Environmental Management and Coordination Act in 1999,
- Rwanda: Environmental Management Act in 2004.

These laws are implemented through the Environment Regulations and procedures established in each country. Compliance to the procedures varies from country to country depending on the attitude, legal and institutional frameworks, political will and competence of the private sector (mainly the Consultants/Environmental assessors).

There is critical danger in some areas that rather than becoming an accepted part of the planning process, EIA will remain an optional technique to be applied when political expediency dictates.
More positively, however, it is necessary to distinguish between the degree of implementation of formal EIA procedures and the extent to which various elements of environmental assessment are becoming integrated with the planning process in a less formal way. It has been noticed in some countries like Sudan, where EIA is carried out when the project implementation has already started, thereby reducing the EIA process to stock taking exercise.

This is mainly due to the attitude, lack of awareness and political support. Improvement in the process starts by creating public awareness, strengthening professionalism through the use of environmental expertise in the assessment of environmental factors, and in the environmental content of planning reports. Positive results have been registered among successful projects where negative impacts have been mitigated. The EIA must nevertheless receive some credit for having acted as a catalyst for improvements in environmental management.

Both directly and indirectly, the introduction of EIA procedures has helped improve the consideration of environmental factors in decision-making and the flow of information to and from the public. But the question remains as to whether EIA, at least in its present form, is accurate enough to achieve these ends.

The experience to date indicates the desire to develop improved procedures more closely integrated with the planning process and more objective and scientific assessments to reduce the excessive reliance on the current subjective and judgmental approaches, to enhance quick, accurate and un-disputable decision-making.

Strengthening the legal and institutional frameworks would enhance the compliance during the implementation of EIA procedures for improved environmental management.

3.1.2 Uganda

In Uganda, the responsibility to oversee, coordinate and supervise the operation of the EIA process is charged with the **National Environmental Management Authority (NEMA).** The basic EIA process in Uganda consists of three major stages: Screening, Environmental Impact Study, and Decision Making. The EIA itself is coordinated by NEMA, in conjunction the responsible Lead Agency (like a ministerial department under which the project falls).

The **Screening stage** has the objective of determining what level of EIA is required for a developmental project, whether a project has or does not have significant impacts. To be able to do this, a checklist is provided that categories which kind of EIA is required for the project.

If the project is found to have significant impacts on the Environment, the Guideline recommends an EI Study to be carried out and an EI Statement be written for the project. Though before the study is done, **Scoping** procedure has to be carried out to identify the major Environmental Impacts to be studied. To carry out scoping the Guideline, leaves the responsibility to the discretion of the developer though monitors their operations, though a checklist is provided that can be used.

In carrying out the **EI Study**, the relevant data collected from Scoping is used, and the EIA team is supposed to go and collect data to address this data. The EIA team is expected to quantify the significant impacts and weigh them against a Threshold value to address the level of destruction of the impact. Though, no method is entailed in the Guideline to aid developers carry out this task.

After the EI Study, an **EI Statement** is written by the EIA team and submitted to NEMA for review, and the review is done in the next stage of the process. Under the Review Stage, the Environmental findings are reviewed in order to make a decision on Environmental Status of the project.

If the project is approved, developer is given a go-ahead notice in form of a **"certificate of approval"** and gives him the permission to go ahead and implement the project. During implementation stage,

3.1.3 Kenya

In Kenya, like Uganda the Environment matters are coordinated National Environmental Management Authority (NEMA). The EIA process in Kenya consists of four stages namely: Project Report, EIA study, Environmental Auditing, and Environmental Monitoring

During the **Project Report Stage**, Screening of the project is actually done, as done in Uganda. And if the project is found to have significant Environmental Impacts as shown the Project brief submitted to NEMA, an EI Study is recommended.

The EI study commends with the **Scoping** exercise, where the objective is to decide on focus the EIA team on what exactly what kind of work is required. This done by first identifying the major EIA concerns, briefing the EIA team on what kind of work is required, determine the assessment methods needed, and provide an opportunity for public involvement, and lastly establish the TOR's for the EI Study. With the TOR's the EI Study carried out.

During the **Decision Making Stage**, the NEMA reviews the Environmental findings, as well as the level of consultation of all stakeholders, then communicate the approval decision to the proponent, whether an approval or a disapproval of the project. Then the project can be implemented if approved.

In Kenya, its law for an **Environmental Audit** to be done on an on-going project at least annually to establish the accuracy of the Environmental Prediction and mitigation. And an organ in NEMA is assigned this task to make sure that all on-going projects are audited.

3.1.4 Egypt

In Egypt Environmental Affairs are managed by the **Egyptian Environmental Affairs Agency (EEAA).** It has the responsibility of supervising the EIA process in Egypt. The report from Egypt did not contain the EIA guidelines. Though from the report provided, it was able to see that the two major stages: **Screening** and then the **EI Study**.

In the screening stage, the project is examined to find where under which category of projects it lies. Projects in Egypt are grouped into; White list projects (projects with minor environmental impacts), Grey list (projects which may result in substantial environmental impacts), and Black List(projects for which a complete EIA must be carried out due to the magnitude and nature of their potential impacts).

For Grey list projects, EEAA may require a “scoped EIA” whose scope is specified by EEAA on the basis of information presented by the developer.

For the Black list of projects, the guidelines are subdivided depending on the nature of the project, that is, A(guidance for Grey List projects), B(guidance for wastewater treatment works), C(guidelines for ports and Harbors), D(guidelines for industrial zones), D(guidelines for Tourist Activities)

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Though, no more could be concluded about the EIA process.

3.1.5 Sudan

In Sudan, the autonomy for Environmental protection is owned by the Higher Council for Environment, this Council requires any project to undergo an EIA, and this is to be done by the Consultant.

Though, the Country Report from Sudan did not highlight the actual EIA guidelines as they are practiced in the country.

3.1.6 Rwanda

The Government of Rwanda has just realized the significance of the Environment Impact Assessment, with the inception of the Rwanda Environmental Management Authority just in January 2004. Though, EIA started to be practiced in 2002with no proper procedures. The EIA procedure involves five main stages: Screening, Scoping, and Preparation of the EIA report, EIA review and project appraisal, project Implementation.

In the screening stage, the aim is to decide the nature and extent of EIA to be carried out. This is done by determining the nature and magnitude of the proposed project potential environmental Impact, then categorize the project in either category A, B or C, depending on the level of EIA required for the project.

The scoping stage, is undertaken to identify the key Environmental Issues and thereafter determine develop the terms of reference for the EI study

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In the Preparing of the EI Statement, a format is given of the information required to be included in the EI Statement.

In the review stage, the review the EI statement is done to find whether satisfactory information has been presented in the EI Statement for a decision to be made about the project.

In the implementation stage, the project is implemented according to the conclusions derived form the EIA process. And the lead agency (the bank) supervises the implementation of the Environmental aspects of the project.

3.2 THE EIA PROCESS OF NON – NILE RIPARIAN COUNTRIES OR INTERNATIONAL ORGANIZATIONS

As basis for comparison, the EIA Guidelines of other countries outside the Nile Basin, an some International Organizations were looked at. The choice of the guidelines depended really on access of the guidelines. The guidelines looked at involved: the EU guidelines, EIA guidelines for South Africa, and the FAO EIA guidelines for Irrigation and Drainage projects. In addition to that, DR.EIA software program was also analyzed to find here it can be applied in EIA process of the Nile Basin Countries.

3.2.1 The European Union EIA Guidelines

These guidelines came about after an EU Directive of 1997, and are written to be practiced in the whole EU region. The EU published four detailed and concise documents entailing the current required EIA practice in June 2001. Each of these documents describes a specific stage in the EIA process. The EIA process is in four stages: **Screening, Scoping, EI Study and EIS Review**.

The screening stage is there to determine whether a project requires EIA or not. This document provides a step by step practical guidance on how to undertake screening. In addition to that, the document goes ahead to describe the screening tools to be used perform an EIA screening test on a project.

In the scoping stage, the content and extent of matters to be covered in the environmental information are covered. This document also goes ahead to provide guidance on scoping procedures and methods. In addition to that the document describes the kind of information and outputs to be looked out for from the project during the scoping stage.

For the EI study stage, the EU guidelines instead give a detailed document on the methods and tools of assessment of Environment Impacts. It goes ahead to give the pros and cons of every method, and under what circumstances the method or tool can be applied. In addition, gives what kind of information each kind of method can provide. It concludes by giving a general approach to an EI Study.

In the EI S Review Stage, the Guideline provides guidance on how to establish whether the EI Statement submitted, is adequate for the decision on development or not. It provides practical guidance on how the review should be carried out. It provides a checklist to be used as a tool for guiding on the adequacy of the EI Statement.

3.2.2 The EIA Guidelines of South Africa (Integrated Environmental Management)

In South Africa, the Council for Environment is entrusted with the responsibility ensuring at all developmental projects undergo an EIA (common known as IEM) assessment. These guidelines consist of three stages: Stage 1- Plan and Assess Proposal, Stage 2-Decision, and Stage 3-Implementation

In Stage 1, the IEM directs the developer on how to write a planning proposal for a developmental project, to address all the environmental concerns before any work is done. Then the developer on writing the proposal, the IEM makes a decision on what kind of impact assessment the project needs (whether Impact Assessment, initial assessment or no formal assessment)

If the project needs Impact Assessment, it has to undergo three principal components and these include: Scoping – to determine the extent of and approach of impact investigation; Investigation – this is done guided by the scoping decisions and is intended to provide enough information on the positive and negative impacts of the project; Report - this requires that the environmental findings should be reported in report form whose format is described in the Guideline. In addition, IEM gives an explanation of the methods or tools for impact evaluation.

In Stage 2, the report is reviewed of its environmental findings to make sure it meets the requirements, so as to enable a decision to be made about the Environmental Stability of the Project.

In Stage 3, on approval an Environmental Contract is drawn between the Council and the developer to protect the allegiance of the developer to the Environmental Plan drawn up, then the developer goes ahead to implement the project. After implementation, a monitoring program is drawn up stating what is to be done, when and who is to do it. Then Environmental Audits are also planned for, to be carried out on the project. These are done to assess the efficiency and adequacy of the whole IEM process.

3.2.3 The FAO EIA Guidelines (for Irrigation and Drainage Projects)

The Food and Agricultural Organization wrote a textbook about the Environment situation of Irrigation and Drainage projects. In this textbook, FAO went ahead to describe and recommend an EIA process that should be used and applied in its projects. The main steps of the EIA process include: Screening, Scoping, Prediction and Mitigation, Management and Monitoring, Audit.

In the screening stage, the project is supposed to be categorized, and this results in a decision on the whether the project requires a full EIA or not to be carried out. This decision may be made by size (of land, flow of water to be diverted or capital expenditure) or site specific information. Though, it stipulates that the screening process is country specific depending on the laws and norms of the country.

In the scoping stage, the most critical environmental issues to study are determined. This is taken to be the most important stage of the entire EIA process. The main output of the scoping study will be the TOR's of the EI Study. The main techniques in carrying out scoping include; baseline studies, Checklists, Matrices, and Network Diagrams.

During the Detailed Prediction and Mitigation studies stage, the TOR's from the scoping stage are used, and this stage is carried out in parallel with feasibility studies. This stage forms the central part of the EIA process. It involves quantifying the environmental impacts and there after proposing mitigation measures for them. And all these impacts should be compared to the "without project" scenario. The main output of this stage is an EI Statement. The major techniques to applied include mathematical modeling, Expert Advice (especially with experts familiar with the locality), Checklists, Matrices, Network Diagrams, Graphical representations and overlays. After the impacts have been quantified, they can be compared by applying weightings to them or using economic cost-benefit analysis or a combination of the two.

The EI Statement from step above also provides a detailed plan for managing and monitoring of the environmental impacts both ring and after implementation, this is known the Environmental Action Plan or Environmental Management Plan. It sets out the mitigation measures needed for environmental management, both in short and long term, plus the Institutional requirements for implementation. A clear definition should be made to which agencies are responsible for data collection, collation, interpretation and implementation of management measures. The guidelines goes ahead to give the weak areas of concern for monitoring, and emphasizes the use of satellite imagery as a technique for monitoring.

The Audit stage is carried out sometime after implementation of the project, it is provided to serve as a feedback and learning function for the EIA process. It is to be done by a separate of team of specialists. It should include an analysis of the technical, procedural and decision-making aspects of the EIA. It includes an analysis of the Baseline studies, accuracy of predictions, and the suitability of mitigation measures. Also the procedural aspects of the EIA process should be included, that is, the efficiency of the procedure, the fairness of the public involvement measures and degree of coordination of roles and responsibilities. Plus decision making aspects like utility of the process for decision making and implications of the development.

3.3 DR.EIA AND THE EIA PROCESS

DR.EIA is a computerized project assessment support tool used to compose useful and credible TOR's instructions for EIA's of Projects. It is a **support tool** to **screening** and **scoping** of small or large middle-sized projects. Though very large and complicated projects like Hydropower and irrigation dams need a category of DR.EIA of their own.

Though, since its inception in 1997, EIA process has under gone a lot of changes and as such the DR.EIA program has also gone through transitions towards a communication tool in support of the EIA process in general. DR.EIA is designed to assist to structure and clarify decision-making on projects and programs between all parties (proponents, consultants, component authorities, and the general public) involved in the process.

DR.EIA, though, was designed to support project managers involved in decision making of EIA of projects, so as to make quality based decisions.

In context, DR.EIA was designed with the objective of enhancing EIA policies in development projects. As such the program has modules built in to support: determining the EIA requirements of planned development projects (screening), establishing the potentially affected environmental, social and economic impacts(scoping), identification of the potentially affected(groups of) people(context analysis),development of alternative approaches, finding relevant information on the EIA procedures and potential impacts, and finally the production of the formatted outputs of screening reports, scoping report and draft TOR's.

The structure of the program consists of five major routines that communicate with each other through standardized procedures (this approach emphasizes flexibility). It consists of a core part that actually executes the routines and procedures of the program and of an external database that contains data and information to be used with the core program. This allows new parts like sector modules or country modules to be built in within the software development effort without affecting the working of the program as whole.

It should be noted that the outputs of DR.EIA are only preliminary and need to be subjected to an actual EIA study in the following phase.

Under the screening, the program selects of the projects proposed which need further environmental consideration, to eliminate those unlikely to have harmful environmental impacts, and to indicate the level of environmental appraisal that a project will require. The screening criteria to be used can be selected from a set of screening criteria installed in the program (like the World Bank, ADB, a country's legislation etc).

Under scoping, the program has a general list of sector related activities (provided the sector module) that allow the user to define the activities related to the proposed project. After this, the user has to indicate the landscape types where the activities will be carried out. With this information, DR.EIA produces a list of potential bio-physical changes for each activity, followed by a listing of potential bio-physical impacts per landscape type, and finally a list of indirect or social impacts that result form the bio-physical changes.

In the analysis of the alternatives, the program uses a stepwise approach to assist the use in properly defining the context in which the project has to operate. Though this module of the program is rather limited in scope and structure, and can be further developed in both concept and structure.

3.4 ENVIRONMENTAL IMPACT EVALUATION TOOLS

There are a number of techniques that an environmental assessor may use to collect and analyze data with an aim of guiding the decision-making process. It is well known that environmental impact assessment is only three decades old, hence the development and use of tools of analysis is also as young. The most common techniques use are;

- Field surveys
- Monitoring
- Modeling
- Guidelines from authorities
- Literature searches
- Workshop
- Specialist interviews
- Public opinion polls

It is desirable to select and use a method of analysis that is:

- selective and comprehensive; that covers a full range of important elements in detail,
- mutually exclusive; that will avoid double accounting of impacts
- interactive and integrated ; covering all aspects of environmental systems in boarder terms
- Objective; to avoid inconsistence, controversies and disagreements. Objective assessments require scientific and numerical evaluations to reduce on areas of disagreements.

During the EIA process a combination of techniques are used, or that approaches are adopted at different stages of the project. Examples of both categories are set out below:

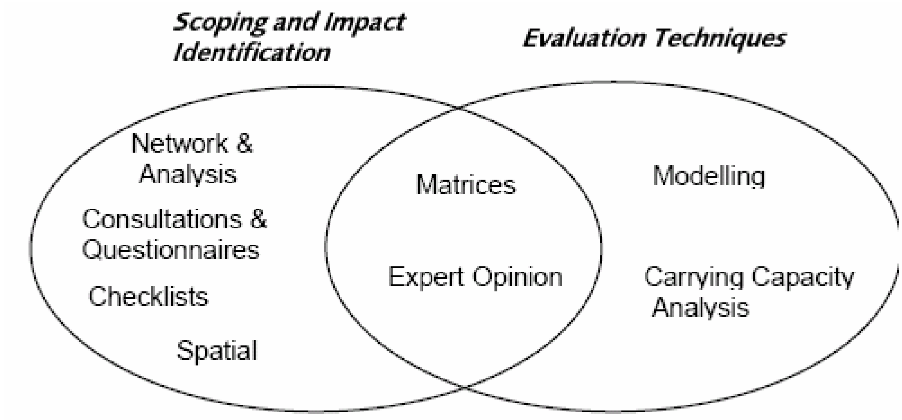


Figure (3-1) Tools for Assessment of Environmental Impacts

3.4.1 Scoping Methods/Tools

- *Baseline Survey Methods/Tools* Baseline surveys are carried out to collect relevant data on the environment to establish the current status and the following tools are commonly used;
- *Checklists;* employed to comprehensively list the environmental effects and impacts to lead the assessor into a more comprehensive analysis. This tool serves to identify potential environmental impacts due to the proposed actions/development project, a list of which is developed as an outcome.
- *Scoping* is carried out to precisely identify the potentially significant environmental impacts. The outcome of the scoping exercise is the Terms of Reference for the full scale EI study which defines the scope of work. Scoping is among the activities carried out at an early stage in the project cycle, where key interest groups or stakeholders fully participate in identification of significant impacts. The methods recommended for this exercise are:
- *Rapid Appraisal Method* (*developed by Resource Analysis Delft*): this allows stakeholders to air out their view depending on their priorities and understanding. This may have significant bearing

on the direction of the EI study. In some cases this referred to as consultation and use of questionnaire. In the method, impact significance is evaluated for varying policy options. It is assigned using normalised criteria varying from strongly negative ---to strongly positive +++. Probabilities are assigned to Impacts. The rapid appraisal system is flexible with policies and strategies being formulated before running the program.

- *Matrices*; employed to reflect the human actions and cause-effect relationship
- *Network & System or Flow diagrams;* to identify action-effect-impact relations
- *Overlays or Spatial analysis or GIS*; to identify geophysical action-effect-impact relation
- Boolean method: allows the assessor to scientifically assess the environmental parameters/impacts and assign significance to each parameter. This method provides an input into quantitative assessment and prediction at a later stage.
- *Dr. EIA*; this is a computer software which enables the assessor to carry out screening and scoping following standard EIA policies either from funding agency or national). With this software, the assessor produces both the screening and scoping reports and Terms of Reference for the EIA study.
- *Expert opinion*; a team of experts may be consulted to provide expert opinion on various issues where experience may play a bigger role.

3.4.2 Evaluation and Prediction Methods/Tools

This stage, which follows the outcome of the scoping exercise, is aimed at ascertaining the magnitudes of impacts and allows the assessor to predict the cumulative impact and finally guide decision-making. Environmental Impact Studies have continued to suffer from the current qualitative assessments leading to controversies and disagreements among the assessors. If the problem is not too complex, scientific methods can be used to obtain useful predictions, particularly in the bio-geophysical disciplines. Due to the fact that not all biophysical processes and particularly the socio-economic effects/impacts are expressed in mathematical terms, the environmental assessment is still carried out largely by qualitative means. The decisions made are very subjective and cannot be validated. This can also lead to manipulation by the assessors who merely give their opinions.

The current thinking is that more objective assessments should be done through use of more scientific methods. Mathematical modeling of processes is hereby strongly recommended. Modeling is an analytical tool, which enables the quantification of cause and effects relationships by simulating environmental conditions.

On the other hand the current tools used for effective evaluation of impacts considers two principles:

- impact indicator scales must be in comparable units.
- assigning of numerical weights must be done through an objective method.

Below are the evaluation methods currently applied;

- ***Battelle System***; this is an environmental evaluation system which attempts o assign values to environmental parameters. The parameters identified through checklists and other methods of scoping are assigned relative weights as the first step. A total of 1000 points are allocated to environmental parameters to reflect their significance. This can ably be done by using the Boolean method. The second step involves transformation of the parameter into an environmental quality through the use of value functions. Each parameter is assigned a quality value between 0 and 1.0. This is to relate various levels of parameter estimates to appropriate levels of environmental quality. While the objective of quantifying the parameters in terms of significance and quality is very clear and is an objective assessment, the means of assigning the magnitudes for environmental quality is still under-developed. The development of such relations should be mathematical/scientific so as to be un-disputable. The third step is to evaluate the expected future conditions of the environmental quality, both with and without the project, using Battelle's equation. It is assumed that after weighting the parameters, the units are comparable and the values can be aggregated to determine the cumulative impact of the project. The project is deemed beneficial if the net cumulative impact between the environment with and without the project is positive, and vise-versa. This helps the decision-maker to make an informed decision.

- ***Leopold matrix****;* This interaction matrix is used to quantify impacts by applying numerical values to magnitude and importance of various actions. The assignment of the values is still judgmental, and is done by experts. The matrix employs weights to indicate relative importance of effects and impacts. A weakness of the system is that it does not provide explicit criteria for assigning the numerical values. For instance there is no basis for deciding which number from 1 to 5 should go in each triangle.

4 FINDINGS

4.1 THE EIA PROCESS

From the review of the existing EIA guidelines of the Nile Basin Countries, the EU guidelines, the FAO guidelines, it seems evident that they all follow the same procedure (four stages: screening, scoping, EI Study, and EI Review). Though, the main difference is in the content of every stage especially the tools or methods emphasized by the guidelines to be used, most of the guidelines actually do not guide on the methods to use for any stage. Another difference, most of the guidelines are silent about the after the implementation stage of the project.

The EIA guidelines of Egypt, though, cannot go without mention. Egypt guidelines, involve general screening stage, categories a project to a white list, Grey list or Black list. After there, the project has to follow sectoral guidelines depending on the kind of project.

4.1.1 Comparison with the EU Guidelines

In general, the EU guidelines also follow the same procedure but are more detailed for every stage. In every step, the EU guidelines give a step by step procedure of how the EIA process can be done for every stage in the EIA procedure. In addition, the EU guidelines go ahead to describe the tools or methods to be applied at every stage of the process, and what kind of information each tool can provide.

4.1.2 Comparison with FAO guidelines

The procedure advocated for by FAO is almost the same as that of the NB countries, but the FAO guidelines include descriptively the two more steps of Environmental Monitoring and Audit (the NB countries' guidelines are silent about these guidelines).

In addition, the FAO guidelines go ahead to describe the methods required to be applied at every stage of the EIA process, though not so much in detail like the EU guidelines.

4.1.3 Comparison with IEM (South Africa)

The IEM guidelines apparently follow the same procedure as the FAO guidelines. And basically have the same differences as those of FAO

.

Though, the IEM guidelines put more emphasis on the implementation stage of the EIA process than other guidelines. They require the developer to come up with an Environmental Management Program as a program for the mitigation measures. And after that, an **Environment Contract** has to be signed between the developer and the IEM to ensure that the developer is true to his word.

4.1.4 Application of DR.EIA

This program is a support tool for Screening and Scoping for small and middle-sized projects though can be upgraded to bigger and complex projects. To be applied to NB countries, the country specific guidelines can be included in the external database of the program, for it to be applied to that country.
For River Engineering projects, the sectoral guidelines can be included inside this program for it to be applied to River Engineering projects.

Most importantly this program can be used as a basis for regional integration of EIA of regional projects. The external database of the program allows for an internet-based source. This can allow a big regional project be given an EI assessment through various country codes.

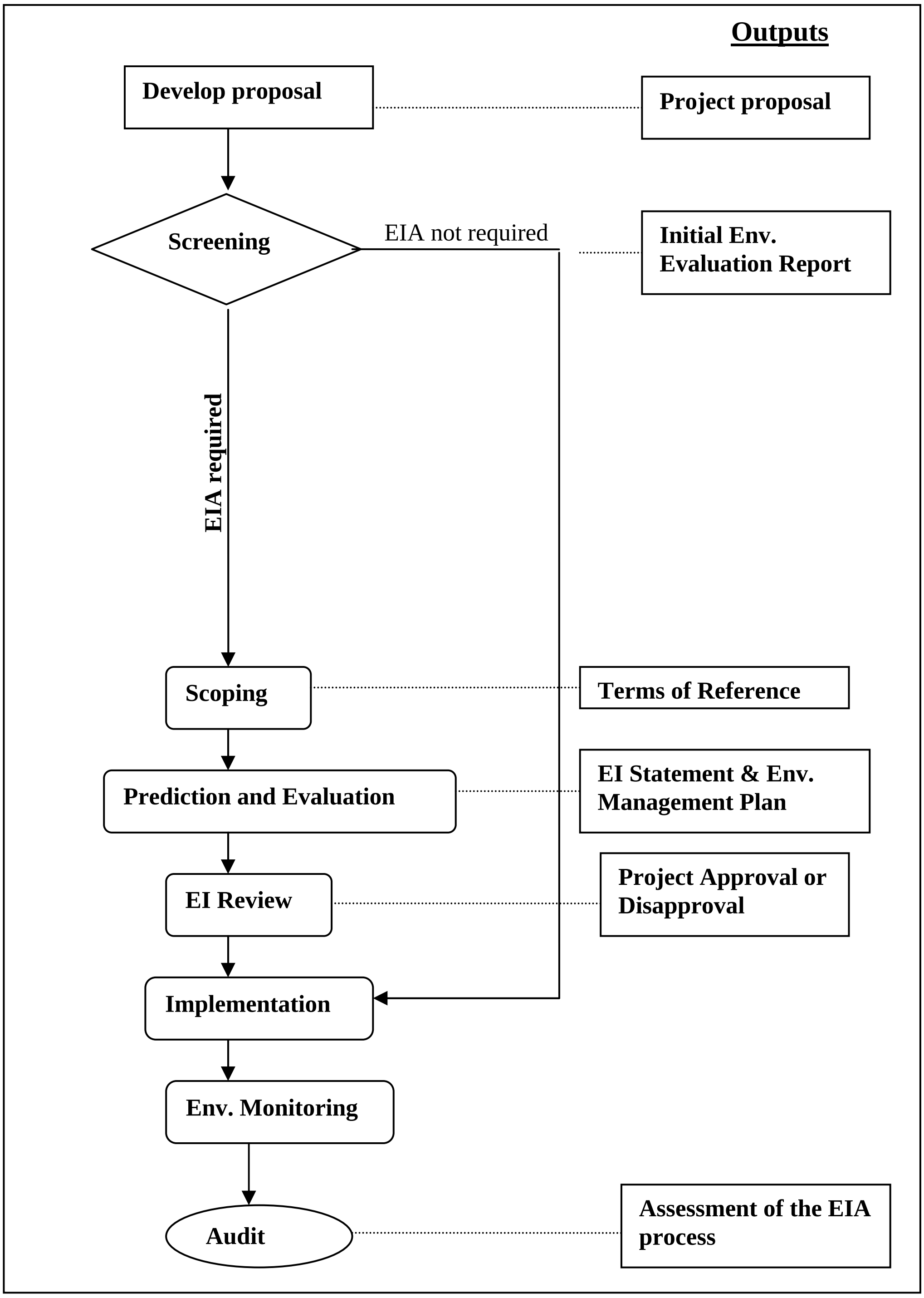


Figure (4-1) Proposed Unified EIA Process

4.2 TOOLS DEVELOPMENT

The EIA is aimed at supporting decision-making in project development process. Currently the EIA is very elaborate, requires calling of experts to give collective opinions before a decision is made. This is due to the fact that the environmental evaluations carried out are largely subjective. Further, controversies and disagreements are common.

In order to reduce on the subjectivity, this study has focused on the development of scientific tools of analysis to allow the assessors to carry out objective evaluation.

Initiatives on the part of scientists have been registered in the area of modeling of physical processes. It is also noted that nature is so complex that it has not been easy to model the process adequately, especially the socio-economic parameters.

The major deficiencies identified in the tools of analysis, which are currently used, are;

- Weighting of parameters to determine the significance and environmental quality is still arbitrary or judgmental.
- Normalization does not reflect the relative importance/value of the parameters under consideration
- In order to compare indicators numerically and to obtain aggregated impacts for each project alternative;
- The impact indicator scale must be in comparable units
- An objective method of assigning numerical weights must be selected.

The major human concern is economic for people who derive their livelihood. This study focused economic value, as the most appropriate impact indicator scale for purposes of comparing likes with likes.

This study attempts to develop the tools of analysis through three approaches;

1. development of mathematical models from first physics principles
2. development of empirical formulations to describe physical processes
3. improve of matrix assessment in assigning significance of impacts

Details are given below.

4.2.1 Mathematical Modeling

I. Introduction

Major water quality problems have been perceived through interferences with various uses of the water and subsequently confirmed through water quality sampling and analysis.

The basic purpose of environmental engineering is to diagnose the type of problem, mitigate, relate that problem to the water use interference and the manifestation of that interference, and then make a judgment on which water quality variables need to be controlled and the means available for control

.

The framework for assessing pollution limitations consists of two parts:

1. A use for which the water body is to be protected or designated.
2. A numerical or qualitative pollutant concentration limit, which will support that use.

Environmental problem principal components are:

1. Inputs, that is, the discharge of residue into the environment.
2. The reactions and physical transport.
3. The output, that is, the resulting concentration of a harmful substance.

Two broad categories for pollution sources are identified

1. Point sources, municipal and industrial discharges
2. Non-point sources (diffuse)

Non-point sources tend to be transient throughout the year due to precipitation at various times of the year. Other inputs such as atmospheric input and leaching of substances out of a solid waste disposal site are more or less continuous.

Determination of whether the effects of these inputs on the dam reservoir, for example, are significant is (partly scientific and partly a socio-economic problem). Estimation of the significance of the effect would be obtained from a comparison with applicable quality standards.

II. Pollutant Mass-loading Rates

For defined sources with continuous flow, the input load is given by

Where $c(t)$ is the concentration of the input $\left[M/L^3 \right]$, $Q(t)$ is the input flow $\left[L^3/T \right]$ and $W(t)$ is the mass rate of input $\left[M/T \right]$, all quantities occurring simultaneously at a given time t.

Previous relationships could under-estimate the loading from a tributary; therefore a different approach is required.

Another method that has been shown to work well in estimating phosphorous loads from tributaries uses the “unbiased stratified ratio estimator.” The flow record may be divided or stratified into various periods, for example, seasonal, annual, or high and low flow seasons. The mean load is then:

$$\overline{W}_p = \overline{Q}_p \frac{\overline{W}_c}{\overline{Q}_c} \left[\frac{1 + \left(1/n \right) \left(S_{QW} / \overline{Q}_c \overline{W}_c \right)}{1 + \left(1/n \right) \left(S_Q^2 / \overline{Q}_c^2 \right)} \right]$$

Where $\overline{W}_p$ is the estimated average load for the period p, $\overline{Q}_p$ is the mean flow for the period, $\overline{W}_c$ is the mean daily loading for the days in which concentrations were determined, $\overline{Q}_c$ is the mean daily flow for the days on which concentrations were determined, and n is the number of days when concentrations were measured.

Also,

$$S_{QW} = \left[1/(n-1) \right] \left[\left(\sum_{i=1}^{n} Q_{ci} W_{ci} \right) - n \overline{Q}_c \overline{W}_c \right]$$

and

$$S_Q^2 = \left[1/(n-1) \right] \left[\left(\sum_{i=1}^{n} Q_{ci}^2 \right) - n \overline{Q}_{ci}^2 \right]$$

Where Q_{ci} are the individually measured flows and W_{ci} is the daily loading for each day on which the concentration was measured. This method is best suited where there is extensive flow data but concentration data are sparse.

Loading from intermittent sources depends on a number of factors. For discharges from combined sewers, therefore, several input loads can be estimated:

1. Equivalent annual loading rate.
2. Average load discharged per event.
3. Distribution of load within an event.

Several quantities are of importance: the volume of precipitation, the duration of the event, and the interval between events. The seasonal variation of rainfall intensity may vary by significant amounts throughout the year.

The simplest estimate of the runoff flow $Q_R\left(L^3/T\right)$ is from the so-called rational formula:

$$Q_R = CIA$$

Where I is the rainfall rate $\left[L/T\right]$, A is the area over which the runoff will occur $\left[L^2\right]$, and C is the runoff coefficient.
The mean load per overflow event is given by

$$W_R = \bar{c}Q_R$$

Where $\bar{c}$ is the average concentration during the event and Q_R is the average flow during the event, assuming that $\bar{c}$ and Q_R do not depend on each other.
The long-term average loading rate can be estimated from

$$W_A = \frac{W_R D}{\Delta}$$

Where D is the average duration of storms $[T]$, and Δ is the average time between storms $[T]$. One should have at least 5 years of rain gage data to estimate these rainfall parameters.

In an approach to estimate the exceedance frequencies of occurrence of a discharged load, which is particularly appropriate for time variable water quality problems, the frequency distribution of the rainfall parameters was estimated by a gamma-type probability density function. The coefficient of variation of the rainfall intensity, v_i, is then used as the relevant statistical measure, where

$$v_i = \frac{s_{di}}{I}$$

For s_{di} as the standard deviation of the rainfall intensity and I is the average rainfall intensity.
If the rational formula for runoff Q_R is used, then

$$v_q = v_i$$

Where v_q is the coefficient of variation of the runoff flow, given by

$$v_q = s_q / Q_R$$

If the concentration and flow of the event are assumed independent, then

$$v_w = v_q v_c \sqrt{1 + \left(1/v_q\right)^2 + \left(1/v_c\right)^2}$$

For v_c as the coefficient of variation of the input concentration and v_w as the coefficient of variation of the input load. Note that if the concentration is assumed constant, then

$$v_w = v_q = v_i$$

III. Associated Water Quality Parameters

The major environmental problems and associated water quality parameters are shown in Table 1. It is clear that so many parameters and indicators are involved, which makes it difficult to use a unified scale for all parameters.

Table(4-1) River Quality Problems and Associated Quality Parameters

Manifestation of the problem	Water use interference	Water quality problem	Water quality variables
1. Fish kills Nuisance odors, H2S "Nuisance" organisms Radical change in ecosystem	Fishery Recreation Ecological health	Low DO	BOD NH3, org N Organic solids Phytoplankton DO
2. Disease transmission Gastrointestinal disturbance, eye irritation	Water supply Recreation	High bacterial levels	Total coliform bacteria Fecal coliform bacteria Fecal streptococci Viruses
3. Taste and odors-blue green algae Aesthetic beach nuisances-algae mats "Pea soup" Unbalanced ecosystem	Water supply Recreation Ecological health	Excessive plant growth (Eutrophication)	Nitrogen Phosphorous Phytoplankton
4. Carcinogens in water supply Fishery closed-unsafe toxic levels Ecosystem upset; mortality, reproductive impairment	Water supply Fishery Ecological health	High toxic chemicals levels	Metals Radioactive substances Pesticides Herbicides Toxic product chemicals

However, a common indicator parameter for surface water quality is the dissolved oxygen (DO). DO is used as an indicator for organic contamination (BOD, COD, TOC, etc.), inorganic contamination, bacteriological contamination of surface water and is surely is.

Our scaling here will be limited to DO as an overall indicator to assess the water quality in dam reservoirs. However, it is very important to note the various physico-chemical processes that take place in lakes and reservoirs

.

Figure 4.2 shows the complexity of the physico-chemical fate of toxic pollutants and eventually the distribution of DO in the lake of a dam. DO is affected by many factors among which are:

1. Depth of the reservoir
2. Thermal Gradients
3. Concentrations of contaminants and biodiversity

Thus, the water quality of the river downstream of the reservoir depends on the same factors. Common mathematical models to calculate the distribution of various contaminant concentrations are rigorous and, therefore, not very useful as can be seen from the following equation for a single contaminant in a mixed media;

$$V\frac{\partial C_1}{\partial t} = W - QC_1 + K_f A\left({f_2 C_2}/{\Phi_2} - f_1 C_1 \right) - K_d f_1 V_1 C_1 + k_l A\left({C_g}/{H_e} - f_1 C_1 \right) - v_s A f_1^{'} C_1 + v_u A f_2^{'} C_2$$

Another type of models is the empirical models which are easy to use and very practical when it comes to such complex systems as dams and reservoirs. However, these models need experimental data, which means monitoring of various types of river engineering structures for prolonged time periods to produce reliable models.

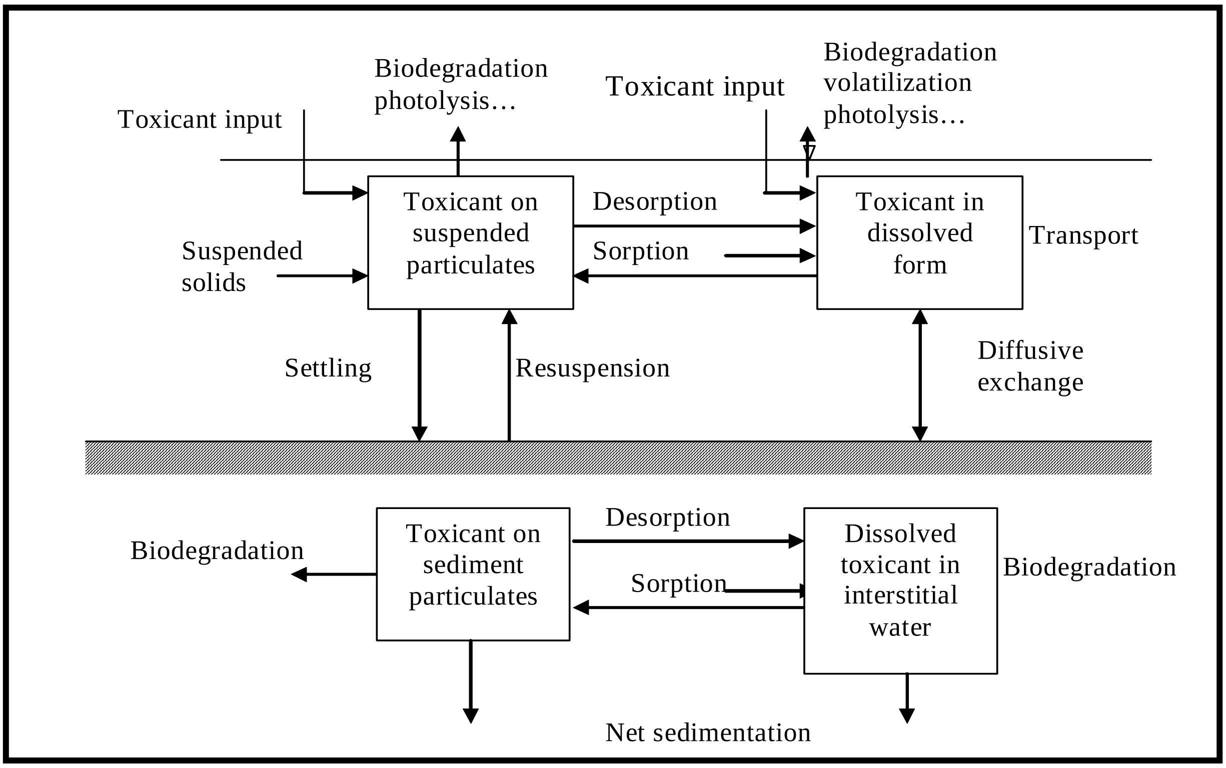


Figure 4.2: Schematic of principal features of physical-chemical fate toxic substances

An empirical model that was proposed for use to calculate the downstream concentration of DO at small dams is given below
Suggested formulation in this case is

$$D_a - D_b = \left\{1 - \left[1 + 0.11ab(1 + 0.046T)H\right]^{-1}\right\} \quad D_a$$

Where D_a, D_b and are the DO deficits above and below the dam, respectively, in mg/l, a is a coefficient equal to 1.25 in clear to slightly polluted water, 1.00 in polluted water, and 0.80 for sewage effluents; b is a coefficient equal to 1.00 for a weir with free fall and 1.3 for step weir or cascades; T is the water temperature in ^oC, and H is the height through which the water falls in ft. This formulation is used for heights 10-35 ft .A further refinement of the above equation is

$$r = 1 + 0.38abH(1 - 0.11H)(1 + 0.046T)$$

$$r = \frac{D_a}{D_b}$$

H is in meters.

However, monitoring of various size river engineering structures is vital for the application of these models. Not only that but also a correlation of the monitored parameters to other key environmental, land use, water use-parameters is needed.

IV. Engineering controls of Rivers and Streams

There are several points at which the water quality in a system can be controlled.

1. Reducing the effluent concentration:
    a. Wastewater treatment
    b. Industrial in-plant process control
    c. Elimination by pretreatment
2. Reducing the upstream concentration
   Augmentation of stream river flow reduces the initial concentration and hence may achieve water quality standards. Thus the concentration can be controlled by the following.
3. Reducing the effluent volume (Qe)
   However, this may affect the downstream transport through the velocity.
4. Increase the environmental, in-stream degradation rate of the substance.
   This latter control can be accomplished by a redesign of the chemical to result in a more rapid breakdown of the chemical by the natural heterotrophic bacteria in the stream.

Environmental controls of indicator bacteria, pathogens and viruses: There are broad controls of pathogenic bacteria, viruses, and parasites:

1. Treatment of wastes without disinfection.
2. Disinfection by (a) chlorination, (b) ultraviolet radiation, (c) ozonation, and (d) chlorine dioxide.

Engineering control for dissolved oxygen:

Point and non-point reduction source of CBOD and NBOD through reduction of effluent concentration and/or effluent flow.

1. Aeration of the effluent of a point source to improve initial value of DO.
2. Increase in river flow through low flow augmentation to increase dilution.
3. In-stream re-aeration by turbines and aerators.Can be achieved by turbines, diffusers, and spraying (lakes).
4. Control of SOD through dredging or other means of inactivation.
5. Control of nutrients to reduce aquatic plants and resulting DO variations.

Eutrophication control techniques:

Principal interest first centers on control of the inputs, in this case, the nutrient inputs. Three general control areas:

1. Control of inputs.
2. Alteration of system kinetics
3. In-stream treatment and flow control

Control of toxic substances:

Control points are several and include:

1. Control at the source including
    a. Waste treatment to reduce chemical input using processes such as:
        i. Adsorption to activated carbon.
        ii. Chemical oxidation
        iii. Ultraviolet photolysis and catalyzation.
        iv. Air stripping.
        v. Biological treatment.
        vi. Ion Exchange.
        vii. Osmosis and Ultra filtration.
        viii. Electro winning.

   b. Control of agricultural runoff containing pesticides and urban storm water runoff containing a variety of chemicals.
   c. Modification of the product.
2. Control within the water body including:
3. Control at point of use including:
   a. Treatment of municipal water supply before distribution.
   b. Consumption of only certain size or weight class of fish where chemical concentrations are acceptable.

V. Conclusions

The use of scientific tools for impact quantification can be complicated, time consuming and very costly process, yet the development of empirical models can be a very useful tool during the screening and mitigation stages of EIA, however this tool need the following:

1. Monitoring of river engineering structures in the Nile basin countries to collect a database of environmental correlations between parameters and impacts, between size and impact, between uses and impacts, and between local conditions and impacts.
2. Establishment of a monitoring network to carry out item number 1.
3. Collection of similar international experiences.

4.2.2 Empirical Formulation

Introduction

There are numerous methods of assessing impacts, which shows that there is a growing concern over the way impacts are evaluated and it also confirms that the subject has not been studied fully so as to come up with proven scientific methods of impact assessment. This research is making an attempt to improve on the methods of impact assessment through development of un-disputable scientific tools for objective evaluation of environmental quality parameters. This in itself will reduce on qualitative and subjective impact assessments, which do not explicitly facilitate the decision-making.

The assessor requires tools to ably predict the environmental impacts. Generally speaking, the current practice has limited accuracy due to the fact that assessment is done subjectively. The issue of weighting the parameters to determine the magnitude and significance is still contentious and above all, comparison is done with different units of measure, which practically does not make much sense.

Concept

The concept used in the development of the scientific tools is:

- The environmental parameter (or the change) must be quantified scientifically
- The economic value of the parameter (or change) must be determined.
- Then the cumulative impact of all parameters can be determined by aggregating the economic values (negative for costs/loss of value, and positive for benefits/gain in value).

This concept was developed from the fact that the major human concern is economic and perhaps social values. Mathematical formulations can be developed for environmental parameters in the biogeophysical disciplines, which can be used scientifically to quantify the impact. Examples; pollution, disease incidences, sediment transport, water flows, erosion, etc.

Formulae can be developed from first principles of physics or by using available data to develop empirical relationships of chosen significant physical variables.

Using first principles of physics is likely to be the most accurate approach but some physical phenomenon can be so complex that the inputs required are unaffordable, however, where simple processes are encountered or where formulae exists, this approach is highly recommended.

Empirical formulation is another approach proposed in this present research due to the fact that it describes the physical phenomena at hand and can be validated. Simple mathematical relations between the environmental parameter of concern and a quantifiable project action can be developed by using measured data. These formulae however have to be calibrated if they are to be used in different areas of interest.

Tool Development

It was proposed that Empirical Formulae be developed for the biogeophysical parameters that can be described mathematically. An Empirical Formula is a mathematical relationship between two or more measurable variables. For simplicity it is recommended that two variables are used, one of which is the environmental quality parameter to be evaluated and the other being a measurable project action. There must be a set of data for both variables observed over a period of time, which would give a distinct relation. Below are a few environmental quality parameters for which formulae can be derived:

i. Malaria Prevalence

There is a direct relation between water and malaria prevalence. This relation if developed can be used to predict the prevalence of malaria for a given development project like reservoir construction. Whereas there are many ecological factors that may contribute to the prevalence/endemicity of malaria such as;

- Vegetation
- Temperature
- Precipitation
- Agro-ecology
- Proximity to water
- Litho logy
- Geomorphology
- Population density
- Literacy

If an area is chosen carefully, all other factors can be kept constant while the water surface area varies. Therefore **clinical malaria events** recorded at clinics at various locations in the chosen area can be related to the **water surface areas** present, provided the other factors remain constant or vary with acceptable limits that would cause insignificant effect on the relation. Selection of area for study may be done by using overlays or GIS to enable identify all features taking into account the significant ecological factors.

Empirical formulations can be improved by considering another sensitive variable like in this case, the population density. Separate formulae can be developed for various population densities, but of course, the formulae will take the same form.

It is envisaged that the Empirical Formula will take a logarithmic form as many natural phenomena:

$$C = B * A^{k}$$

where; C = clinical events per year of malaria
B = constant
A = surface area of water bodies
k = constant (gradient)

Therefore, with this equation in place, the situations; with and without the project, can be determined because the water surface area can be easily determined for both situations as well as the clinical events without the project. Then the clinical events with the project can be predicted. The difference in the clinical events under the two situations; with and without the project is actually the impact of the project, which can be converted into economic value. In this case it will definitely be loss of economic value to the society due to the fact that money will be spent on treating patients and to certain extent loss of human labor due to the deaths arising out of malaria. The loss of economic value is a negative impact and can be costed using the average rates for treating malaria clinical events and cost of labor loss.

The costed impact is now the Environmental Quality Value for malaria parameter and can be compared with others. It can now be used in the Battelle system of evaluation to come up with the cumulative impact for decision-making whether the project is environmentally sound or not.

ii. Salinization of Irrigated soils

Ayers & Westocol, 1985, developed a relationship between yield potential (%) and Salinity in the root zone, (EC: mS/m^2), for various crops; wheat, cotton, sugarcane, Tomatoes, Rice, Maize, Pepper, Orange and Beans. This relation gives reflects the productivity of a given area under certain salt conditions. Productivity can easily be converted into economic value (benefits or loss). The impact of salinization manifests itself in loss of productivity, hence loss of economic value of the irrigated land.

In order to develop the empirical formula for salinization, data from old functioning irrigation scheme would form the basis. Ultimate salinity can be plotted against quality of irrigation water for various schemes and a relation derived there from.

The equation can then be used to predict the salinity condition with the project depending on the water to be used. The difference between the salinity of the soil without the project and salinity with the project is the measure of the negative impact of salinization. This can then be converted into economic value by determining the loss of productivity for the crop of interest using the Ayers & Westocol Charts. With the known unit benefits of the crop under consideration, a monitory value loss can be easily computed. This value will be referred to as the Environmental Quality Value for salinization parameter.

iii. Sediment Deposition

Sediment transport predictors are in place. Incidentally, the predictors are generally empirical formulations which can be used to estimate sediment loads in changing flow regimes.

If the project is to reduce river flows, then Lanes Balance can be used to estimate sediment accumulation in the river channel. Sedimentation in this case may have a negative impact in that Navigable channels are obstructed. This may required the project to meet the dredging cost as a recurrent cost in order to maintain the channel. The unit cost of dredging multiplied by the annual volume sediment load will give the value of the negative impact.

However on the other hand, the sediments may be of a positive economic value, say in case of quality building sand or gravel, which can be mined for building purposes. Mining will solve the problem of sedimentation and at the same time there will be economic benefits. The annual tonnage of these sediments can be value in monitory terms.

The economic value of sedimentation would then be referred to as the Environmental Quality Value for sediment deposition.

iv. Scouring and Erosion of River Channels

Empirical Equations to determine scour are available. In case of reservoir project, the water released downstream may be so clean that they cause scour/erosion of the river channel. The extent of scour can be predicted and an annual cost for armoring or maintaining the channel can be estimated. This cost would constitute the Environmental Quality Value for Scouring or erosion.Noise Cost of noise barriers *v. Borrow pits Value of land loss*

vi. Inundation Value of land loss

vii. Quality of Return Flows from Irrigation schemesCost of treating water

viii. Fish catches Value of productivity (either increase or loss)

4.2.3 Boolean Approach -to Cross Impact Analysis

Cross Impact Analysis

The Boolean matrix approach to cross impact analysis is used for selection of significant impacts relevant to evaluation of river basin projects. The methodology is a marriage between quantitative methods and qualitative subjective values that require a high level of commitment and dedication from participating experts. The combination of Boolean properties with expert judgment is to identify hidden relationships between environmental Impacts conditioning a given system.

In the Boolean approach, a survey of environmental criteria affecting the river basin system is made and impacts conditioning the system selected. A cross impact analysis is made leading to the evolution of significant impacts conditioning the evolution of the system. The significant impacts result from expert analysis through brainstorming on factors affecting the environment. Strategic thinking and evaluation is required in order to identify significant impacts conditioning the future state of environment.

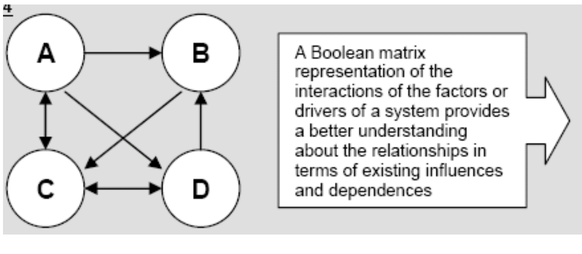
Cross impact analysis identifies various orders of impacts affecting water resources projects. In addition, hidden relationships between impacts evolve through the analysis. Significant impacts critical to the evolution of the system are identified. The resulting impacts are classified as dominant, key, resultant or autonomous (4-2).

Table (4-2) Impact Classification (Modified from Rafael Popper, 2003)

Impact type	Description of Impacts
Influential impacts	Dominants of the system. Have high influence and low dependency
Key or relay	Unstable Impacts. Have a high level of influence and dependency over the system.
Resultant impacts	Impacts with medium influence and high dependency playing a strong role in system evolution. Require attention in order not to produce a fracture.
Autonomous impacts	Impacts with low influence and dependency.

a) Mapping and Classification of Interconnections between Impacts

Mapping and classification of environmental impacts is carried out using Boolean matrices. The matrices have important properties in networks and evaluation of systems evolution. One (1) means that there is an interaction (i.e. influence, impact, etc) between a pair of impacts and zero (0) means that no interaction exists An illustration of interactions considering impacts A, B, C and D in shown in figure 4.3.



	A	B	C	D	Tot. I
A		1	1	1	3
B	0		1	0	1
C	1	0		1	2
D	0	1	1		2
Tot. D	1	2	3	2	8

Figure (4-3) Direct Influence Matrix (Adapted from Rafael Popper, 2003)

In the figure, the number eight (8) in the bottom right corner of the matrix indicates the total number of paths or connections that exist between impacts A, B, C and D (note the eight arrows in left side diagram of the box).

The sum of a row represents the total direct influence (through direct paths) that a specific impact exerts over the system (the number 3 at the end of the first row indicates that A has three direct ways of influencing other impacts within the system). The evolution of highly influential impacts has the greatest effect on the system.

The sum of a column represents the total direct dependency that an impact has on the system (i.e. number 1 at the end of column 1 indicates that there is one path though which the system can directly influence over impact A). Dependent impacts are those that are most sensitive to system evolution, in this case C. Both the sums of a row and column provide two indicators, influence and dependency, which are useful for impact classification for significance (GODET 1994, [Ibid]).

b) Use of Influence and Dependency to Classify Impacts

The direct influence-dependency map presented as figure 4.4 provides descriptive information about the system being evaluated (figure 4.2) and helps to explain assumptions made in advance about the importance of certain impacts.

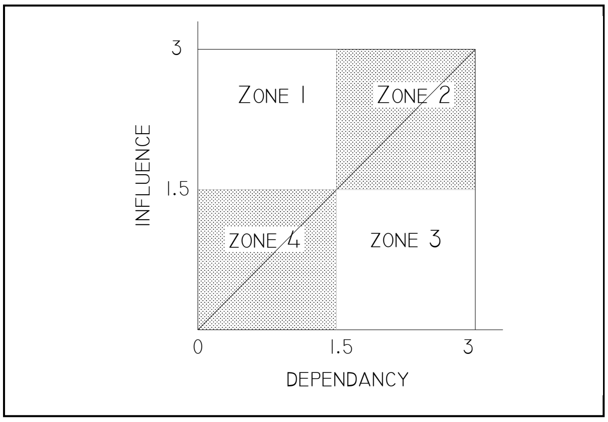


Figure (4-4) Use of Influence and Dependency to Classify Impacts Ibid

The direct influence map is divided into four zones: Zone1 (Influential or determinant impacts: impacts which condition the system), Zone 2 (Key or relay impacts: high influence and high dependency, unstable by nature), Zone 3 (Resultant impacts: influenced by determinant and relay impacts), Zone 4 (Autonomous impacts: trends or impacts relatively disconnected to the system). In figure 4.4, impact A belongs to Zone 1, Impacts B and D belong to Zone 3, and impact C belongs to Zone 2. Impacts with low influence and dependency (zone 4) are disconnected from the system.

c) Looking for Hidden Interconnections (Cross Impact Analysis)

Mathematically indirect influences identify hidden connections from several multiplications of the Direct Influence Matrix (DIM) by itself (DIM*DIM=DIM^2). The number of times the matrix is multiplied depends on the size of the system. Small systems consisting of 10 to 20 Impacts require 4 to 5 multiplications (DIM^4 or DIM^5) in order to reach a stable pattern while for larger systems of 20 to 60 impacts the hierarchy still experiences minor changes at the power of 7 or 8. An illustration of the dimension 2 matrix related to figure 4.2 is shown in figure 4.5

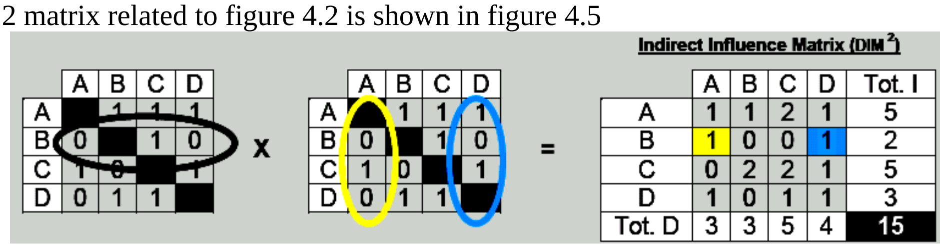


Figure (4-5) Indirect Influence Matrix of the Second Order, DIM2 (modified Ibid)

The mathematical basis for figure 4.5 involves the multiplication of row B (left) times column A (middle) resulting in number 1 in the cell [B, A].

- Operation: B row * A column = 0*0+0*0+1*1+0*0= 1, which means there is a path of length 2 through which B influences over A.

- Operation: B row * D column = 0*1+0*0+1*1+0*0= 1, which means there is a path of length 2 through which B influences over D.

Looking for hidden interconnections involves careful analysis of the resulting indirect influence matrices (DIM^2, DIM^3,…, DIM^8). Identifying significant impacts involves a combination of impacts with direct high level of influence and dependency on the system with those that reach the same hierarchy though hidden interactions. It is worth noting that some impacts that are important for the authority that mandates the EIA are located in the autonomous or excluded variables zone of figure 4.4.

d) Impact Significance

Significant impacts are derived from the classification developed from figure 4.6 as figure 4.4. A recipe for classification of the impacts or systems variables conditioning the system for a river basin project is as follows.

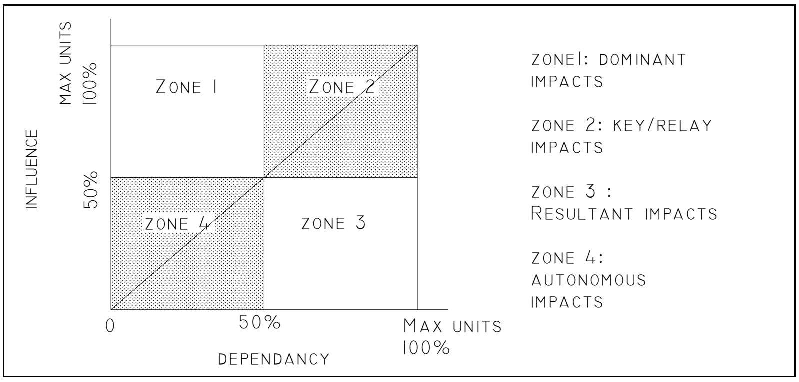


Figure (4-6) Zones of Systems Variables used in the Cross Impact Analysis.

Environmental impacts and actions are classified as follows.

- The maximum units attained by impacts either from influence or dependency on the system is chosen from the dimension matrix corresponding to system stability.
- Impacts selected from the cross impact analysis are those where either the influence or dependency exceed 50% of the maximum units above.
- Impacts, for which both dependency and influence fall below 50% are disconnected from the system, insignificant to evolution of the system and hence are not used for evaluation.

Selection of significant impacts can be represented mathematically as follows.

IF (OR (Dependency>0.5*Max Units; Influence>0.5*Max Units) = TRUE; System Variable;”-”)

The Boolean approach is validated using a dams development project in the Nile basin.

Application - dams and reservoirs

The Boolean approach is used to assign significance to impacts relevant to system evaluation. A review of dams and reservoir projects in the Nile basin resulted into table 4.3 for impacts and actions conditioning a river basin system. The impacts are evaluated in an interconnected framework involving upstream and downstream considerations thereby bringing transboundary use of water resources into focus.

Table (4-3) Initial Variable Identification for dam and reservoir Development

Impact category	Impact Zone	System variables
Ecosystem	Upstream	Thermal regime [US]
		Sedimentation [US]
		Water Quality [US]
		Backwater effect [US]
		Seismicity [US]
		Flora [US]
		Fauna [US]
		Aquatic macrophytes [US]
		Riparian Vegetation [US]
	Downstream	Altered hydrology [DS]
		Water table modification [DS]
		Volume of runoff [DS]
		Water Quality [DS]
		Sediment transport [DS]
		Channel Morphology [DS]
		Flood plains [DS]
		Coastal deltas/estuary [DS]
		Flora [DS]
		Fauna [DS]
		Aquatic macrophytes [DS]
		Riparian vegetation [DS]
Social Impacts	Upstream	Displacement [US]
		Communities livelihood [US]
		Public health [US]
		Agriculture [US]
		Cultural heritage [US]
	Downstream	Wetlands [DS]
		Agriculture [DS]
		Fisheries [DS]
		Pastoralism [DS]
		Delta & coastal communities [DS]
		Urban development [DS]
		Archaeology [DS]
		Cultural heritage [DS]
Economic	Regional	Employment
		Storage
		Hydropower generation
		Navigation
		Municipal & Industrial WS
		Flood control
		Tourism & Recreation
Political	Regional	Transboundary conflicts
		Negative Public Opinion
		Lack of Institutional coordination.

The Boolean approach assigns significance to environmental impacts and actions for use in evaluation. The development option [dam and reservoir project] is decomposed into environmental Impacts [table

4.3]. The environmental impacts are then entered into MS Excel spreadsheets in an interaction matrix, which identifies inputs each impact, expects to receive from others.

In the interaction table Boolean operators of 1 and 0 are assigned by experts to paired comparisons of environmental impacts and actions to indicate the existence or lack of an interaction in a direct influence matrix. This direct influence matrix (DIM[1]) is the core of the cross impact analysis. The DIM[1]matrix for no development is shown in Appendix 1. A graphical representation of the matrix is presented as figure 4.7.

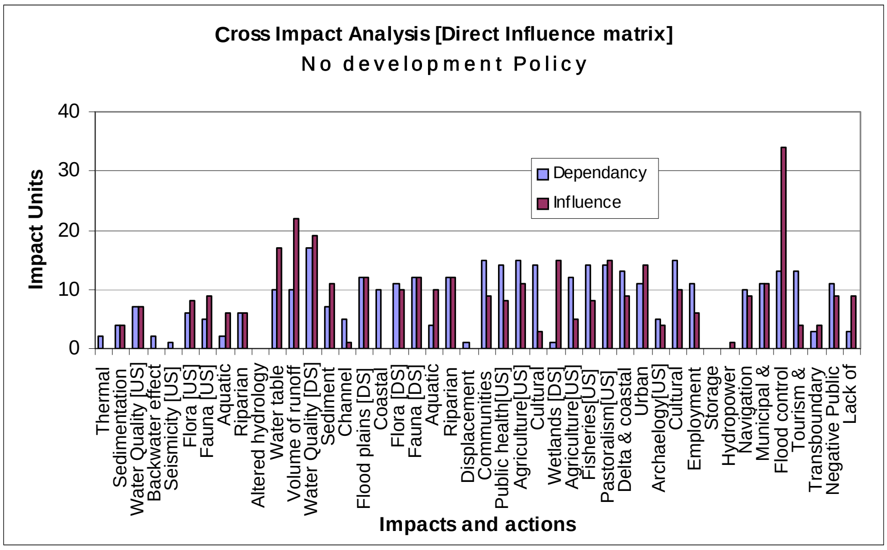


Figure (4-7) Direct influence Matrix for the No Development Scenario

The direct influence matrix is subjected to a series of multiplications until no significant changes in trends of influence and dependency of impacts are eminent, in this case the dimension 8 matrix. A graphical representation is shown in figure 4.8.

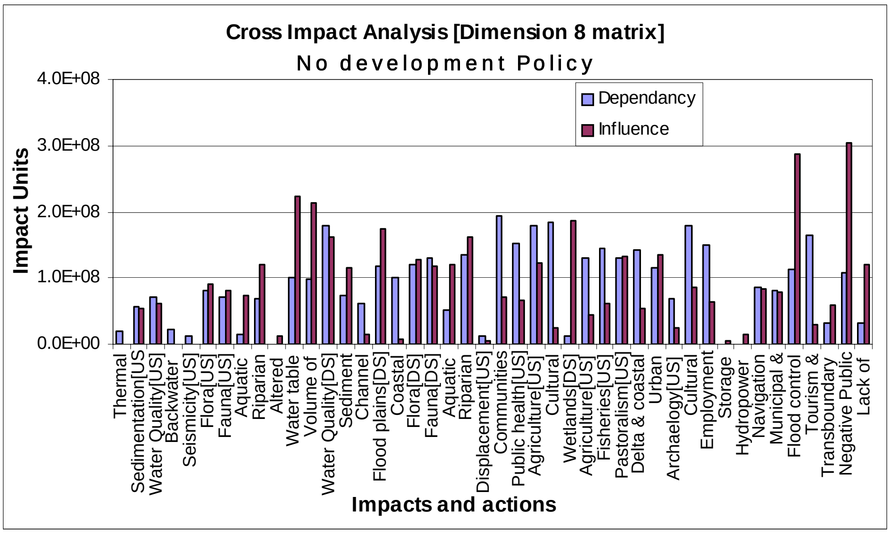


Figure (4-8) Dimension 8 Matrix for the No Development Scenario

The next stage is to classify the environmental impacts and actions. Impacts are classified as dominant or influential, key or relay, resultant and autonomous impacts for evaluation of impact significance. In the Boolean approach, autonomous impacts are not selected for system evaluation since they are disconnected from the system.

The relation ship developed in section 1.1 (d) is used for selection of the significant impacts conditioning the system i.e.

IF (OR (Dependency>0.5*Max Units; Influence>0.5*Max Units) = TRUE; System Variable;"-")

The results of the above criterion when applied to the dimension matrix (DIM[8]) for the no development scenario are shown in table 4.3. The table, which is an extraction from Ms Excel, shows typical results for selection of environmental impacts and actions conditioning the system and the relevant indicators for the No development alternative from the cross impact analysis. In addition, the % contributions [column 6] for selected impacts are derived using the spreadsheet function below.

IF (Dependency>0.50*Max Units, Dependency [value], IF (Influence>0.50*Max Units, Influence [value], 0))

A plot of the significance [influence / dependency] of selected environmental impacts and actions expressed as a percentage of system variables and actions the dam and reservoir system for the No Development scenario is shown in figure 4.9.

Table (4-4) Significant Impacts for the No Development Scenario

NO DEVELOPMENT SCENARIO

Influence-dependancy of the cross Impact Analysis						
Max value for dependancy		**194348966**				
Max value influence		**304677818**				
Frame of reference [max of tv		**304677818**				
50% of frame of reference		**152338909**				
IF (OR (Dependency>0.50*Max Units; Influence>0.50*Max Units)=TRUE; System variable;"-")						
Impact category	**Impact zone**	**Selected Impacts**	**Impact Indicators [No Development Scenario]**	**Impact Significance**		
				Selected Variable Wt.	% Wt	EIUs
Ecosystem Impacts	**Upstream**	-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
	Downstream	-	-	0	0.0	0
		Water table modification[DS	Water table modification	222485522	8.5	85
		Volume of runoff[DS]	Runoff[DS]	213503634	8.1	81
		Water Quality[DS]	Dissolved Oxygen[DS]	178992701	6.8	68
		-	-	0	0.0	0
		-	-	0	0.0	0
		Flood plains[DS]	FP Degradation[DS]	175422567	6.7	67
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		Riparian vegetation[DS]	Riparian vegetation[DS]	161297974	6.1	61
Social impacts	**Upstream**	-	-	0	0.0	0
		Communities livelihood[US]	Communities livelihood[US]	194348966	7.4	74
		-	-	0	0.0	0
		Agriculture[US]	Agriculture[US]	180227903	6.9	69
		Cultural heritage[US]	Cultural heritage[US]	184988380	7.0	70
	Downstream	Wetlands[DS]	Wetland degradation	185683055	7.1	71
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		Cultural heritage[US]	Cultural heritage[US]	179305166	6.8	68
Economic impacts	**Regional**	-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		-	-	0	0.0	0
		Flood control	Flood control	286198150	10.9	109
		Tourism & Recreation	Tourists	163824394	6.2	62
Political Impacts	**Regional**	-	-	0	0.0	0
		Negative Public Opinion	Public opinion	304677818	11.6	116
		-	-	0	0.0	0
			SUM	2630956230	100.0	1000

Dash (-) implies that the impacts/ action is disconnected/autonomous from the system.

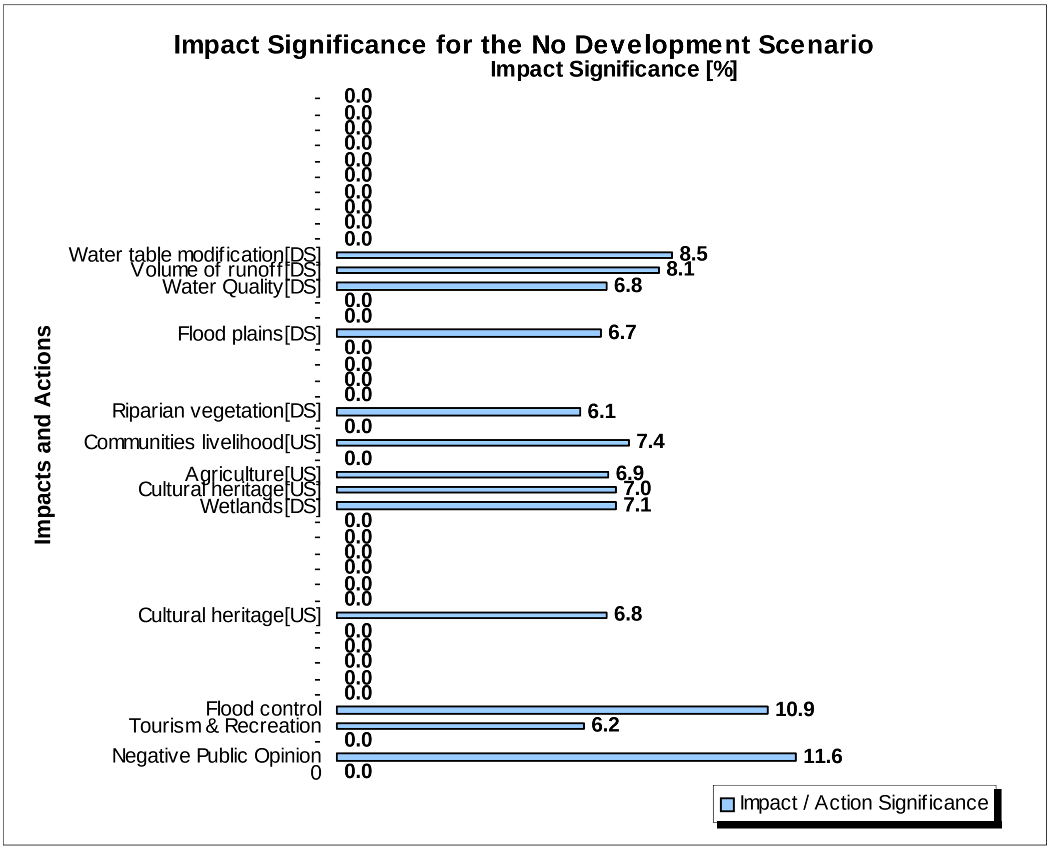


Figure (4 -9) Impact Significance as derived from the cross impact analysis

From figure 4.9, direct influence matrix, it can be noticed that impacts conditioning the river basin system according to the criterion of figure 1.4 include volume of runoff and flood control. These impacts would be evaluated if the direct influence matrix were the primary consideration for assigning impact significance.

However, when a cross impact analysis is carried out up to the dimension 8 (figure 4.8), hidden interactions lead to evolution of other impacts such as water table modification, water quality downstream, flood plains, riparian vegetation, communities livelihood, upstream agriculture, cultural heritage, tourism and negative public opinion as dominant and influential impacts conditioning the system (table 4.3)

At this stage, the DIM^8 matrix and selected impacts conditioning the system (table 4.3 and figure 4.9) provides in a concentrated form, an immense amount of information, which can be used for analysis if resources, time and information are not available for an extensive assessment. At this stage interim evaluation results can be communicated to specialists and stakeholders participating in the EIA.

Considering figure 4.9, which represents the % significance (Influence/dependency) for each of the individual impacts variables for the No development scenario, negative public opinion [11.6%] is the greatest factor if a dam is not constructed which translates into poor quality of life due to poor socio-economic development. On the other hand flood control [10.6%], points to vulnerability to floods and destruction to infrastructure. The least significant would be riparian vegetation [6.1%].

The selected variables from the cross impact analysis can be used as a basis for comparison with other development scenarios and subsequently used for recommending for a detailed EIA for a chosen development scenario.

In addition, Environmental Impact Units [EIUs] can be computed from the percentage significance in table 4.3. The computations are based on 1000 units as recommended by the Battelle Environmental Evaluation System.

Following the selection of significant impacts indicators are assigned in order to evaluate impacts using the principal of the Environmental Evaluation System developed by the Battelle Columbus Laboratories. Indicators for significant impacts are the principle output of the cross impact analysis.

Indicators for significant impacts and actions for impact prediction and evaluation are chosen based on: the relevance to policy and management needs, relation to goals, targets or objectives, good quality data, spatial and temporal extent and ability to detect changes in the system.

At this stage of the EIA, impact significance has been assigned to environmental impacts relevant to evaluation of a development scenario. The next stage is to assign impact magnitude to the selected systems variables in a decision support system where the environmental quality is determined using scientific or empirical methods based on sound technical information within the Nile basin riparian countries.

4.3 TOOLS DEVELOPMENT

The process of tool development is still ongoing. The tools developed so far concentrate on impact significance. The process of assigning impact magnitude will be done using scientifically developed value functions. It is proposed to develop environmental quality functions based on economic values of the various impacts. This together with the Environmental Evaluation system developed by the Battelle Columbus laboratories should aid in evaluation of projects.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS -THE EIA PRACTICES IN NB COUNTRIES

In the NB countries, the EIA process is virtually the same, that is, consists of three major steps: Screening, Scoping, EI Study and EI Review. Though the following are the few weaknesses that need to be addressed in these guidelines,

- The guidelines leave a lot of discretion to the developer in carrying out an EIA.
- They all do not contain a description of the methods or tools to be applied when carrying out an EIA study at any stage of the process.
- The level of public participation in the EIA process is not easy to measure, many reports showed low levels of public participation in the EIA process.

On a positive side, many of the NB countries are still very young in this practice of EIA, and are showing tremendous improvement in its practice. With time, this process could be streamlined.

On the question, of creation of unified EIA guidelines for all the NB countries, yes it is possible especially with the help of DR.EIA program. As a start, this program can be applied to a regional project through codes of different countries, and the Environment effect per country ascertained.

5.2 RECOMMENDATIONS

5.2.1 Proposed EIA Guidelines

From the analysis of different EIA guidelines for the NB countries and the International Organisations, the best EIA practice for the NB country projects is summarized as follows: The proposed steps include the following.

- Stage 1 – Develop a Project Proposal
- Stage 2 – Screening (leading to sectoral guidelines)
- Stage 3 – Scoping (under the sectoral guidelines of a the project)
- Stage 4 – Prediction and Evaluation
- Stage 5 – Environmental Impact Review
- Stage 6 – Implementation
- Stage 7 – Environmental Monitoring
- Stage 8 - Environmental Audit

5.2.2 Training

The study has so far revealed that EIA studies are not carried out efficiently within the Nile basin riparian countries which are attributed to lack of knowledge in EIA practices and methods. It is therefore proposed to have training programs for practitioners of EIA.

5.2.3 Tool Development

The development of tools for impact assessment should be continued so that effective methods of impact assessment can be developed for the Nile basin riparian countries. Data bases for various projects within the Nile basin riparian countries should be developed. This should aid in the development of efficient environmental quality parameters using scientific and empirical approaches.

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