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Environmental impact assessment: A case study of hydropower project

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ABSTRACT

Although hydropower is very environmentally and economically sound project, it has effects on a local or regional scale. Present work addresses these issues and presents a viable procedural layout on environmental impact assessment (EIA) for implementing such project to the upcoming environmental engineers. The rapid impact assessment matrix (Pastakia, 1998) was used to get numerical impacts (adverse or beneficial) of different parameters. This method analyses and presents in a structured, friendly and transparent environment the numerous parameters and alternatives of an EIA. It considers all 4 components: physical/chemical, biological/ecological, social/cultural, economic /operational. Based on the analysis, it is shown that such a project will be positive economically but negative otherwise considering the other three components.

KEYWORDS

Environmental impact assessment;
Land environment;
Hydropower;
Rapid impact assessment matrix;
River pollution;
Water resources.

INTRODUCTION

Enhancing the level of energy consumption, particularly in less developed and developing countries, is a global challenge. In the context of electric power, as an important form of energy, the thermal and hydropower on a global basis, have occupied the largest proportion. Between thermal and hydropower, hydropower is a clean source of energy seen on a global scale. Hydropower plants convert the kinetic energy contained in falling water into electricity. The energy in flowing water is ultimately derived from the sun, and is therefore constantly being renewed. Energy contained in sunlight evaporates water from the oceans and deposits it on land in the form of rain. Differences in land elevation result in rainfall runoff, and allow some of the original solar energy to be captured as hydropower. An essential requirement is, therefore, that the water should be at a suitable height above a lower reference point to where the water could flow and be discharged. The difference in levels between the water and discharge point represents the potential energy that would become available for use should water is allowed to flow between the two levels. Figure 1 shows the type of hydropower installation.

Hydroelectric plants convert the potential energy of water into an electrical output. The process involves flow of water from the source, through the turbine to

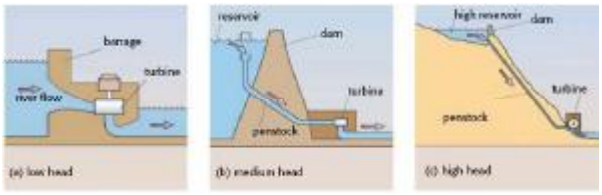

Figure 1: Types of hydropower installation[3]

the turbine outflow (tailrace), which acts as a sink. In the process of conversion, use is made of water turbines, of associated civil structures and of rotating electrical machinery.

Hydropower is currently the world's largest renewable source of electricity, accounting for 6% of worldwide energy supply or about 15% of the world's electricity[17]. When developed in accordance with good environmental and social practices, hydropower plants have the advantage of producing power that is both renewable and clean. Hydropower projects are seen as greenhouse gas reducing, industrialized countries can therefore earn emission credits by investing in such projects in developing countries[19]. It is hence likely that hydropower projects will be popular to cope with increased energy consumption in many developing countries.

But on a local or regional scale, the environmental and socioeconomic impacts can be negative and serious. The landscape and the dammed rivers often change their characteristics severely after the completion of a hydropower project. Sometimes the ability of people living in the area to use natural resources to improve their livelihood can be highly limited after a project. In rural areas in developing countries, using the surrounding environment for small scale farming, hunting and fishing can be equally important to an employment as means of earning a livelihood. The people worst affected by such a change in the environment are often the poorest ones with the lowest safety margins. Therefore before a hydropower project is undertaken, it is important to try to predict in what way the project is likely to affect the area and the people living in it, and to include actions in the project plan that will prevent, mitigate or compensate for negative impacts[1]. This is normally done by performing an Environmental Impact Assessment (EIA).

EIA is a tool "used for reducing negative environmental consequences of development activities and for promoting sustainable development[10]". EIA is a process of identification, prediction and evaluation of a project's impact on the environment and is, essentially, an aid to the decision-makers responsible for planning[4]. It could also be manipulated into a management tool for environmental sustainability so that a project will be both economically and environmentally sound[9]. EIA particularly aims to optimize a trade-off between developmental activities and socio-ecological losses. It is a management tool to be linked closely to the project life cycle to ensure that appropriate environmental information is provided at the correct time. The overall objective of the EIA is to design developmental projects and activities taking into consideration the environmental perspective.

Upcoming engineers do know about the different types of pollution and its remedial action but generally they lack in professional approach in tackling any real project[14]. Keeping this in our view, this study investigates and gives a procedural layout of the environmental impacts of the hydropower project. Using the software (RIAM Basic[1]), analysis of a general hydropower plant setup is being done to show quantitatively the effects of different parameters.

Eia study: Hydropower project

The economic growth is solely dependent on the level of infrastructural development and electrical energy forms a very important input to the development process. India has the unique distinction of having set up the first hydropower plant in Asia[20] at Shivanasamudram in 1902. Since then, hydropower plants have contributed significantly to national demand for electricity. But it is still short of providing electricity to everyone. Looking to the future demand of energy matching with the economic growth, it is a timely need to expand power generation by developing the country's hydropower potential. In 2003, the Prime Minister of India announced a 50,000MW hydropower initiative. Currently, only 21% of this 50,000MW capacity has been harvested. There is a shortage of 10,000MW of electricity in India. The goal of the Government of India is to increase the current hydropower generation to 40%. Investment and expertise from the private sector must play a central in promoting and achieving this de-

velopment. While hydropower holds an important role in the energy and development strategies of India, such natural resource projects are inherently challenging. Environmental and social impacts-potentially both positive and negative-are inevitable[2]. The responsible response is to develop a clear understanding of such impacts, drawing from analytical as well as local knowledge, and minimize the negative impacts through appropriate design. Any residual negative impacts should then be appropriately mitigated and compensated; with ongoing monitoring and adaptive management where necessary.

Key issues

The United Nations Environment Programme(1988) enunciated the simplest and most important principles relating to EIA methodology:

- Focus on the main issues
- Involve the appropriate persons and groups
- Link information to decisions about the project, present clear options for the mitigation of impacts and for sound environmental management and
- Provide information in a form useful to decision-makers.

Unfortunately these recommendations are not always heeded. Too much stress is often placed on mathematical modeling techniques rather than practical assessment methods, and environmental statements tend to provide enormous amounts of detailed, unnecessary information. This can confuse the readers and misdirect them towards the appraisal of less significant environmental impacts. So we put forward a list of various aspects, on which EIA study should have assessed for any hydropower project. We are also suggesting in brief the mitigative measures to make these impacts less severe.

Impacts on land environment

A hydropower project requires significant amount of construction materials, which needs to be extracted from various quarry sites in and around the project area[13]. Normally quarrying is done along the hill face and left untreated after extraction of the required construction material. These sites can become permanent scar on the hill face and become potential source of land slides. So suitable measures should be provided for quarry site stabilization.

During construction phase, various equipments will be brought to the construction site. The placing of these construction equipments would require significant amount of space. Similarly, space will be required for workshop, storing of the equipments and materials etc. In addition, land will also be temporarily acquired for storage of the quarried material before crushing, cement, rubble, sand, fuel storage, parking for vehicles etc. Temporarily various storage sites need to be earmarked for this purpose. The storage site should be selected in such a way that it should lead to minimal impacts on the human life and wild life.

A large quantity of excavated rock is expected to be generated in any hydro electric project as a result of tunneling operations, construction of access roads etc. The muck so generated needs to be properly disposed otherwise it can lead to significant adverse impacts on environment. Sometimes muck is disposed along the river bank which ultimately finds its way into the water body, leading to the adverse on river ecology. Construction of roads in such area can give rise to erosion hazards, if adequate protection measures are not undertaken.

Impacts on water resources

The construction of diversion weirs and storage dams for diversion of discharge of hydropower generation would lead to reduction in flow downstream of the weirs and dam sites up to confluence point of tailrace discharge. However, reduction in flow is likely to have marginal impact, as the discharge during the lean season may be low, but the same is supplemented by contributing from intervening streams[7].

Impacts on water quality

Any hydropower project construction is likely to last for a period of 3 to 4 years. This means that lots of people comprising of workers, technical staff, security guards etc. are likely to work during the construction phase. The construction phase also leads to mushrooming of various allied activities to meet the demands of the of the immigrant population in the project area. Thus, the total increase in population during construction phase can be expected to be around 1000 to 1500 for a medium to minor project[15]. The total quantum of sewage

generated may be in the order of 0.2 to 0.3 MLD. The biological oxygen demand(BOD) load contributed will be about 200-240kg/day. The sewage generally shall be disposed off in nearby streams or channels through open drains, where ultimately it will find its way to river or stream. The inadequate sewage treatment and disposal facilities could lead to increased incidence of water borne diseases. Thus it is necessary to commission appropriate sewage treatment facilities in the vicinity of the project area.

The flooding of forest and agricultural land in the submergence area increases the availability of nutrients resulting from decomposition of vegetative matter. Enrichment of impounded water with organic and inorganic nutrients becomes a major water quality problem immediately and commencement of the operation[11]. So detailed dissolved oxygen (DO) modeling is to be done to estimate the DO level as also other physiochemical and biological parameters in the nearby stream during its initial years of operation and thereafter too.

Impacts on aquatic ecology

During the construction, huge quantity of muck is generated at various construction sites which if not properly disposed off, invariable would flow down the river during the heavy precipitation. Such condition can lead to adverse impacts on the development of aquatic life, which needs to be avoided. Among the aquatic habitants, it is the fish which would be most affected. The migratory fish species are likely to be affected due to obstruction to their migratory route when any diversion structure is created.

Impacts on noise environment

Increased noise level is anticipated only during the construction phase due to operation of various equipment, increased vehicular movement, blasting etc. Generally these sites belong to no man's land, so no significant impact can be attributed due to increased noise level. However, presence of river ecology, it is imperative to conduct detailed noise modeling studies on them.

Impacts on air pollution

Normally diesel is used in construction equipment. The major pollutant which gets emitted as a result of diesel combustion is SO_2[16]. The suspended particulate materials (SPM) are minimal due to low ash content in diesel. So detailed model studies should be done to ascertain the increased SO_2 level. The operation of the crusher during the construction phase is likely to generate fugitive emissions, which can move even up to one km. Since there are no human habitants nearby of the hydropower sites, no major adverse impacts can be anticipated on this account.

Impacts on socio-economic environment

The constructions will generally last for about 3 to 4 years. Those who would migrate to the project area are likely to come from various other parts mainly having different cultural, ethnic and social backgrounds. Due to longer residence in one place, a new culture, having a distinct socio-economic similarity would develop which will have its own entity[6]. Job opportunities will improve significantly in the surrounding area. Any infrastructure projects are significant parts of socioeconomic development in every nation, even though it is still a controversial issue because of large displacement of the local inhabitants. Lack of proper resettlement leads to impoverished situations of displaced people and this will constrain society's development[5]. What is thus necessary is some means for reconciling the plight of the displaced people. This aspect should be clearly mentioned in any EIA report.

Apart from above mentioned points, EIA professional should involve public participation as a part of their EIA studies. The main purpose of the participation is to secure that the interest of the affected population are treated adequately in the project planning. Participation can be beneficial to the local people, helping to reduce negative socio economic impacts from hydropower projects. Participation can also introduce democratic element into negotiations and agreement that may form a base for a long term and solid relationship between the parties. It is also implied that the local people can strengthen their organizational structure which will make them better prepared to define their role in the development process[8].

Methodology

This section presents EIA methodology using the Rapid Impact Assessment Matrix (RIAM). RIAM[12] is a method used to evaluate all sorts of environmental impacts. It allows the completion of subjective classifi-

cations justified for each analyzed item, resulting not only in a clear way, the outcome of the assessment, but also a register for subsequent revaluations. It analyses and presents in a structured, friendly and transparent environment the numerous parameters and alternatives of an EIA. It considers all 4 components: physical/ chemical, biological/ecological, social/cultural, economic/operational.

The RIAM is a scoring impact of components against pre-defined criteria, and transposing scores into ranges describing the degree of positive or negative impacts. Each component is evaluated against each criteria and the value recorded in the matrix. In this instance, the RIAM used the following assessment criteria: importance (A1), magnitude (A2), permanence(B1), reversibility(B2), and cumulation(B3). Using the RIAM formula, the score for each component is then derived[12]. The physical/chemical(PC) components were restricted to those that related to the changes in the quality of groundwater and air pollutants that cause degradation to the environment. Biological/ecological (BE) components reflected changes that might occur with respect to fauna and flora and aesthetics. The sociological/cultural (SC) components are concerned with the effect of the landfill on the public health and safety of the people living in the areas surrounding the landfill, in addition to the impacts on housing. The economical/ operational(EO) components deal with those impacts related to the management mechanism of solid wastes, maintenance, and operation of landfill facilities.

TABLE 1: Environmental classifications according to RIAM

Environmental classification (ES)	Value of the class	Value of the class (numerical)	Description of the class
72 to 108	E	5	Extremely positive impact
36 to 71	D	4	Significantly positive impact
19 to 35	C	3	Moderately positive impact
10 to 18	B	2	Less positive impact
1 to 9	A	1	Reduced positive impact
0	N	0	No alteration
-1 to -9	-A	-1	Reduced negative impact
-10 to -18	-B	-2	Less negative impact
-19 to -35	-C	-3	Moderately negative impact
-36 to -71	-D	-4	Significantly negative impact
-72 to -108	-E	-5	Extremely negative impact

TABLE 2 : Factors aonsidered in the EIA analysis

PC	BE	SC	EO
Geophysics	Impacts on biota	Public acceptability	Future energy need
Soil	Impacts on aquatic habitats	Work opportunity	Indigenous development
Ground water	--	Population growth of the area	Overall Economic Scenario
River water	--	--	--
Climate	--	--	--
Air quality	--	--	--
Noise	--	--	--

The degree of damage and benefit, according to RIAM is shown in the TABLE 1. The first step in the RIAM is to set up a number of different options for the assessment in question, and the RIAM program will individually process these. Present analysis has been done for implementation phase. TABLE 2 shows the parameter considered during this phase.

Discrimination of the results for the phase of Implementation phase is as follows:

TABLE 3 : Summary of scores

Range	-108 -72	-71 -36	-35 - 19	-18 -10	-9 -1	0 0	1 9	10 18	19 35	36 71	72 108
Class	-E	-D	-C	-B	-A	N	A	B	C	D	E
PC	0	1	2	1	1	1	0	1	0	0	0
BE	0	0	1	0	1	0	0	0	0	0	0
SC	0	0	0	1	0	0	0	0	0	2	0
SC EO	0	0	0	0	0	0	0	0	0	3	0
Total	0	1	3	2	2	1	0	1	0	5	0

Graphical presentation of the results according to categories for the phase of implementation is shown in figure 2.

RIAM indicates that the parameters in the PC category are having negative impacts. The most adverse impact is shown by River water quality. And this is obvious. Same is the case for the parameters considered in the BE categories. As hydropower constitutes major infrastructure development. Public acceptability(local) is adverse, as they have to vacate their belongings. But this type of electricity generation project is major boost to the economy of the nation as well as local areas also.

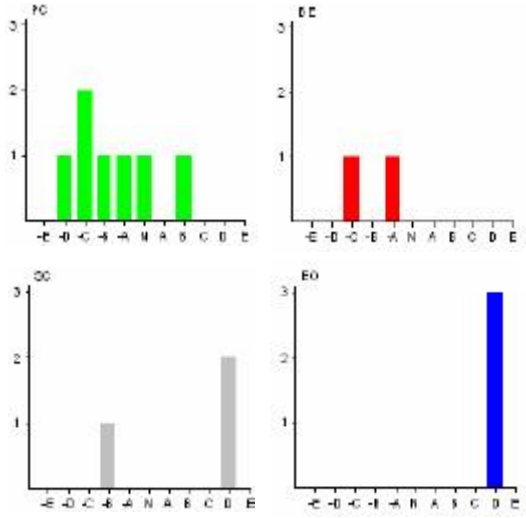

Figure 2 : RIAM Results for the implementation phase

CONCLUSIONS

Generally any EIA report will be a part of the government censored report and no one knows what parameters they have considered or not. This study is generally for a new environment engineering student, of which they should know about the different parameters affected by any hydropower project and what could be done in order to have minimal adverse impacts. This work uses RIAM to judge the quantitatively impacts of different parameters which will be going to be affected due to hydropower installation.

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