Hydropower, a Good Alternative for Nepal: Challenges and Approaches

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The adverse impacts of hydropower development are well documented in the published and gray literature (World Bank 1996; WWF 1999; Scudder 1997), as well as addressed by the World Commission on Dams which commissioned a world-wide comprehensive review of impacts and mitigation (WCD 2000). A number of reviews and case histories for hydropower projects in Southeast Asia and Nepal have also been completed in recent years (Garcia and Garcia 2000; Garcia et al 2005a,b; Garcia 1999; ADB 1999; SEATEC et al 2000a,b,c,d and 2001; Upadhaya and Shrestha 2002; Onta 1998; Pandey 2001). Adverse impacts related to hydropower development can be serious and significant, leading to increased poverty, social dislocation, losses in fishery resources and declines in biodiversity among a host of other associated impacts. Adverse impacts are project-specific and are related to project design and the social, physical and biological environments of the project site as well as the mitigation measures implemented during both construction and operational phases of the project.

Hydropower projects are not created equal. Run-of-the-river projects with high head and small reservoirs typically have a much smaller footprint and have fewer adverse environmental impacts on the social, biological and physical environments than large reservoirs in lower elevations that can require the dislocation of people and loss of productive lands and major ecological changes. However, in some cases, larger reservoirs can provide additional benefits such as flood-control, irrigation, aquaculture and recreation/tourism opportunities. Projects need to be considered on a project-specific basis and be fully committed to the premise that affected people will be at least as well off with the project as they would be without the project.

Given the adverse environmental impacts associated with hydropower development, why is hydropower a good alternative for power generation in Nepal?

- *Minimal contribution to global warming*: Hydropower generation does not generate significant quantities of CO_2. Some CO_2 is generated during construction, but this is minor and comparable to what would be required to construct any power generation facility.
- *Clean*: Hydropower generation does not generate air or water pollution, although there is a potential for water quality impacts in and downstream of larger reservoirs.
- *Security*: Hydropower development requires large capital outlays. But, once built, they are not dependent on imported fuels and the security issues associated with being a land-locked country.
- *Stability*: Cost of development, construction and operation can be well documented and predicted. Once built, the fuel is free and power generation costs are not subject to fluctuations in fuel or transportation costs. Many hydro projects I am working on are over 50 years old, and several are over 100 years old. Under the right conditions, hydropower facilities can run at low operational costs for 50 years or more providing low-cost, clean electric power.
- *Technological transfer and self-sufficiency*: Within Nepal there is growing institutional knowledge and capacity regarding this sector. Enough projects have proceeded in Nepal to enable Nepalese nationals to complete much of the engineering, environmental and social work elements and analysis. In addition, there is now a large cadre of Nepalese construction workers who have worked with international construction companies and have had critical safety and technical training. As a result, Nepal has a trained work-force ready to work on large construction projects.
- *Power exports*: Nepal has the opportunity to export power, thereby contributing to balance of trade and providing needed revenues for the general economic and social development.
- *Peaking*: Hydropower projects such as the Kali Gandaki 'A' Project can be designed to provide peaking power—a very useful tool in power management. In most cases, peaking capabilities requires some degree of storage capacity.
- *Potential*: Nepal has vast hydropower generation potential that has only lightly been tapped.

- *Poverty alleviation*: Hydropower development, in association with linked development projects, can contribute to poverty alleviation and improved living conditions and health for communities in the project area as well as nationwide.

Although I have provided what are, in my perspective, good reasons why hydropower generation is a good option in Nepal, there are serious engineering, social, environmental, fiscal and political challenges. Under the best of circumstances, large infrastructure projects are subject to delays and cost overruns as exemplified by high-profile projects in the US and Europe, including Boston's 'Big Dig' tunnel, the San Francisco Bay Bridge Project and the English Channel ('Chunnel') Project. In Nepal maximizing efficiency and meeting schedules is complicated by having to transport large equipment through other countries, graft, political instability, security, remote project locations, poor roads and infrastructure, monsoon, unstable steep slopes and high sediment loads. This combination of obstacles synergistically affects the ease by which projects can be successfully completed and appropriate mitigation implemented.

In addition, local communities in various project areas have learned that they can stop work on projects (sometimes justifiably, sometimes not) and thereby have their needs or desires met. Maintaining good, clear and consistent communication with local communities is a critical. Good community liaisons cannot be overemphasized.

A brief review of key environmental challenges and suggested approaches follow. These are neither intended to be extensive or exhaustive but, in my opinion, are of high priority and importance.

Landslides

Landslides are an important risk factor across much of the Himalayas. The unstable geology, combined with torrential monsoon downpours, provides conditions that increase the risk and probability of landslides across many areas of Nepal. The frequent requirement to build roads in support of hydropower project development contributes to the risk of landslides.

Both the Kali Gandaki 'A' (KGA) and the Khimti Khola (KK) hydroelectric projects have had significant landslide issues. The slope above the desander basin on the KGA Project required extensive treatment and material removal to minimize landslide risk into the desander basin. The treatment and amount of materials removed was well beyond that specified in the construction contracts or the environmental documents and had significant effects on schedule and cost as well as environmental impacts. There was also additional treatment required to stabilize slopes in the area upslope of the pressure shaft and numerous locations along the project-related road system. Landslides also became an issue by periodically blocking passage along transportation routes that were not project-related.

In the Khimti Khola Project, landslides were an issue upslope of the desander basin as well. Another landslide issue became apparent at one of the muck disposal sites where the toe of the slope was destabilized by a stream course and resulted in destabilization and significant downstream sediment deposition.

As such, hydropower schemes in Nepal outside of the Terai will have landslide issues and challenges. Unanticipated landslide issues posed significant cost, schedule and environmental challenges on both the KGA and KK projects. In both these projects, landslide risks were recognized early in the design and feasibility phases, but they were nonetheless underestimated.

Early iterations of the KGA design included the desander basin and powerhouse that were to be constructed underground, in part, to minimize landslide risks. However, after a number of design iterations and geotechnical evaluations, they were brought above ground. In the case of the KK project, the powerhouse is underground. The KGA and KK underground facilities were proposed and developed by Norwegian engineers, but the resulting designs were influenced by other local factors. Norwegian engineers are typically comfortable with designing underground facilities, as there is a long tradition of underground facilities in Norway.

Suggested Approaches

Good geotechnical information and assessment of landslide risk at the hydropower facilities and access routes are of paramount importance in successfully constructing and operating a hydropower facility. This cannot be overemphasized. Project-related landslides or risk of landslides have had major effects on cost, schedule and impacts to the local environment and affected people. It is a keystone issue in the design and construction process. Where possible, high-risk landslide areas should be avoided; if not, they should be clearly outlined and understood and proper design, engineering and construction measures carefully evaluated and implemented.

Where technically and financially feasible, underground facilities should be fully considered and should be at least evaluated as an alternative in the feasibility and design stages. Best Management Practices (BMPs) related to drainage control, road design, slope stabilization and revegetation should receive a high priority of attention during feasibility and design stages. Minimizing and flagging areas of disturbance and, where possible, scheduling ground

disturbance outside of the monsoon periods can also reduce risk.

BMPs for road design must include a good routing study that carefully considers landslide risks as well as minimizing cut and fill. Issues are always site-specific, but areas that pose long-term landslide risks should be avoided. One wants to avoid situations like the Devil's Slide area along the California coast. After 50 years and multi-millions of dollars of remedial costs to try to contain landslides along the route, the highway will now be routed through a tunnel to avoid the landslide area. There simply was not a feasible engineering solution to stabilize the slopes, and the final solution was to reroute and avoid the area.

Sediments

Sediment loads are both a design challenge and an environmental challenge for hydropower development throughout the southern slopes of the Himalayas. The large seasonal sediment loads characteristic of Nepal's rivers require sediment/ desander basins to remove sediments from the water that eventually need to go through power generation turbines. Construction, maintenance and operations of these facilities present many engineering and environmental challenges.

In addition, in part related to the landslide challenge described above as well as the Monsoon climate of the southern slopes of the Himalayas, project-related erosion and subsequent sedimentation can be problematic. The discarding of spoils into watercourses during non-monsoon periods is a particular problem that can be avoided or minimized. For instance, construction activities within the wetted perimeter occurred commonly in both the KGA and KK projects during the dry season. Reasonable and planned sediment loading into the watercourses during the Monsoon are not problematic and can fall within the range of loads that are common within various rivers.

Suggested Approaches

A review of the success of the currently deployed designs for sediment removal should be initiated. Have the designs worked? Have they been cost-effective? Are there operational considerations? The review should also consider alternative design elements that may improve the efficiency and operation of the designs currently in place. It would behoove Nepal and other Himalayan countries to be at the forefront on this most pertinent issue. Other engineering solutions such as generator designs that are less sensitive to abrasion caused by sediment loads should also be considered. Identifying watersheds with reduced sediment loading, or reaches where sediment loads are less problematic should also be a consideration in terms of feasibility.

BMPs with regards to erosion control are not complicated issues and should be required consistently. Measures described above under landslides should be applied including minimizing surface disturbance when possible during the Monsoon, proper drainage, silt fences and bails, benching of slopes, and revegetation.

If necessary, sediment loading within stream courses should coincide with the monsoon period and should be controlled to fall within a small percentage of the natural sediment loading that would be expected without the project. Such a schedule for sediment loading was prescribed on the KGA project but not rigorously enforced.

Biodiversity

epal is blessed with very rich biodiversity, both aquatic and terrestrial. Included are many species recognized nationally and internationally as threatened or endangered. This includes high profile species such as the Bengal tiger, snow leopard and rock python, but probably also includes a number of lesser known species or invertebrate taxon yet to be described. Species richness is enhanced by the wide range in elevation, habitats and ecosystems that occur from the low elevation Terai plains to the upper slopes of the Himalayas.

Hydropower Projects, including the KGA and KK, can have adverse impacts on these species. There are localized disturbances related to construction activities, loss of habitat, project-related 'takes' (kills of individual specimens), migration impediment, secondary impacts related to forest impacts and improved human access. Other significant impacts occur due to transmission line conflicts with bird migration and primary (old growth) forests.

Suggested Approaches

Preparing a Biological Assessment (BA) specifically focused on rare, threatened or endangered species is recommended for any hydropower project having impacts on these species. This should be a part of the overall Environmental Impact Assessment process and should be prepared by the project proponent. The BA should refer to the project description and describe in detail project impacts, measures taken to avoid or minimize impacts, remedial actions and actions proposed to compensate for unavoidable impacts. The BA needs to be submitted to the national agency that is responsible for endangered species (such as Nepal's Department of National Parks and Wildlife Conservation) as well as the project's panel of experts for review. The national agency will then need to develop a Biological Opinion (BO) that details the

project requirements with regards to endangered species. Measures could include biological monitors, mitigation for degraded or lost habitat, allowance for a certain 'take' of habitat or individuals, constraints on periods of activity, worker education, etc. The most onerous penalty in this arrangement is that projects that are not in compliance with the BO can be halted. However, stopping projects on large infrastructure projects is very expensive and politically difficult for agencies to enforce. Nevertheless, agencies must maintain their rigor in this regard to ensure, among other things, continued donor agency support.

Projects should avoid primary forests, national parks and wildlife refuges as much as possible, and these factors should be considered during feasibility studies and thereafter. If impacts to these areas are unavoidable, major mitigation costs should be 'part and parcel' of the project. In the US, mitigation for lost endangered species habitat is often compensated by the requirement of acquisition and long-term protection of similar habitat in adjacent areas. Ratios are such that the loss of one acre of endangered species habitat requires more than one acre of compensatory habitat. Multinational corporations are used to complying with agency regulations and mitigation issues, so Nepal should not allow itself to accept any less. For good or bad, this is part of the business climate that must be factored into 'successful' project design, construction and operation.

Fisheries

Impacts to fishery are well documented as a result of hydropower development and were anticipated for both the KGA and KK projects. Typically, impacts to fisheries are significant and long-term and have affected fishery resources wherever hydropower projects have been developed. Migratory riverine species are the fish community that is most likely to suffer major adverse impacts. At times, riverine fisheries can be replaced by a reservoir fishery that can be larger than the original fishery; however, the fishery will be different and there can be significant off-site fishery impacts (upstream and downstream) due to impediment to migration and impacts to migratory species. In addition, there can be impacts to communities accustomed to one type of fishery.

As described above, KGA and KK projects both recognized the potential for adverse impacts to fisheries. The potential impacts of the KGA project were larger, as the fishery was larger and migratory fish populations were a major component to the fishery. Both projects implemented mitigation measures that addressed fish passage, entrainment, minimum flows and peaking flows. Mitigation measures included fish passage design, trapping and hauling, a trash rack and louver system, a mitigation hatchery, ramping and monitoring. However, during the construction phases, only a portion of the mitigation measures stipulated in the EIAs were implemented. Some measures that were clearly spelled out were never implemented. For example, on the KK project, measures to minimize entrainment were never taken. On the KGA project, the testing of trapping and hauling during the construction phase was funded but never successfully implemented for various reasons. As a result, significant adverse impacts to fisheries are possible, if not probable.

Suggested Approaches

The establishment of Wild and Scenic Rivers or selected watersheds that would not be developed for hydropower, but maintained for recreational and ecological purposes, would be a major step in protecting fishery resources and aquatic biodiversity. There are opportunity costs in terms of hydropower generation in these systems, but recreation, tourism and ecological benefits to Nepal for protecting selected watersheds should be considered.

Measures taken to date to mitigate for fishery impacts should be evaluated for effectiveness, feasibility and cost effectiveness. A number of hydropower projects have been completed in the foothills of the Himalayas and an assessment of attempted fish mitigation measures and their success or failure should be considered in future efforts. A selected Panel of Experts could do this quickly and cost effectively.

Where possible, projects should be developed in reaches above the major migratory areas of the rivers. Alternatively, projects above the facilities that already block migratory fish should be considered. But this should be tempered with more information, as the extent and patterns of migratory behavior for fish in the southern slopes of the Himalayas are poorly documented. This should only be considered where it can be documented that long-range migratory fish such as masheer have been extirpated.

The artisanal fisherpersons should become a strong part of the mitigation planning effort with regards to fishery impacts. It is their livelihood and way of life that are often jeopardized by hydropower development. Including them in setting the goals for mitigation and even in implementing and monitoring are highly recommended. Special social measures may be required, such as retraining, should adverse impacts to their income and way of life become apparent.

Compliance

Both KGA and KK had extensive mitigation measures spelled out in the EIAs, SEIAs, Environmental

Compliance Monitoring Plans, Acquisition, Compensation and Relocation Plans, construction contract clauses and clauses in various loan documents of the international lending agencies. Both projects had Environmental Management Units that monitored and reported on compliance. In these two projects, and in other projects reviewed by the author, non-compliance with measures identified in the regulating documents were simply not implemented or poorly implemented. In some cases, mitigation measures were unreasonable. However, in many cases, compliance took a much lower priority than schedule or budget. In some cases it was more expedient not to comply, as there was little to force compliance. Oftentimes, the policing was done by a Panel of Experts or its equivalent. There were earnest attempts to implement mitigation measures, particularly where local communities benefited from the measures. There was less compliance on measures that had little local political clout. However, enforcing compliance was a difficult matter, largely due to conflicts of interest and weakness in the institutional strengths of the oversight agencies.

Suggested Approaches

With regards to the construction contractors, Environmental Performance Bonds are an option, as well as enforceable penalty clauses for lack of compliance. Line item budgets for compliance measures are also an option, but were not particularly successful on the KGA project. For example, there was no budget allocated to the training and employment of Project Affected Family (PAF) members, but this was ultimately carried out fairly successfully. There was budget for implementation for the fish trapping and hauling, but this was not completed successfully. The project responded to pressure from the Panel of Experts as well as local communities who were very much aware of the mitigation requirements. Still, line item budgets, with the provision that non-performance on environmental contract areas are treated with the same degree of concern as they are in the traditional engineering and construction elements, are a reasonable approach, and are well understood by multinational corporations.

Simplifying construction contract clauses should be considered. This was somewhat necessary in the case of KGA and KK, particularly with regards to safety. Nepal did not have, at the time, legislation addressing safety at the work place or agencies to oversee or enforce safety. Nonetheless, it is better to have focused clauses that are enforceable than extensive clauses that are ignored.

Continued Nepal institutional strengthening is paramount. Nepal should be able to rely on its own institutions and expertise to ensure that mitigation and compliance measures integral to the proposed project are fully carried out. They should not have to rely on outside experts. Nevertheless, the continued use of outside experts is probably wise, as outside experts are not as subject to the financial and political pressures that local staff and institutions now may bear. The role of outside experts as a Panel of Experts in a Quality Assurance/Quality Control (QA/QC) role is reasonable.

Reporting

The reporting burden related to compliance was large on both the KGA and KK projects. Since the reports are typically reviewed by international agencies, they are written in English. Reporting on compliance with the environmental and social requirements in large infrastructure projects is required and important. It is oftentimes difficult for Nepalese nationals to write clearly and succinctly in a second language (e.g., English). Reporting should not be such a burden such that it becomes more important than the implementation of the mitigation.

Suggested Approaches

Monthly Progress Reports should be shortened and simplified, no longer than 10 pages, with appended tables and data. Quarterly and Annual Reports should also be succinct, clear and short. Required technical studies, plans, etc., should be appended and briefly summarized in the main body of the Compliance Report. Sufficient information should be provided to determine whether the project is complying with the requirements, and where and when it is not. Measures taken to alleviate non-compliance or why non-compliance is unattainable need to be spelled out. Reports should be edited by a good writer fully fluent in technical English writing.

During project operations, compliance reporting is also required and necessary. Monthly reporting on release flows is recommended. This should be a simple letter report identifying compliance or non-compliance. The Annual report should address additional mitigation items and tabulate performance for the year.

A structure should be put into place early on to identify non-compliance and to ensure that those issues related to non-compliance are quickly addressed. Otherwise, reporting becomes formulaic, rather than an instrument for change and improvement. A suggested approach is a high-level monthly meeting addressing outstanding issues and their resolution. The specific mechanism for resolving how that process would occur would be dependent on the contractual and institutional arrangements.

Community relations

Successful implementation of a hydropower scheme in rural Nepal requires excellent community relations. Construction projects are often stopped by local communities for reasonable and sometimes unreasonable causes. Without local support, or—in extreme cases—strong police power, projects cannot go forward in the face of local opposition. Local communities recognize that construction of hydropower projects is a ready source of revenues that can be tapped for local projects such as road building, trail improvements, schools, temples, water supplies, rural electrification, etc. In some cases, the demands are rational; but, in some cases, they are not. Communities are very much aware of the mitigation requirements spelled out in the various environmental and social documents and are quick to point out when they are not receiving what they interpret are required.

Hydropower development should be structured so that it contributes to local poverty alleviation as well as national benefits. Unfortunately, there have been several instances when early commitments made by project proponents were not carried out. Affected communities are quick to point out the cases of unfulfilled promises and they become a long-term irritant that results in conflict between the project proponent and the communities.

Suggested Approaches

It is important to present project construction and operation in terms of how local communities will benefit. As part of Public Outreach Programs, the benefits and commitments should be made clear. Avoiding false promises is paramount. Besides the standard requirements for just compensation for the taking of land, buildings and other resources, the following generalized measures are suggested:

- *Rural electrification*: These programs were implemented in both the KGA and KK projects and should be implemented in all cases such that affected communities receive the benefit of electrification. We recognize that local electrification does not always meet an economic test but it should be fully supported nonetheless.
- *Local hiring*: Both KGA and KK made efforts to hire locally and had various training opportunities. Some advanced training in areas targeted for project development would be prudent. Job opportunities should continue through the operations phase. A cadre of Nepalese nationals is being developed who now have fairly extensive experience in working on heavy construction projects, and these skilled residents should also be utilized as is reasonable.
- *Telecommunication*: Large hydropower development requires the establishment of good telecommunication, and part of the community program should be to provide telecommuni-cation accessibility to local communities.
- *Infrastructure*: Some budget allocations should be provided for local infrastructure projects that would be prioritized and documented in advance. Local communities should be included in developing a list of projects and their relative priority. These may include water supply projects, roads, bridges, trails, toilets, etc.
- *Community liaison*: A well-respected senior Nepalese citizen needs to be the point person on community relations on all hydropower projects. This person would be responsible for maintaining relations with local communities and listening to their grievances. He or she would also need to have a direct conduit to the highest level of Project Management so that responses are quick and definite and have meaningful support. Scheduled community meetings and an 'Open Door' policy are recommended.
- *Language*: At least the SEIA and other most pertinent documents should be available at a local library and written in Nepali. It would behoove projects to also produce a low-cost monthly newsletter written in Nepali that documents project progress and compliance with environmental and social programs.
- *Compliance*: Many of the issues that local communities have had with hydropower projects throughout Asia were due to the project developers not complying or implementing environmental and social requirements stipulated in the guiding documents. These have ranged from construction contractors camping in unauthorized areas, to landslides affecting agricultural areas. These issues can be resolved through use of consistently-required contract clauses and oversight.
- *Death*: Accidental deaths at large construction facilities are a matter of fact. Construction contractors and project proponents need to have a transparent policy in place to address this probability.

Summary

The suggestions above are not provided in detail, nor are they exhaustive, and are for the purposes of discussion and debate that will hopefully lead to reasonable policy positions and enactment. However, they are given with the firm belief that hydropower provides a reasonable approach to power development in Nepal.

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