ENVIRONMENTAL ASPECTS OF SMALL HYDRO POWER STATIONS

by

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INTRODUCTION

The need to exploit small hydro sources is becoming popular in the developing as well as developed countries. Small hydro development has been taking place steadily since a very long time, where encouraging factors existed. This development has mostly taken place in remote mountainous areas to meet the local energy demand and also in plains through development of canal drops wherever found attractive. To cope up with the increasing energy demand in the country, exploitation of all possible sources, including the hydro resources is getting concerted attention. No doubt, hydro schemes-small or large are somewhat capital intensive to some other type of generation but have the significant advantage of in-built protection against inflation.

Small hydro projects are rather distinct from the conventional major and medium hydro electric projects. Small gestation period and simplicity in project layouts are their attractive features.

Assessing environmental impacts should be a part of the pre-feasibility and feasibility studies for small hydro power projects. The environmental assessment is used along with power, economic and social analysis in evaluating the desirability and feasibility of a proposed project.

PLANNING FOR SMALL HYDRO PROJECTS

Planning of large hydro power plants is usually linked up with national hydro power development plans. The formulation of development plan for a large hydro project involves identification, pre-feasibility studies of all or a number of selected potential sites which forms a basis for ranking them according to merit and detailed feasibility studies.

However, the planning for a small hydro power development cannot sustain the cost involved in a comprehensive set up required for a large hydro power programme. Even though SHP have got similar components as that for a large hydro stations, each SHP must be tailored to suit the local topographic, geologic and other conditions at site.

For the hilly and remote areas, where grid supply is not available it is highly desirable to install the micro hydro power station there, provided other favorable parameters exist there. For such stations, a local grid can be made. This will greatly help for the following:

1. To prevent migration of people for such remote areas to plains.
2. To improve the quality of the life of people living in those areas.
3. To check deforestation by making available electrical energy for cooking and other purposes.
4. Socio economic upliftment of tribal population in these areas.

PLANNING WITH RESPECT TO ENVIRONMENT IMPACTS

Planning of SHP should be such that there is no adverse effect on environment and ecology of the area. At pre-feasibility stage, following major questions are sought -

a) Is the provision of electrical energy in the area desirable and will the development be stimulated by the provision of electrical energy be productive and protective of the resource base?
b) Is there enough water of adequate quality to support a hydropower project?
c) Are there any legal, historical, religious, archeological, scientific, wildlife or habitat features of the project area that would preclude project development.
d) Will relocation of people be required? If so, is relocation feasible?
e) In the event of diversion structure failure, would any downstream populated area be endangered?
f) Are there any special physical characteristics of the site that would make it not feasible, such as volcanic activity, earthquakes, soil & rock instability or inability to store water.

If the answer to either of the first two questions is no or the answer to any of the other four questions is yes, there are serious environmental questions about the site. It should either be eliminated from further consideration or major attention must be given for resolving the issues raised by these questions.

It should also be the endeavor of the planners that the area be developed like a tourist spot or the place where people like to visit. Table - 1 below indicates what impacts can be on environment while planning a small hydro power project.

A detailed examination of the causes and impacts from Table - 1, lead to the following environmental concerns pertaining to small hydro electric projects:

- Effects of construction
- Effects on fisheries and other aquatic life.
- Effects of storage of water in the dam or water quality and vectors of diseases.
- Effects on downstream caused by quality of discharges, discharge of toxic wastes and possible changes in channel configuration.
- Effects on recreational facilities.
- Effects of dredging and filling of wet lands.

During reconnaissance survey the permanent and temporary impacts of the above mentioned environmental issues need to be assessed alongwith measures identified to mitigate the effects. Actual costs of amalgamation of the individual environmental concerns can be estimated. For such features which cannot be estimated, costs can be computed based on costs of similar features provided in other projects.

Table 1: Environmental Impacts of Hydroelectric Projects

ACTIVITY		IMPACT	
(A)	CONSTRUCTION OF DAM	1.	Reservoir sedimentation, turbidity and deterioration in water quality.
(B)	POWER HOUSE, SWITCH-YARD	1.	Pollution and disturbances to flora and fauna by work force.
		2.	Visual intrusion caused by construction activity.
		3.	Disturbances to recreational spots and activity.
(C)	CONSTRUCTION OF TRANSMISSION LINE	1.	Damaging of flora.
		2.	Endangering the lives of fauna.
		3.	Visual intrusion
(D)	STREAM DIVERSION THROUGH CHANNEL AND CONDUCT	1.	Dewatered river bed
		2.	Migration of fish affected.
		3.	Depletion in ground water recharge where diversion is taken off from an effluent stream.
		4.	Change in flow regime.
(E)	PONDING	1.	Flow disruption.
		2.	Channel degradation during generation or spilling and flushing of silt from dam, Trapped nutrients and sediments.
		3.	Changed water temperature.
		4.	Change in land uses:
		5.	a) submergence of agricultural land mostly potentially prime b) Submergence of human settlement c) Submergence of monuments/site of historic importance d) Loss of white water recreation
		6.	Change in aquatic plant life and fish species.
		7.	High evaporation rate
		8.	Sedimentation adversely affects fish

			spawning areas by burying them.
		9.	Provides increased habitat for mosquitoes and snails which are vectors of diseases like malaria, yellow fever dengue, encephalitis etc.
(F)	OPERATION OF HYDROPOWER STATION	1.	Increase in toxicity in the downstream due to release of sewage disposal from power house and release of toxic chemical formed in the impoundment through aquatic food chain.
		2.	Released water containing greater concentration of hydrogen sulphite, and reduced ionic forms of iron and manganese.
		3.	Fish mortality from turbine passage.
(G)	PEAKING OPERATION OF POWER STATION	1.	Damage to fish spawning ground and nesting ground for water fowls and other aquatic birds.
		2.	Erosion of Banks.
		3.	Transport of nutrients from the shallow water to deeper water in pond.
		4.	Affects recreational facilities due to fluctuating level.
		5.	Exposure of drawdown zone creates visual intrusion.

Table 2 Below indicates some potential negative impacts leading to environmental problems and their mitigating factors also.

Table 2

Potential Negative Impacts		Mitigating Measures	
	DIRECT		
1.	Negative environmental effects of construction: a) Air and water pollution from construction and waste disposal b) Soil Erosion c) Destruction of vegetation	1.	Measures to minimize impacts : a) Air and water pollution control b) Careful locations of camps, buildings, borrow pits, quarries, spoil and disposal sites. c) Precautions to minimize erosion d) Land reclamation

	d) Sanitary and health problems from construction camps		
2.	Dislocation of people living in inundation zone	2.	a) Relocation of People to suitable area b) Provision of compensation in kind for resources lost. c) Provision of adequate health services, infrastructure, and employment opportunities.
3.	Loss of land (agricultural, forest, range, wetlands) by inundation to form reservoir.	3.	a) Sitting of dam to decrease losses. b) Decrease of dam and reservoir size c) Protection of equal areas in region to offset losses. d) Creation of useable land in previously suitable areas to offsets losses.
4.	Loss of historic, cultural or aesthetic features by inundation	4.	Sitting of am or decrease of reservoir size to avoid loss. Salvage or protection of cultural properties.
5.	Loss of wild lands and wildlife habitat	5.	a) Sitting of dam or decrease of reservoir size to avoid/minimize loss. b) Establishment of compensatory parks or reserved areas. c) Animal rescue and relocation.
6.	Proliferation of aquatic weeds in reservoir and downstream impairing dam discharge, irrigation systems, navigation and fisheries and increasing water loss through transpirations.	6.	a) Clearance of woody vegetation from inundation zone prior to flooding (nutrient removal). b) Weed control measures. c) Harvest of weeds for compost, fodder or biogas. d) Regulation of water discharge and manipulation of water levels to discourage weed growth.
7.	Deterioration of water quality in reservoir	7.	a) Clearance of woody vegetation from inundation zone prior to flooding. b) Control of land uses, wastewater discharges, and agricultural

			chemical use in water shed. c) Limit retention time of water in reservoir. d) Provision for multilevel releases to avoid discharge of anoxic water.
8.	Sedimentation of reservoir and loss of storage capacity.	8.	Hydraulic removal of sediments (flushing, sluicing, release of density currents). Operation of reservoir to minimize sedimentation (entails loss of power benefits).
9.	Formation of sediment deposits at reservoir entrance creating backwater effect and flooding and water logging upstream.	9.	Sediment flushing, sluicing.
10.	Scouring of riverbed below dam.	10.	Design of trap efficiency and sediment release (e.g. sediment flushing, sluicing) to increase salt content of released water.
11.	Decrease in floodplain (recession) agriculture.	11.	Regulation of dam releases to partially replicate natural flooding regime.
12.	Disruption of riverine fisheries due to changes in flow, blocking of fish migration, and changes in water quality and limnology.	12.	Maintenance of atleast minimum flow for fisheries. Provision of fish ladders and other means of passage. Aquaculture and development of reservoir fisheries in compensation.
13.	Increase of water-related diseases.	13.	Design and operation of dam to decrease habitat for vector. Vector control.
14.	Conflicting demands for water use.	14.	a) Planning and management of dam in context of regional development plans. b) Equitable allocations of water between large and small holders and between geographic regions of valley.

15.	Social disruption and decrease in standard of living of resettled people.	15.	a) Maintenance of standard of living by ensuring access to resources at least equaling those lost. b) Provision of health and social services.
16.	Environmental degradation from increased pressure on land.	16.	a) Choice of resettlement site to avoid surpassing carrying capacity of the land. b) Increase of productivity or improve management of land (agricultural, range, forestry improvements) to accommodate higher population.
17.	Disruption / destruction of tribal / indigenous groups	17.	Avoid dislocation of people and where not possible, relocate in area allowing them to retain lifestyle and customs.
18.	Increase in humidity and fog locally, creating favorable habitat for insect disease vectors (mosquitoes, tsetse).	18.	Vector control
	INDIRECT		
19.	Uncontrolled migration of people into the area made possible by access roads and transmission lines.	19.	Limitation of access, provision of rural development and health services to try to minimize impact.
20.	Environmental problems arising from development made possible by dam (irrigated agriculture, industries, municipal growth).	20.	Basin-wide integrated planning to avoid overuse, misuse and conflicting uses of water and land resources.
21.	Poor land use practices in catchment areas above reservoir resulting in increased siltation and changes in water quality.	21.	Land use planning efforts which include watershed areas above dam.

From Table- 1, it is also evident that the mode of operation of the power station, i.e. run-of-river or peaking, effects the environment to different degrees and that the impact of run-of-river mode operation of the power station is much less as compared to the power station capable of meeting peaking power. However, if run-of-the river scheme involves a long diversion channel more than say 50 meter in length, the construction of the channel

may involve deforestation and destabilization of hill slope. To ameliorate the effects of the channel construction it will be necessary to take adequate measures for stabilizing the hills slopes, for providing super passage for drainage of water and for providing passages for the wild life.

SOME SPECIAL ENVIRONMENTAL ISSUES

Damming the river and creating a lake like environmental has profound effects on the hydrology and limnology of the river system. If the inundated land is heavily wooded and not sufficiently cleared prior to flooding, decomposition will deplete oxygen levels in the water. This affects aquatic life and may result in large fish kills. Products of anaerobic decomposition include hydrogen sulfide, which corrodes generator turbines and is noxious to aquatic organisms and methane, which is explosive and a green house gas.

Oxygen depletion typically occurs first in the deeper water where oxygen used by bacterial in decomposition is not offset by oxygen released by plant photosynthesis. When the intake for power generation is located at the lower level of the reservoirs, as is usually the case, water released from the turbines into downstream waters may be deficient in oxygen and may contain hydrogen sulfide. It may also be lower in pH and colder than the surface water. Releases of water with these characteristics can adversely affect plant and animal communities in the river below the dam.

CONDUCT OF ENVIRONMENT IMPACT ASSESSMENT

The preparation of an environmental impact assessment can be simple or complicated. The potential impacts are many and varied. Modifications are frequently made in the proposed project during the assessment. To cope successfully with these factors, following process should be adopted.

a) The results of the pre-feasibility assessments are reviewed. Persons knowledgeable about the area are consulted for advise on pertinent information.
b) Available information is reviewed and summarized. It includes maps, project descriptions etc. A more detailed work plan is prepared to guide the remainder of investigation.
c) Agencies, organization and individuals that need to know about or be involved in the investigation are informed and plans laid for their involvement.
d) Field studies are undertaken. New data is collected if necessary. During the field visit, some judgments can be made about the overall impact of the project and about mitigating measures or alternative ways either to enhance its usefulness or to reduce adverse environmental impacts.
e) Impact assessment report is written and reviewed. Inaccuracies are corrected and the judgments made by the impact assessment team are evaluated.

MEASURES TO MAKE RUN-OF-RIVER SHP ENVIRONMENTALLY SUCCESSFUL

The construction of big hydro-electric schemes bring about a considerable change in the landscape of the countryside. This is due to the diversion of river course from one catchment to another, rise in the level of existing lakes or reservoirs, submergence of adjacent public property to create new reservoirs etc. But in SHP also some changes may take place, which may partly affect the local flora and fauna of the area. These changes may attract opposition from the inhabitants of the area concerned. But modification of the nature by man is a prerequisite for any development. Man made action may have its effect on the environment, disturbing the balance of the nature. At the same time the very existence of man is dependent on all other communities in the total bio-sphere and it is in the interest of man to keep them alive and in a proper balance.

Hydro Electric Projects started in a spirit of general goodwill should not land into an atmosphere of suspicion and opposition. The SHP's located on Run-or-River scheme may add to the aesthetics and beauty of the area if well thought off and given due consideration for the same. It can also be used as a place of great tourist attraction. Such consideration may make the schemes environmentally successful.

ECOLOGICAL ASPECTS

Hydropower development entails upon nature and on the sitting of components which often affect landscape and natural environments. Efforts should be to create new cultural landscape that are alive-not dead ruins. Also the goal should be to protect the natural environment and old cultural landscapes. But it is also widely recognized that modern hydropower developments are usually so extensive and of such special character that landscapes and part of landscapes affected must be dealt with and fashioned according to present day needs and techniques. As far as possible, and architect should be involved in the project since its inception. Man has always left his mark on nature through use and activity. The big difference is that due to increased information and technical skills, today's man has a much greater ability to influence and change his environment, be it positive or negative.

Many hydro-electric schemes are located where natural fall is available. In India, the Himalayan areas in general is an active seismo-tectonic belt comprising of the World's youngest mountain chain with a complex geological section full of faults and fractures. As the hydro-pore pressure in the area increases with water storage, the intensity of the earthquake gets enhanced. The environmental degradation of catchment area can not be predicted in the absences of data and hence it calls for detailed investigation.

For Pooyam Kutty Hydro Electric Project (in Idduki district in the Western ghats of Kerala) about 3001 hectare of rich forest would be cleared and 6000 hectare of continuous stretch of thick forest would also be destroyed. It would submerge about 2800 ha of

landscape consisting of natural tropical forests. In case of Tehri project also about 1500 hectare of fertile land which is only 36% of the submerged area would be submerged.

SHPs fortunately involve a less area and no dams are generally constructed on run-of-river schemes. Even then every efforts should be taken to prevent deforestation and environmental degradation.

Some of the measures to improve the environment of the area and enhance the socio economic development of the area are as below