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Framework for Strategic Environmental Assessment in Context of Hydropower Development in the Indian Himalayan Region

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Abstract

Under prevailing influence of fatal energy demands, power sector policy of India is now emphasizing on development of hydropower as a potential source of electricity. Owing to profuse water resources and favorable geography, Indian Himalayan Region (IHR) has become a preferred destination for hydropower in India. It has been planned to produce around 78% (117239 MW) of total potential of country from IHR only. Though various inter linked and complex issues of environmental protection pertaining to large scale developments are broadly covered under the prevailing EIA regulation, however, it has been demonstrated by several researchers that EIA has its own limitations. Moreover, IHR, an important landscape on earth constitutes a fragile unique ecosystem having peculiar settings and functions and therefore such regions should be treated specially. Strategic Environmental Assessment (SEA) has been established in many countries as a proactive and comprehensive tool to assess impacts of policies, plans and programs early in decision making. Therefore, on identifying the scope and opportunities, this paper presents a working framework of SEA in context of hydropower development in IHR. This paper is an effort to evolve SEA in spatial and sectoral contexts together.

Key words: *EIA, Strategic Environmental Assessment (SEA), Hydropower, Indian Himalayan Region*

Introduction

With due consideration to lessen the negative and augment the positive environmental impacts of developmental actions many countries have adopted Environmental Impact Assessment (EIA) as a decision tool. EIA is now being practiced in more than 100 countries worldwide (Donnelly et al., 1998). Under the Environment (Protection) Act 1986, Ministry of Environment and Forest, Government of India has formulated and enacted the dignified EIA regulation in 1994 (MoEF, 1996), and the same has been amended a few times in last 16 years. Environmental Clearances (ECs) have been granted to nearly 6000 projects so far (under Central/National body, since 1986) and the number is increasing rapidly. Although the role and importance of EIA in environmental management can't be ignored, but it's actual execution seems to be inadequate. The evidence of growing awareness in the face of continued failure of the EIA process is manifesting in terms of violent conflicts all around the country (Rajaram and Das, 2007). Despite the existence of government's EIA notification, environmental degradation continues to be a major concern in developing countries (Habib, 2005). The quality of EIA reports in India is improving but the experiences with regard to the effectiveness of the EA process in influencing the project design and implementation is not fully satisfactory (World Bank, 1999). Despite the many methodological and administrative advances in EIA over the past two decades, recent experience in many countries confirms that there is still considerable scope for strengthening the process (Sadler, 1996). There are several other noticeable national and international experiences which have been demonstrating the weakness of the EIAs as it is being currently practiced (Jay et al., 2007; Nadeem and Hameed, 2006; Murthy and Patra, 2005; Vagholikar, 2005; Momtaz, 2002; Chatterjee, 2009). It is, therefore, now being argued that long-term environmental sustainability can be achieved by evaluating the consequences of past, present and future developments in the light of international experiences gained so far. The innovations for improving the methodologies of environmental assessment and limitations of the formalized EIA process worked as a driving force for evolution of a more comprehensive decision tool which is known as Strategic Environmental Assessment (SEA). The need for SEA has arisen from the shortcomings and project-specific nature of EIA studies and the awareness to address the issues in the process of policy and plan making (CSIR, 1996). SEA is emerging as a comprehensive tool in environmental decision making, encompassing the unaccountable environmental considerations and alternatives directly into policy, plan and program design.

Need for development of a Regional SEA Framework for hydropower Sector

Indian Himalayan Region (IHR), on account of richness and uniqueness of biodiversity elements is represented fairly well within the protected area network (Table 1) of the country. The region is well known for its ethnic communities coupled with its vast tourism potential that has attracted tourist world over since times immemorial. The population density and per capita income of the states within Indian Himalayan Region (Table 1) are lower than national average; although recently the rate of development of these states has been increasing but at the same time anthropogenic pressures is also rapidly increasing. Distinguished workers from various backgrounds have been elaborating that the Indian Himalayan Region (IHR) constitutes a fragile ecosystem that has its own peculiar settings and functions which make it imperative to have special considerations. On the other hand, as a result of energy hunt efforts of the government, IHR has been identified as the most potential region of the country. As per the government sources, IHR which is only 16.23 % geographical area of country is being embattled to exploit 78.84% of total hydropower potential of the country (Table 1).

Hydropower in India is becoming one of the most promising energy options due to availability and added advantages of owning 'low cost' and 'green energy' status, thus government of India is trying to increase the share of hydroelectricity. In process of developing the so called 'green source' of electricity, clusters of small and giant projects are being constructed. This crowding approach can indeed lead to shaky proliferation of the planned action as well as the environment. Indubitably the Himalaya owns all physical settings desired for installation of an efficient hydropower project but perversely the natural resources, environmental and climatic gains, fragile ecosystem, seismic and other inherent vulnerabilities are indeed the matter of cautious debate before the further policy implementation takes place emphatically. To make this development sustainable, it is now imperative to proactively evolve a balance between actual gains and losses and then strategically advance the development. Given the fragility and vulnerability of the Himalayan ecosystems, developmental interventions in the IHR thus call for proactive environment management. The project level EIAs and their actual implementation is always a cause of apprehension, thus there is a need to put forward a comprehensive impact assessment framework in action (Thakkar, 1999). Agrawal et al. (2010) has profoundly analyzed the developmental stresses in terms of hydropower vis-à-vis present EIA practice in context of IHR, they urged for adaptation of proactive approaches as SEA for environmental assessment in IHR. To overcome the discoursed challenges associated with EIAs and to upgrade the environmental assessment process, in early 90s a new tool "SEA" came in discussion globally.

This concept has been continuously evolving through critical research and discussions rapidly. It has been more than a decade since SEA is being rigorously discoursed, approved and adopted internationally in theoretical and analytical ways (Runhaar and Driessen, 2007; Chaker et al., 2006; OECD, 2006; Maria, 2000; Fischer, 1999). The concept of SEA in its progression has developed into operations frameworks in many countries as US, UK, Canada, Denmark, Netherlands etc. with specific directives/regulations.

SEA, particularly in energy sector has been applied by Nilsson et al. (2005), apart from that there is a very pertinent example of SEA application in hydropower sector itself from Lao PDR. The study made assessment of the combined impacts of 21 hydropower projects planned for implementation before 2010. The study successfully resulted in formulation of several noteworthy recommendations on safeguard of social, ecological and technical issues (LAO 2004). Clive et al. (2003), studied the status of implementation of EIA and future adaptation of SEA in Asia, the study advocated for the future adoption of SEA in Asia, similarly Dusik and Xie under a World Bank program studied the scope and opportunities of SEA in East and Southeast Asia (Dusik and Xie, 2009). In India, the only SEA work exercised by Rajvanshi (2001) under India Eco-development Project (IEP) which was not for any of the listed activities under EIA notification, considers itself as a starting point for promoting SEA in the country. The role of SEA in the formulation of integrated and sustainability oriented conservation policies and its tremendous potential as a flexible planning tool is reasonably well-understood to motivate EIA practitioners for future SEA initiatives in the country and the region (Rajvanshi, 2001). In the light of discoursed state of affairs so far, the concept of Strategic Environmental Assessment (SEA) appears as an appropriate decision tool in systematically gauging and optimizing the material gains and environmental damages of a developmental endeavor. This concept seems further imperative for a region like Himalayas. As per the present environmental legislation in India, there is no any government policy or approved framework on SEA so far, thus it also urges to take up elementary moves in developing SEA in India.

Methodological framework

SEA, with a lot of experimentation and improvements, has been evolving under many sectors in several countries of world with adoptive customizations in its operational forms/frameworks (Rajvanshi, 2001; Che and Shang, 2004; Nilsson et al., 2005; Say and Yucel, 2006; Retief, 2007; World Bank, 2009). Extensive literature review is presented in Retief (2007) on quality of SEA processes with case studies from different sectors in South Africa. Finnveden et al. (2003), elaborated about the different stages of SEA and analytical tools which can be applied to facilitate and enhance the SEA process, and also suggested an interactive framework of SEA methodologies for energy sector. In principle, the concept of SEA is derived for policy, plan and/or program, while in the present case, need based effort has been made to add a new catalytic factor into the present structure, that is 'a special area or region' where the policy/plan/program is to be implemented or in other words the region which is going to receive all positive and negative impacts of a policy.

SEA system has been divided into three general procedural forms, in its standard (EIA-based) model the SEA of policies and programs generally follows the EIA process with similar steps and activities but with differences introduced by more fluid policy requirements (Caratti et al. 2004). The most stringent definition of SEA proposes that principal stages of SEA and EIA procedure are the same (Lee and Walsh 1992). Based on the learning from the internationally accepted work, here it is proposed to extend the basic principles of EIA to a broader scope for undertaking strategic assessment of various interlinked processes and their direct or indirect interactions with the environmental parameters. In the present case, the scope of study is based on two fundamental constants one is a particular 'sector' and second is a 'specific region', which is making it a relatively new domain. It is apt to mention here that it would be difficult to include all micro level issues into the framework in one go, therefore, based on the substantial practical experience of carrying out EIA studies in IHR, discussions with local stakeholders and cogitation of available literature, it has been tried to include maximum possible critical issues in the framework keeping scope for further amendments in future. The operational procedure tailored for this particular SEA framework mainly comprises of six major stages and to strengthen these stages few auxiliary elements have been included (Figure 1).

The specific rationalization for each stage and sub-stage is methodically discussed ahead in next subsections under an explicitly designed framework for hydropower development in IHR. It is important to clearly mention here that few sub-stages of the presented framework (as in Figure 1) have not been elaborated separately as these are same as in project EIAs.

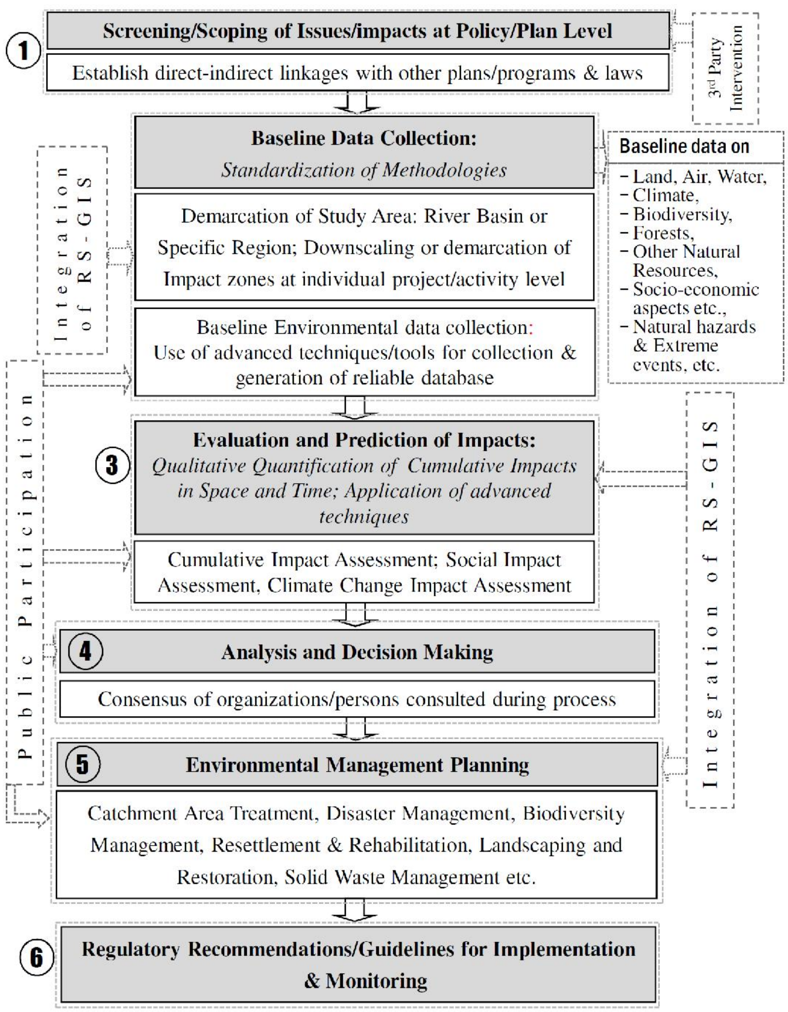

Figure 1: The proposed SEA framework concept**.**

Table 1: State wise salient bio-geographic features of Indian Himalayan Region and hydropower potential.

IHR State	Geographical Area* (km^2)	Population (As per 2001 Census*)	Population Density* (As per 2001 Census)	Forest cover, * (km^2) (2001)	Number of Protected Areas in IHR (2000)**		Per Capita Income for the year 2005-06, (`)***	Total Hydropower Potential (MW)**** (As on 31.08.2010)	
					National Parks	Wildlife Sanctuaries		Identified (reassessment)	Developed + Under Construction
Arunachal Pradesh	83743	10,91,117	13/km^2	68041	2	11	23,788	50328	3115.0
Uttarakhand	53483	84,79,562	159/km^2	23939	6	6	24,585	18175	5051.4
Himachal Pradesh	55673	60,77,248	109/km^2	14385	2	32	33,805	18820	10601.0
Jammu & Kashmir	222236	1,00,69,917	99/km^2	21245	4	15	18,630 (2004-05)	14146	3449.0
Sikkim	7096	5,40,493	76/km2	3193	1	5	26,412	4286	2636.0
Meghalaya	22429	23,06,069	103/km^2	15584	2	3	23,420	2394	322.0
Mizoram	21081	8,91,058	42/km^2	17493	2	4	22,417 (2004-05)	2196	0.0
West Bengal Hills	3149	16,05,900	510/ km^2	2196	2	3	25,223	2841	369.0
Manipur	22327	23,88,634	107/ km^2	16926	1	3	20,326	1784	105.0
Nagaland	16579	19,88,636	120/ km^2	13344	1	3	20,998 (2004-05)	1574	75.0
Assam Hills	15322	9,98,509	65/km^2	12230	--	4	18,598	680	375.0
Tripura	10486	31,91,168	304/km^2	7065	--	4	24,706	15	0.0
IHR	**533604**	**3,96,28,311**	**74/km^2**	**215641**	**23**	**93**	**----**	**117239**	**26098.4**
INDIA	**3287263**	**1,02,70,15,247**	**324/ km^2**	**675538**	**95**	**500**	**25,956**	**148701**	**46366.8**

Sources: ** http://www.gbpihed.nic.in ; ** http://www.wii.gov.in/envis/envis_pa_network/index.htm); *** http://pbplanning.gov.in/pdf/Statewise%20Per%20Capita%20Income%20%20Current.pdf ; **** http://www.cea.nic.in/hydro*

Baseline data collection

Standard Methodologies for baseline data collection

Quality of any Environmental Assessment (EA) work solely depends on environmental baseline data and therefore considerable amount of time and energy should be invested on this. A comparative study of some randomly selected EIA reports of hydropower projects proposed or existing in IHR only is presented in Table 2.

The table is methodological discrepancy in EIA studies as a result of autonomy the present EIA legislation allowing. It may be noted in the table that for biodiversity assessment, which indeed requires greater attention in the context of IHR, no specific methodology have been followed for baseline studies (Table 2). Similarly, for socio-economic surveys, the adopted methodology varies significantly in selected EIA reports. In addition to the EIA reports referred in Table 2, some other reports were also studied and it was found that at times only secondary data from 'Census of India' is used for socio-economic assessments without validating it from primary data. Another similar observation on assessment of impacts on aquatic ecology shows that majority of the reports are putting frivolous efforts on it. Together these glimpses put forward for adoption of standardization of methodologies and uniform approaches for baseline data collection. Although very recently Ministry of Environment and Forest (MoEF), Government of India has probably started to partially redesign the existing EIA framework particularly for river valley projects and started developing a 'Guidance manual for EIA and clearance of river valley projects' which is in draft form so far. Certainly such documents can strengthen the EIA process in country; however in lack of strong legal strength the effective implementation cannot be assured. Under the proposed SEA framework, it is espoused to develop a set of region specific methodologies with an obligatory fulfillment of 'required minimum size' of primary data. Additionally, the methodologies should be able to accommodate all heterogeneous parametric issues at one common platform and there should not be any disagreements from stakeholder's (mainly local people) or government's perspective.

Demarcation of influence zone: Scale issue

A characteristic limitation of present EIA process is its confined project level approach, which does not solicit for inclusion of any other nearby projects/activities under environmental assessment. As per the EIA guidelines, for baseline data collection and impact assessment studies a standard influence zone which is a circular area of 10 km radii centering the dam site should be covered. Taking the benefits of flaws in existing EIA guidelines, practitioners adopting 'convenient' instead of 'desirable' methodologies and therefore every second EIA report of hydropower sector adopted different methodology for impact zone delineation which actually misleads the unique understanding of impact/influence zone (Table 2). In general, the influence zone is demarcated simply drawing a circle of 10 km radius taking dam/barrage site as the center point. While doing so, it is overlooked that; *a) other components of the project, especially powerhouse site in case of hydropower projects can be located far away from the dam site (more than 10 km in most of the cases), b) hydropower projects with high dams result in substantial submergences of area, because reservoir extends to many kilometers in the upstream river reaches*. Taking example of Tehri hydropower project (1000 MW) which is one of the largest operational hydropower projects in central Indian Himalayan region, its reservoir spreads over approximately 42 km^2 at the full reservoir level. The length of the reservoir along Bhagirathi river is 44 km and along the Bhilangana river is 25 km (Jain et al. 2007). Another similar example is Tipaimukh multipurpose project (1500 MW) on Barak river in North-East India, which is creating quite a lot of far-reaching impacts in downstream upto Bangladesh (Zakir 2005). Therefore, ideally speaking, the entire area encompassing all major project components should be considered as influence zone under EIA studies for a single project. However, under present SEA framework, influence zone proposed to be extended at regional level first covering a river valley and further downscaling for extensive studies at individual project level following the foresaid demarcation and cumulative assessment.

Evaluation and prediction of impacts

The entire exercise requires initial understanding of existing state of the environmental attributes and then in conjunction with the proposed activities the impacts are identified and categorized as positive and negative gains. However, at present in project EIAs emphasis is given on theoretical assessment of impacts instead of applying quantification tool/models for prediction (see Table 2). Thus, in support of the theoretical assessment, it is appropriate to imply statistical simulation models for prediction of spatial and temporal distribution of impacts. While predicting social impacts group of local peoples may be consulted for general consensus.

Table 2: Methodological discrepancies found in few arbitrarily selected EIA reports of hydropower projects from Indian Himalayan Region.

Particulars of Environmental Parameters		Hydroelectric Projects				
		1	2	3	4	5
		Rampur HEP (412 MW)	**Uri HEP (240 MW)**	**Vyasi HEP (120 MW)**	**Vishnuprayag-Pipalkoti HEP (444 MW)**	**Kotlibhel – 1A HEP (195 MW)**
Study Area	Location (State)	-Himachal Pradesh	-Jammu & Kashmir	-Uttarakhand	-Uttarakhand	-Uttarakhand
	River	-Satluj	-Jhelum	-Yamuna	-Alaknanda	-Bhagirathi
	Influence area (Area under study)	-7 km aerial distance from power house, dam site and other project appurtenants	-The whole catchment and direct impact and indirect impact zone	-7 km aerial distance from the periphery of reservoir rim	-7 km from dam site	-Free draining area between dam site and next u/s project and 7 km downstream from power house
Air	Air Sampling Parameters	- 2 sampling locations; 1 season - SPM, RPM, SO2 and NOx	- 3 sampling locations; 1 season - SPM, SO2 and NOx	- 4 sampling locations; 3 season - SPM, RPM, SO2 and NOx	- 3 sampling locations; 1 season - SPM, RPM, SO2 and NOx	- 4 sampling locations; 1 season - SPM, RPM, SO2 and NOx
Water	Sampling locations for river water quality	- 4 sampling locations for water quality; - 6 sampling locations for phytoplankton and benthic population study - 3 sites for fisheries study were selected.	- 6 sampling points for water quality	- 4 sampling locations for water quality - 4 sampling locations for aquatic ecology *Sampling locations were within 7 km radius of the dam site.	- 5 sampling points for water quality - 3 sites for aquatic ecology * Sampling locations were within 5km radius of the dam site	- 9 sampling locations for water quality - 5 sites for aquatic ecology on a stretch of 45 km on river Ganga and Bhagirathi
	Aquatic ecology	Phytoplankton, benthic population and fishes were enumerated based on secondary source data	Phytoplankton, zooplankton, benthos and fishes enumerated based on primary analysis within the project area	Phytoplankton, zooplankton, benthos, fisheries, aquatic weeds were enumerated based on sampling and secondary sources	Phytoplankton, zooplankton, benthos and fisheries, aquatic weeds were enumerated based on primary and secondary sources	Fisheries and benthos based on primary and secondary sources

	Recommendation for Environmental Flow	10% of lean season flow	Not mentioned	2 cumec	Not mentioned	Report claims additional inflow below dam axis due to reverse slope between TRT and dam
Biological	Floral Study: Sampling Methodology	- Random quadrat sampling - Sampling area for the project was only within 1 km on the either side of the river banks - 2 season sampling	-Random quadrat sampling -Sampling was done only in dominated vegetation type (coniferous and scrubs forest) of free catchment of the project. - 3 season sampling	- Random quadrat sampling - Sampling was done for different forest type present in submergence and influence zones of project study area - 3 season sampling	- Quadrat sampling followed by belt transect - Sampling was done only at three selected sites within 1 km on either side of the river bed - 3 season sampling	- Random quadrat sampling - Sampling was done for submergence and influence zone of project study area i.e. 7 km radius from project site - 3 season sampling
	Number of quadrates	- 20 for trees and shrubs (10mX10m) - 10 herbs (1mX1m)	-10 for trees and shrubs (10mX10m) - 25 herbs ((1mx1m)	- 46for trees and shrubs (10mX10m) - 46for herbs (1mX1m)	- 3 sites were selected instead of quadrates	- 48 circles of 10m radius for trees and 5m radius for shrubs in 8 transect - 4 (1mX1m) square plots for herbs in each circle
	Vegetation analysis methodology	Species list recorded during study was given and their Importance Value Index	Species list, economic importance, forest produce, medicinal value, Importance Value Index (IVI) of trees	Species list, Economic importance, Medicinal value, Importance Value Index (IVI) and species diversity indices	Species list, Economic importance, Medicinal values, Importance Value Index of the recorded species	Species list, economic importance, medicinal value, Importance Value Index (IVI) and species diversity indices
	Faunal study: Sampling Methodology	Only checklist of that faunal species is given	Strip and line transect method (Rodgers 1988) was used, on the basis of checklist of faunal elements were given	Belt transect method was employed for faunal study and on the basis of which distribution of faunal elements were given	Visual survey in the study area and from the secondary source	Line transect method was employed and on the basis of which distribution of faunal elements were given
Socio-	Project affected families (PAFs) surveyed (%)	39.53 % (85 out of 215 families as per revenue records)	40 % (494 out of 1237 families; survey was conducted among the project affected villages)	100 % (137 families out of 137)	70.50 % (251 out of 356 families)	64.13% (202 out of 315 families)

	Compensation package to the PAFs (on account of Land, homesteads, trees, livelihood etc.)	Compensation package given in report that can be used in estimating PAFs amount	Compensation package given in report that can be used in estimating PAFs amount	Compensation to be paid to PAFs given individually	Not prepared at the PAF level	Compensation package given in report that can be used in estimating PAFs amount
Cum. Impacts	Cumulative impacts Assessment	Not attempted in EIA report	Not attempted in EIA report	Not attempted in EIA report * 5 other hydropower projects in upstream and almost same in downstream side of the project	Not attempted in EIA report * 3 other hydropower projects in upstream side of the project.	Not attempted in EIA report * More than 2 hydropower projects in upstream of the project site
Prediction	Prediction of impacts and use of quantification tool	Quantification of impacts at individual level is presented in report but overall quantification and prediction is not given	Qualitative assessment but no quantification tool was used	Qualitative assessment and Wegner & Rhyner (1972) mathematical matrix was used for quantification	Quantification of impacts at individual level is presented in report but overall quantification and prediction of impacts is not given	Rough qualitative assessment but no quantification tool was used
EMP	Use of advance tools/techniques in designing EMPs	- No application of RS-GIS approaches - None of the tool/model used in any of the EMP formulation	- RS-GIS approach used in designing CAT plan - DAMBRK model used for flood simulation	- RS-GIS approach used in mapping and designing EMPs - DAMBRK model used for flood simulation	- RS-GIS approach used in designing CAT plan - DMP is absent in report	- RS-GIS approach used in mapping and designing EMPs - DAMBRK model used for flood simulation

Abbreviations: SOx – Oxides of sulphur; NOx – Oxides of Nitrogen; RPM – Respirable Particulte Matter; Policy; cumec – m^3/s; D/S – Downstream; U/S – Upstream; PAFs – Project Affected Families; EMP – Environmental Management Plans; Cum. – Cumulative; Socio-Econ – Socio-Economic; DMP – Disaster Management Plan; CAT – Catchment Area Treatment

Cumulative Impact Assessment

One of the most important reasons compelling for moving over to SEA is the ignorance of cumulative impacts in project level EIAs. From personally reviewing many completed EIA studies of hydropower projects particularly from IHR, it has been experienced that almost all studies are omitting the cumulative impact assessment. Invariably, in individual project level EIA's arguments are put forward that similar species (floral or faunal) biodiversity or other natural resource is existing in contiguous forest/areas of the influence zone and henceforth it is recommended that no serious threats to biodiversity of a region is envisaged. However, it is very easy to comprehend that if a large number of densely allocated projects becomes a reality, there are definite threats to biodiversity of the region. Yet another but extremely important issue pertains to cumulative flood hazard assessment exercising composite dam break analysis as series of dams/barrages have been proposed on almost all rivers of Himalaya, as indicated in Table 3. Additionally, so far it is being overlooked that in near future Himalayan rivers are going to be severely fragmented because of series of diversion/storage structures of hydropower projects and thus the velocity and volume of flow would change suddenly in fragmented stretches and this would have serious implications on aquatic ecology. Further, environmental flows are really essential for maintaining the downstream ecology but there also discrepancies exist at individual projects level EIAs as generally they do not put required efforts on this vital aspect. There are few more similar issues those does not make a holistic sense separately needs to be assessed cumulatively and, therefore with the aim to deal with such important issues, cumulative impact assessment is required to act as an integral part of entire SEA framework.

Table 3: River basin-wise number of hydropower projects in India.

River Basin	Number of schemes	Probable Installed Capacity (MW)
Indus	190	33382
Brahmaputra	226	66065
Ganga	142	20711
Central Indian River System	53	4152
West Flowing Rivers of Southern India	94	9430
East Flowing Rivers of Southern India	140	14511
Total	**845**	**148251**

Source: CEA, 2008. (http://cea.nic.in/reports/hydro/hydro_develop_12th_plan.pdf)

Social Impact Assessment

Social impact assessment includes the processes of analyzing, monitoring and managing the intended and unintended social consequences of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions (IAIA, 2003). The need of an EIA automatically solicits for Social Impact Assessment (SIA) in most of the cases. Where it is required as per the provisions of any law, rules, regulations or guidelines to undertake environmental impact assessment also, the SIA study shall be carried out simultaneously with the Environmental Impact Assessment study (MoRD, 2007).The term 'Environmental and Social Impact Assessment (ESIA)' is no longer new, various international works/experts putting environmental and social impact assessment together which is quite justified. Therefore, here in this proposed framework of SEA, SIA has been added as an integral part of the framework. Adequate work has been done on social impact assessment internationally for example [Finsterbusch et al. (1983)], [NOAA (1994)] etc., that defined the fundamentals of the process. In India also, there are regulations relating to SIA such as NRRP, 2007 and Land Acquisition Act, 1984 however, very recently Anthropological Survey of India, Kolkata has developed a 'Social Impact Assessment' manual (draft) (ANSI, 2010) particularly on methodologies for conducting SIA in the country. Such guiding documents on SIA have provided methodological structures to be adopted in the country. Therefore, it is proposed that the specific methodology and policy guidelines for conducting SIA shall be assimilated from national as well as international SIA good practice documents with appropriate region specific modifications. However, there is one specific issues which needs to be addressed at policy level is identification of 'affected peoples' or 'Affected Family', as per the India's national R&R policy. The minor issues dealing with affected family identification are discussed in next subpart.

Identification of project affected families and compensation

Social environment has always been a major concern in respect of hydropower development. Unplanned and redundant resettlement and indecent compensation leads to discontent and its repercussions in various forms to the peoples. Therefore, in this regard the most important task is the clear-cut identification of 'project affected families'. Usually, it's relatively easy to evaluate the losses and compensate where land is the only property affected people lose, however, particularly in case of hydropower development it is little intricate as there might be several direct and indirect losses people may suffer from. Some of such issues further needs attention in the context of hydropower projects in the IHR, these are:

- In case of hydroelectric projects involving submergence, it is often seen that the local communities are settled at the higher elevations whereas their fragmented small agricultural fields are scattered on the hill slopes in lower reaches. Consequently, instead of total land holdings only partial land comes under submergence (at FRL). This creates controversies in the process of land acquisition and also in defining the affected families fully affected or partially.

- If a project owner acquires some part of agriculture land (say 50% or more) of a farmer and compensates them for that but after few years the adjoining agriculture land gets waterlogged and/or the houses cracks down because of the reservoir water intrusion, such practical aftermaths can causes huge damage to a family financially as well as mentally. As a matter of fact, in India, if a marginal hill farmer's 50% agriculture land is acquired or becomes infertile, he will have to look for some other livelihood for sustenance, therefore a proactive mechanism needs to deal with such matters here.
- Recently another very complex and eye opener issue related to hydropower development induced air pollution came into notice in India. According to the published articles, as a result of construction activities of hydropower projects in sutluj river basin in Himachal Pradesh (a Himalayan state), deposition of heavy dust on crop plants is taking place which is resulting in low crop yields and eventually dropping off livelihood of the local apple farmers (Kandhari, 2010).

These issues are based on personal experienced and ground realities while working in IHR. Thus, under the proposed SEA framework, it is strongly prescribed to take into account of such policy issues. It is strongly believed that under present framework of SEA, it would be possible to incorporate and overcome these challenges adapting a comprehensive approach evolved by the experts and people's participation at different level.

Climate Change Impact Assessment

Probably climate change is one of the key challenges world is facing and trying to prevail over today. Climate change is directly or indirectly associated with almost all kinds of developments on the planet earth, therefore, mitigation strategies/action plans are being formulated at different levels and sectors. World Commission on Dams has already reported that dam reservoirs are also a source of GHG emission, which directly contributes to the climate change. Moreover, construction of dams and associated components under hydropower projects causes large scale forest degradation or sometimes complete forest cover change, which significantly affects the carbon stores/sink of the earth and thereby increases the climate change. Himalayan region, where hydropower projects are being built over dense to very dense forests, it's quite obvious that the loss of forest or in other words loss of carbon sink is significantly large. Thus, it is required that the thought *'hydropower - a green energy'* should be looked from a different angel. So far climate change has not been a part of EIAs especially in India, however, now it appears quite indispensable to embrace climate change study and mitigation as an integral part of environmental assessment studies. Strategic Environmental Assessment (SEA) has got the potential to provide such an opportunity to directly link climate change and hydropower development. Therefore, under present SEA framework climate study change has been incorporated as one of the important element. Climate baseline along with the baseline studies for other environmental components can be developed for a region along with the key indicators and problems however; mitigation and adaptation issues can be taken into full account under management plans.

Environmental management planning

The basic aim of preparing Environmental Management Plans (EMPs) under EIA is to mitigate the negative impacts and also maximize the positive ones; however, it has been practically experienced that it differs a lot project-wise by reason of personal interests and understanding of the project owners/executor. SEA, on policy or program level offers advantages to strategically harmonize environmental assessment procedures, here in present SEA environmental management planning has been included harnessing this power of SEA with the idea to design harmonized comprehensive EMPs for an environmentally homogeneous regions i.e. Himalayas. Within the present SEA framework, it has been attempted to fabricate EMPs so that the project-level management plans formulation and implementation discrepancies can be avoided. There can be many independent management plans with respect to hydropower projects in IHR, however, catchment area treatment, biodiversity management, disaster management, landscaping & restoration, solid waste management, resettlement & rehabilitation etc. have particular relevance. Although all the management plans are equally important elements of present SEA framework but the subsequent discussion under the subheads 3.4.1 to 3.4.3 covers grounding of some of these management plans with particular issues based approach.

Catchment Area Treatment

The prime objective of Catchment Area Treatment (CAT) plan is to conserve water, soil and minimize the soil erosion to the maximum possible level within the catchment area of the reservoir which ultimately aims to enhance the effective life of the project by reducing the sediment inflow into the reservoir. IHR on account of its land use, geological/soil and topographic peculiarities is prone to severe soil erosion. Every year thousand of tones of soil wash out from hills down to the plains. All these factors make CAT plan an integral part of environmental management plans (EMPs) of a hydropower project. Under project-level EIAs, the catchment is delineated upto dam site or a free-draining catchment area between two dams if there is another dam/barrage in upstream. Management plan for such delineated area is prepared applying remote sensing and GIS technique. Although RS-GIS approach is quite acceptable but it has its own demerits in following sense:

- Consultant/expert assign weightings to landuse class, slope category and soil type for developing a erosion intensity map. A small alteration in any weight to a class can significantly change the area under particular erosion class and thereby its treatment measures. Till now there are no rules or standard criteria for assigning these weights.

- Treatments measures suggested in different CAT plans varies consultant to consultant depending upon their personal understanding. This leads to significant changes in the physical and financial provisions of the CAT plan.

It is henceforth felt that unique methodology should be developed for such planning. Under present SEA framework, this issue can be resolved very effectively by developing comprehensive CAT plan at river basins level or at a regional scale.

Biodiversity Conservation

Uprety (2005) reviewed EIA reports approved in last one decade time in Nepal and found that the EIA itself has not been effective in considering biodiversity aspect, this experience has evolved the news course of action for SEA in Nepal, specifically for biodiversity management planning. Himalaya harbors a wide variety of ecosystems ranging from dry deciduous forests to conifer forests, grasslands to alpine meadows and range of agro-ecosystems which depend on elevation range. Biodiversity conservation planning for such an important landscape can't be a usual task. However, biodiversity conservation under EIA studies in India so far appears ineffective in most of the cases as main focus is on listing of species and suggestions for compensatory forestation only. It urges to adopt a comprehensive and proactive instrument for biodiversity conservation in Himalayas. SEA, a recognized proactive tool capable of embracing a wider scope of biodiversity conservation seems a wise adoption. Present SEA framework again adopts a comprehensive approach for biodiversity management at regional/basin scale focusing on the following issues:

- Assessment of status of faunal and floral diversity at regional/basin scale.
- Identification of sensitive habitats, corridors, breeding grounds, endemic species etc.
- Species/habitat wise threat assessment.
- Appropriate planning for *in-situ* and *ex-situ* conservation, conservation of habitat, corridor etc.

The above mentioned points require essential inclusion in a comprehensive biodiversity management plan. Undoubtedly this can only be achieved with the help of subject experts having experience of working in the local areas.

Disaster Management Planning

Due to dense allocation of hydropower projects in the river basins of IHR, there would be series of such structures along the length of rivers. This chain of dams in a row inflicts serious threats to life, property and environment due to possible cascading flood disasters. In project specific EIAs, disaster management plan is considered as a standalone activity which possesses no consideration of other similar project activities in upstream or downstream for cumulative assessment. Thus, at present disaster management in this way is more or less a formality. Therefore a comprehensive planning under SEA framework can better deal this serious issue in IHR. Modern modeling techniques like genetic algorithm (GA), artificial neural networks (ANN) etc. can be applied for regional or basin wise cumulative flood estimation and planning in addition to the available models like DAMBRK and FLDWAV.

Other essential elements of proposed SEA framework

The conceptualized SEA framework as presented in Figure 1 also comprises certain vital elements which plays significant role at different stages of framework. These tools/processes can wholly augment the conceptual legitimacy of the framework, are discussed under subheads 3.5.1 and 3.5.2.

Public participation

Diduck *et al.* (2007)[38] conducted an extensive study on public participation in the environmental assessment of hydropower development focusing on two case studies of hydropower projects in Uttarakhand state, a part of IHR. The study concluded that the present state of public hearing particularly in hydropower sector is weak and only more decentralized and more active involvement of public can improve the system[38](Diduck 2007). Moreover, several researchers have also emphasized on important role of public involvement in EIA[36, 37](Gibson 1993, Sinclair and Diduck 1995). Adding to the above experiences, the issues raised in this discussion so far regarding hydropower development have ascertained direct interaction with the local people, thus public participation appears to be a key constituent of SEA framework. The process at plan, program level can be made more transparent and tangible as owner or other stakeholders have least role to play and local peoples are the real participants. Under SEA, the entire process of public consultation can be made more inclusive and unbiased at different stages and on particular issues.

Integration of Remote Sensing and GIS approach

The use of geospatial maps and overlays to account for natural features in planning has a long history and is still important today[14](CSIR 1996). The advancement of geospatial technology offered immense potential for enormous applications throughout the sectors. Today the quality of satellite data is so finer that it can provide minute details on an earth surface feature, therefore utilization of satellite data with the help of professional Geographical Information Systems (GIS) tools can drastically improve the quality and authenticity of primary data used in environmental assessment. GIS, as a powerful tool can be used in generating primary data on almost all environmental parameters starting from biodiversity to river morphology. GIS-based approaches can also be used to test scenarios and predict cumulative impacts at policy/plan level[39](Sol et al. 1995). Environmental monitoring and management can really turn into a transparent and easily accessible system with the help of RS-GIS based decision support. If once a functional and reliable database is generated, it can be used by governments or any user agency for multiple applications.

Conclusion

India comes on 7th place and there are many countries down the list when we talk about hydropower potential. The basic purpose of this effort is to fabricate an operational procedure for Strategic Environmental Assessment (SEA) in context of hydropower development in Indian Himalayas, nevertheless with equal pertinence to other mountainous region of the world together. In last more than one decade, striking researches on SEA in many sectors has been published but the energy sector seems little unexplored. The notion that SEA needs to be developed and refined within a particular national context has been widely supported (Marsden, 1998; Thissen, 2000; Dalal-Clayton and Sadler, 2005, Retif, 2007). Thus, present work can be seen as an augmenting effort in the direction of promoting SEA in a regional and sectorial context. It is expected that the proposed framework can help the researchers, governments and planners to understand the need of SEA in particular context of pristine mountains. Globally the Protected Area (PA) concept has been promoted as a vital tool to protect the world biodiversity. It is no hidden fact that most of the PAs of world exist within the landscapes like Himalayas, this compiles to put special values for conservation of such landscapes.

Ethics

All the authors read and approved the manuscript and no ethical issues involved.

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