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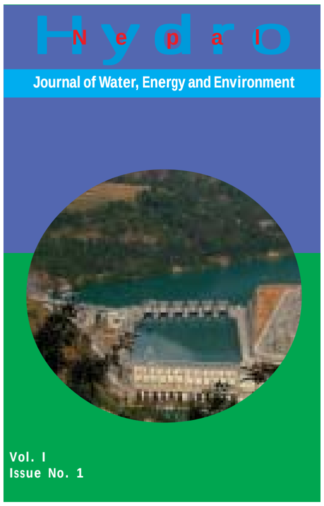

Cover image
A view of Kali Gandaki dam in Nepal

Photo courtesy
Rajendra P. Thanju

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E-d-i-t-o-r-i-a-l

Looking ahead…

It gives us immense pleasure to publish Hydro Nepal as a Souvenir to mark the World Environment Day: June 5, 2007. The slogan of the day is Melting Ice- A hot Topic?

Energy consumption is one of the main indicators of development of a country and hydroelectric power is one of the cleanest, renewable and environmentally benign sources of energy. Nepal is blessed with an immense amount of hydro-electric potential and ranks second in terms of water resources after Brazil on global scale. Nepal is endowed with economically exploitable hydro-power potential as high as 42000MW of installed capacity out of total hydro potential of 83000MW. This immense hydropower potential needs to exploitation in broadening the market that is developing in the domestic and regional areas. Despite the immense hydropower potential in Nepal, only 40% of its population has access to electricity including 33% from Nepal Electricity Authority (NEA) grid and 7% from other alternative source of energy, according to the 10th plan.

The core area of Hydro Nepal is water, energy and environment. The main objectives of this souvenir edition of the Hydro Nepal is to provide insight in various aspects of hydropower development in Nepal and sharing knowledge, skill and expertise among experts involved in this process. We do hope that this souvenir edition and subsequent editions of this professional journal will provide professionals involved in the field of hydropower development and its environmental management a common platform to contribute for a fruitful exchange of ideas, knowledge and insights to support sound, sustainable and environ-friendly generation of hydroelectric power. In addition, this journal will be an invaluable source of resources for professionals, students, business houses, companies, developers, bankers and others interrelated in any aspects of hydropower development.

We believe that with a cooperative and collaborative approach and efforts from among the experts who are involved in the pursuit of excellence in the development of hydroelectric power and its environmental management can help realize better results in harnessing the immense hydropower potential of the country in generating clean, green and sustainable energy.

Don Messerschmidt
Executive Editor

Hydropower, a Good Alternative for Nepal: Challenges and Approaches

John C. Garcia

Abstract: Although Hydropower development is a good option for Nepal, there are serious challenges to the successful construction and operations of such facilities. This article briefly addresses why hydropower development is appropriate for Nepal as well as some of the more important social and environmental challenges. The author also makes suggestions to approach these challenges.

Key words: Hydropower, social and environmental impacts, landslides, sediments, biodiversity, poverty alleviation, fisheries, compliance, community relations, reporting, Nepal.

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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Kali Gandaki 'A' Hydroelectric Project in Environmental Perspectives

Rajendra P. Thanju

Abstract. Hydropower is one of the cleanest, renewable and environmentally benign sources of energy. Nepal is blessed with immense source of water resources and huge hydropower potential. The Kali Gandaki 'A' (KGA) Hydroelectric Project is the largest hydropower project constructed so far in Nepal. The project is a daily pondage type scheme with an installed capacity of 144 MW.

The KGA is one of the first largest hydropower projects that has been well studied environmentally and socially in the pre-project, construction and operation stages. A full team of multi-disciplinary professionals was involved during the construction phase to monitor environmental impacts and compliance with contract clauses, and to implement the mitigation measures.

Implementation of KGA in what was once considered as a remote area, has resulted in multifold beneficial impacts to the local community. Improvement of public infrastructure, enhanced educational facilities and employment of local populations, including affected families during project construction and operation phase, have enhanced the quality of rural lives. The KGA operation has contributed significantly to Nepal's power system and has boosted the economic development of the country.

Key words: Hydropower, environmental monitoring, impacts, mitigation, resettlement, Nepal

Hydropower is one of the cleanest, renewable and environmentally benign sources of energy. Nepal is blessed with immense source of water resources and huge hydropower potential. Kali Gandaki 'A' Hydroelectric Project is the largest hydropower project implemented so far in Nepal. The project is located in the Western Development Region of Nepal. The main component of the project is located at Syangja District in Gandaki Zone, and other components partially encompass other districts such as Gulmi, Palpa, Parbat, Kaski and Rupandehi.

Figure 1. View of Kali Gandaki Dam

The feasibility study of the project was carried out in 1979 with the financial assistance from United Nations Development Program (UNDP) which was updated in 1991. The detailed engineering design and preparation of tender documents commenced in 1993 with the financial assistance of Asian Development Bank (ADB), United Nation Development Program (UNDP) and Finnish International Development Agency (FINNIDA) jointly. The preparatory works like access road construction was started in 1993 with internal resources from Government of Nepal and Nepal Electricity Authority (NEA).

The construction works were divided into seven lots. Impregilo SpA (IgL), Italy, was the civil contractor (for lot C1, C2 and C3); Noell Stahl-und Maschinenbau, Germany, for Hydraulic Steel works (Lot 4); France/Japan JV of Mitsui/Toshiba/Alstom (Former CEGELEC), for Electrical Works (Lot 5); Japan joint venture of Mitsui/Toshiba for Mechanical works (Lot 6); and TATA International /Marubeni, Japan, were the contractors for transmission line and substation works (lot–7), respectively. The project is owned and operated by the Nepal Electricity Authority (NEA). The project engineers were Morrison Knudsen International Inc., USA, in association with Norconsult International, Norway, and IVO International, Finland.

Construction of the hydropower component was started in 1997 under the loan assistance of Asian

Development Bank (ADB) and Overseas Economic Corporation Fund (OECF, now known as Japan Bank for International Cooperation, or JBIC). The project construction work was completed in 2002. The generation unit was tested in May 2002 and commercial production began from August 2002.

Project features

The major project components include hydropower dam and powerhouse, project access road, transmission line and substations, as described below.

Hydropower

Kali Gandaki 'A' Hydroelectric Project is a daily pondage type scheme located on the Kali Gandaki River with an installed capacity of 144 MW. The project generates about 842 GWh of electric energy annually by utilizing a net head of 115m. The main structures of the project are concrete gravity diversion dam about 100m long and 43m high, open surface desander, headrace tunnel of about 6 km in length and 7.4m diameter, and a surface powerhouse. The rated discharge of 141 m^3/s feeds three Francis type turbines in the powerhouse. The surface area of the reservoir is 65 ha, followed by a 5.3 km long back water level. Permanent camps are located at Beltari and Mirmi in the Shree Krishna Gandaki Village Development Committee (VDC) of Syangja District.

Access road

The access road of the project crosses steep and hilly terrain. Total length of the access roads is about 28.5 km. The access road starts from Batuwa, 82 km from Pokhara on Siddhartha highway (3.5 south of Galyang Bazaar) and ends at the left bank of the dam, which is about 20 km away from the highway. The access road for the powerhouse branch out from Jaipate is about 8 km long.

Figure 2. Boat transportation in project reservoir

Transmission lines

The power generated from the project by 3 units of turbines of 48 MW each capacity is evacuated to the central grid via a 132 kV single circuit, a 66 km long transmission line to Pokhara and a 44 km double circuit transmission line to Butwal. A sub-station is constructed at Lekhnath Municipality of Kaski District, whereas the pre-existing Jogikuti substation of Butwal has been upgraded.

Environmental studies

From the initial stage of project, environmental concerns were the integral part of design optimization. The environmental studies/activities of the project during pre-project, construction stage and operation phase are briefly described below.

Pre-project phase

The Environmental Impact Assessment (EIA) study was conducted in 1996 according to National EIA Guidelines of 1993 and Asian Development Bank Guidelines of 1990. The report was duly approved by the Asian Development Bank (ADB).

The interaction and consultation programs during the project preparation stage reflected views of different stakeholders, which were considered in the detailed design phase of the project, and possible adverse environmental impacts were avoided to the extent possible.

Environmental documents

From the beginning, environmental consideration was given priority in the project. Various environmental documents were prepared during engineering design and tender documents preparation. The primary documents that guided environmental activities of the project are given below. These documents were used in cross-reference with each other:

- Environmental Impact Assessment (EIA), Vol. 1-2, 1996.
- Mitigation Management and Monitoring Plan (MMMP), 1996.
- Acquisition, Compensation and Rehabilitation Plan (ACRP), 1996.
- Tender documents with conditions of particular applications, including social and environmental clauses.
- ADB: Summary Environment Impact Assessment (SEIA), 1996
- ADB: Report and Recommendation of

President to Board of Directors, 1996 RRP-NEP 26362)

- Loan Agreement with ADB

The EIA explained the impacts and proposed mitigation measures as identified during the detail study of the project and provides justification for the mitigation. The MMMP described how the mitigation spelled out in the EIA, ACRP and in Tender Clauses will be carried out. The MMMP provided a guide to mitigation management and environmental monitoring. The main objective of ACRP was to insure that people affected by project-related property and land acquisitions would be as well off after the project as they were before. The Tender Documents specified what action construction contractors were required to take to protect the environment.

In addition, the contractors were required to develop an Environmental Protection Plan, a Health and Safety Plan and a Waste Management Plan, and contractors disturbing vegetation were required to submit a Revegetation Plan. These Plans augmented the MMMP and specified how the contractors met and implemented the environmental mitigation requirements specified in the EIA, ACRP and the Tender Documents.

The loan document between ADB and NEA defined the role, responsibility and mandate of Kali Gandaki Environmental Management Unit (KGEMU). The loan document included basic provisions in environmental aspects, which were to be carefully addressed to comply with ADB's policies and procedures. Included in this document are: institutional requirement for monitoring; establishment of the KGEMU; provision for a construction stage International Panel of Experts (POE)[1] on environmental and social aspects; implementation of MMMP; contractors' compliance with tender clauses; compensatory flow of 4 m^3/s; operation and management of a fish hatchery program; and clauses regarding minimization of resettlement, enabling communities to benefit from the project, preferential hiring, and the need for public consultation.

Social mitigation policy

The Resettlement Policy defined in project documents provides that the Government of Nepal and the NEA shall take or cause to be taken all necessary measures to ensure that all the population adversely affected by carrying out the project shall generally:

- improve or at least regain their prior standard of living;
- be relocated, if necessary, in accordance with their preferences and be fully integrated into the community in which they move; and
- be provided with appropriate, agreed upon compensation and required physical rehabilitation of infrastructures, community facilities, including rehabilitation grants, skill training and employment opportunities. All such measures should at least satisfy the requirement of the ACRP.

Environmental impacts

Major impacts occurred due to the implementation of the project on physical, biological and socioeconomic and cultural environment are summarized below:

Physical environment

- Submergence of forest land and other land uses due to creation of 5.3 km long (65 ha) reservoir.
- Hydrological changes in the 13 km stretch downstream between the dam and the confluence with the major tributary, Badi Gad.
- Impacts on hydrology downstream of the power plant are restricted to the dry season when the facility is used for peaking. The changes in flow and stage pose hazards to water users immediately below the power plant site.
- Generation of 6.2 million tons of muck/spoil.

Biological environment

- Removal of 6,093 trees of various species (khayar, bakaino, ipil-ipil, simal, sissoo and sal) due to implementation of the project.
- Soil erosion and land slides due to project construction works.
- Loss of wildlife habitat around dam, powerhouse sites and nearby areas.
- Impact on migration of long range migratory fishes due to damming of river.

Social/cultural environment

- Loss of approximately 208.68 ha of land due to placement of project structures and facilities, including access road.
- Altogether 1,468 families lost their land (or part of it), their houses, or both, out of which 263 families were defined as SPAF[2] and 1,205 families as PAF[3].
- Impacts to indigenous Bote (fisherman) community. About 21 houses, 5 cowshed and approximately 13 *ropani* of land from the Bote families were acquired.
- Impact on Setibeni Sheela, a religious site.

- Reduction of white water rafting in Kali Gandaki River from 5 days to 3 days.

Environmental monitoring and mitigation management

The Nepal Electricity Authority, project engineers and contractors were responsible for the monitoring and implementation and management of mitigation measures. KGEMU was the key unit established under the consultant umbrella to monitor environmental mitigation measures carried out by contractors, to carry out environmental mitigation programs and conduct environmental monitoring during the construction phase, as spelled out in EIA, MMMP and Tender Documents.

The environmental monitoring and mitigation management activities carried out during the project construction stage are briefly described below.

Kali Gandaki Environmental Management Unit (KGEMU)

The KGEMU was formed in January 1997 with the commencement of project construction. It was the first organization of its kind in hydropower projects in Nepal to monitor and mitigate the adverse environmental impacts due to the project construction and was established as per the provision in the loan agreement between NEA and ADB. Considering multidimensional activities and mandate, KGEMU was staffed with a diverse group of environmental professionals. The environmental advisor and trainer, an expatriate position, was responsible for reviewing the performance and manage KGEMU for the first year. Moreover, an expatriate manager and an International Panel of Experts (environmental and social) were also engaged to guide and review the environmental and social works of the project throughout the project construction stage.

Monitoring activities were considered an important aspect. KGEMU staff conducted compliance monitoring of the international contractors regarding environmental obligations as mentioned in the contract documents. About 108 environmental and social clauses were incorporated in tender documents of the civil contractor (IgL).

Significant shortcomings on the part of contractors were documented and informed to the relevant contractors for necessary improvements. Several engineer's instructions were issued to the contractors to make them comply with their contractual obligations. However, the contractors' environmental compliance status was satisfactory, but needs greater enforcement mechanism to achieve better performance in future projects.

Social research and impacts studies

The professional staff of the KGEMU conducted several impacts monitoring studies among the affected populace of the project areas during the period of the project construction. This research effort paid off handsomely, resulting in about 18-20 studies on various types of social impacts, a research record rarely achieved in other hydropower projects (POE 2002). The findings of these researches on impacts and issues were conveyed to the project director and the ADB, through POE reports and ADB Supervision Mission reports.

Mitigation implementation/adaptive management

The project mostly followed the mitigation approaches proposed by the project environmental documents. Nevertheless, the project also espouse to adaptive management approach in order to minimize and/or mitigate the unforeseen adverse impacts arises during the course of project implementation. Resettlement and Rehabilitation program for affected Bote (Fishermen) families and implementation of Community Support Program were good examples of adaptive management of the project. Some of the major mitigation measures implemented and/or constructed during construction stage of the project were as follows;

Physical Environment

- Installation of siren warning system in powe-rhouse and dam site.
- Protection measures for water qu-ality at project areas.
- Restoration of the disturbed site using bioeng-ineering measures at head work site, powerh-ouse site, access road and transmission line tower locations.
- Management and control of 6.2 million tons excavated materials were carried out as per the approved plan submitted by the contra-ctor.

Biological environment

- Establishment of project central nursery with production capacity of 60,000 seedlings/year and grass slip production (150,000-200,000/year) for bioen-gineering and slope stabilization purposes in project site.
- Establishment of satellite nurseries to provide seedlings to local communities.
- Plantation of 319,694 seedlings of different species at different project components and community land.

- Restriction on hunting and poaching during construction period of the project.
- Construction of fish hatchery.
- Implementation of fish trapping and hauling program.
- Construction of trash rack, fish bypass system and collector channel at headwork site.

Social/cultural environment

- Cash compensation for the loss of land, house and other assets. The formal tenants of *guthi* (communal) land were paid an additional 42% compensation, totaling 75% vis-à-vis legal provision of only 33% compensation. Compensation also provided for standing crops and grass damaged during the project construction.
- Provided additional rehabilitat-ion grants (house rent) to the affected families at the rate of NRs 1,000 per month for 4 months.
- Grant to pay the government la-nd registration fee provided as an incentive to those affected families who purchased replacement land.
- House loss compensated at repl-acement cost. Affected households were also provided the construction materials from their old house for reuse.
- Priority of hiring affected family members including local people. Provided employment to 2,568 people during construction. More than three-fourths of the SPAFs/PAFs were employed and the local-outsider employment ratio in the project was 50-50% during construction. Both the families' standard of living and the local economy soon exhibited the positive impact of these regular cash inflows during the project construction period.
- Implementation of micro-credit revolving fund program with an earmarked budget of NRs 2,900,000.
- Protection of Setibeni Sheela, a holy stone religious site, by constructing a gabion wall with height ranging from 2 to 8 m, a walking path with railing around the sacred stone to facilitate devotees to worship and encircle the stone.
- Construction of cremation sheds and renovation of temples.
- Implementation of skill development training program.
- Resettlement and rehabilitation of Bote (fisherman) families.
- Implementation of community support program, which includes conservation of local religious and cultural sites, literacy program to local women, support to local schools, renovation and construction of drinking water, etc.
- Establishment of a primary sch- ool at Andhimuhan Bote village, as an important gesture of project mitigation attempts for the Bote community.
- The study shows that the empl-oyed SPAF/PAFs have secured NRs 128,000 average annual cash income compared to the 22,000 rupees that families earned annually before the project started. This indicates that the cash income of the SPAF/PAFs was nearly six times greater than the previous cash income.
- Regular celebration of World Environment Day to enhance environmental awareness among local public.

Environmental aspects during operation phase

The Kali Gandaki 'A' Hydroelectric Plant has been under commercial operation since August 2002. The Environmental and Social Studies Department (ESSD) of the NEA carried out the post-construction Environmental Impact Study of the project. ESSD staff has recently completed operation phase environmental and social monitoring activities of the project for two year (2005-2006) and prepared an Environmental and Social Operation Manual for the project. These activities have been carried out as per ADB requirement, with reports submitted regularly to ADB.

Findings

Major findings of environmental and social monitoring/studies during operation phase of the project include;

1. Release of 4 m^3/s minimum of water during dry season and 6 m^3/s on religious days has been observed.
2. A siren warning system is in operation at the powerhouse and dam site.
3. Reduction in bed load below the dam after construction has occurred. However, total sediment loads downstream has not changed from the pre-existing conditions.
4. The KGA project has had a positive effect on forests, with regards to energy consumption,

as the use of alternative sources of energy has increased,

5. The post-construction Environmental Impact Audit study indicates that construction disturbances have settled down.
6. The Reservoir Sedimentation Study is being carried out annually by the KGA department. A bathymetric survey of project reservoir by echo sounding technology has been implemented.
7. The fish bypass system is under operation.
8. Fish hatchery operations and management are being carried out smoothly by the Nepal Agricultural Research Council (NARC).
9. Release of different species of fingerling in Project reservoir has been implemented.
10. Three has been a decrease in average land holding size of the affected families in comparison to pre-project levels.
11. The quality of reconstructed houses appears better than old houses. Some of the new houses are roofed with iron-sheeting and are cemented, replacing homes that were previously thatched.
12. All the newly built houses have been handed over to the affected Bote (fishermen) families.
13. The Kali Gandaki Primary School for Bote children is operating smoothly with classes up to class 3.
14. The agricultural occupation of affected families has declined by about 5% whereas service category has increased from 6.90% to 9.58%. Similarly the occupation levels of labor and wages during pre-project period of 0.54% have also slightly increased to 0.64% in post-project period.
15. The intermixing of local and outside laborers created both positive and negative effects. The positive effects reported are the exchange of skills, ideas etc., between groups, while the negative effects reported are some unacceptable socio-cultural behaviors such as theft and disruption in law and order during the project construction period.
16. The local economy is now more integrated with the national economy because of the project access road and the boat transportation on the project reservoir.
17. Implementation of the project has established and enhanced the local infrastructures in the project area, specifically at the dam and powerhouse sites.
18. 225 people were employed during the operation phase. Local employment in the operation phase is about 69%.
19. Due to the fluctuation and peaking effects of the project to the downstream of dam and below the powerhouse site, the *sankhar* (traditional fishing gear) used by the Bote fisherman to harvest fish has been affected, causing adverse impact on their income and livelihood.
20. There seems to be an improvement in the health status of families, since more houses now have toilets and separate cowsheds. Previously, people and livestock shared common space.

Projects benefits

The implementation of Kali Gandaki ‘A’ Hydroelectric Project in the region, once considered as remote area, has resulted in multiple beneficial impacts to the local community. The improvement of public infrastructure such as access roads, rural electrification, telecommunications and health services, enhanced educational facilities and employment of local population, including project-affected families during the project construction stage and operation phase, have benefited local communities by enhancing their quality of life.

About 4,256 rural households have benefited from rural electrification in the project areas and additional new households are being electrified.

The project has also implemented Community Support Programs (CSPs) to address the local needs and to build good rapport with local communities, which was not foreseen during project planning. However, the project had also faced difficulties in fulfilling the never-ending demands of the communities, mainly due to the unavailability of funds from alternative sources.

The operation of the project has contributed significantly to Nepal’s power system, reducing the need for load shedding, catering to the need of energy for future electrification and boosting economic development of the country. The benefits to government and the local populations include improved infrastructures and employment opportunities. The project has contributed in producing trained and experienced manpower in various skilled job, including environmental monitoring and management of large hydropower projects.

Conclusions

Most of the proposed requirements set forth in the various project’s documents for mitigating adverse environmental impacts due to project construction have been implemented. The impacts of the project due to the access road, rural electrification and employment have created a local transformation. The beneficial impacts of the project have significantly affected at the local, regional and national levels in positive ways.

A considerable amount of cash flow to the local community during project construction ensures at least the previous living standard of PAFs and SPAFs. Most of the PAF and SPAFs have managed to achieve a better standard of living and some have invested money in modernizing houses and purchasing land. Local people, including the affected families, are now more amenable to more commercial activities for income generation.

The project can be considered as a pioneer in the field of environmental monitoring and management of large hydropower project in Nepal.

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End notes

1 Professor Michael M Cernea and Dr. Donald Graybill were members of international POE for social and environmental aspects of the KGA Project, respectively.

2 SPAF: Seriously Project Affected Family denotes the affected families who lost their house or more than 50% of their income or land.

3 PAF: Project Affected Families denotes the affected families who lost their assets to the project.

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The Dynamics of Social Inequality in the Kali Gandaki 'A' Dam Project in Nepal: The Politics of Patronage

Kavita Rai

Abstract: This research article utilizes concepts from the 'Anthropology of Clientelism' to explain the dynamics of social inequality after the construction of the Kali Gandaki 'A' hydroelectric dam project. As Nepal's rural societies are largely agrarian, Scott's (1976) moral economy theory, positioned against Popkin's (1979) political economy approach acts as the basis of argumentation of how patronage politics links the different social strata at the local level. The access to the KG 'A' project resources (financial in terms of compensation and project employment and natural in regard to access to land and water) and the acquired outcomes explains the strategies that local actors took to gain from the project intervention eventually changing the dynamics of social interaction and levels of inequalities internal and external to their own social groups.

Key words: Dam, clientelism, compensation, Kali Gandaki 'A', patronage, resettlement, social inequalities, Nepal

Introduction: Dams, development and social inequalities

One of the arguments in the implementation of dam projects is that the benefits will ultimately lead to a win-win situation for all. Large dams in particular are viewed as panacea for the pervasive poverty in the Himalaya-Ganga (Dixit 1994).

Critics of this argument counteract by arguing that people in rural areas are not winning because they receive little direct benefits. Displacements of local families from dam interventions are also critiqued as a price paid for development. Ethical questions are often raised because of the inequitable distribution of benefits and affected people being more vulnerable or worse off (Cernea 2000). Meanwhile, hierarchical relationships of patronage between state bureaucrats and locals, class and other striations also bring about disputes, unequal resettlement and compensation provisions and take more time to negotiate (Gandhi 2003). Within this context, state policies and laws provide the framework for compensating the people affected directly and indirectly. However, the main assumption as taken here is that the hierarchical structure of the Nepalese state and society and the ubiquity of patronage politics will negatively affect even those development programmes that aim at inclusion and redistribution. This hierarchical structure emerges out of a complex social structure where caste, ethnicity and class do not fit into neatly structured divisions. Baral (2000) views inequalities to stem from a hierarchical state that thrived on a system of patronage that has been historically and socially exploitative in nature with the ruling classes enjoying the benefits.

With social inequalities and patronage inherent in Nepali society, development processes are, therefore, apt fields for their manifestation. Dam interventions are not exempt. Equity issues are gaining importance. As the World Commission for Dam report (2000:120) points out, 'the emergence of equity as a critical ingredient of development underlines that this "balance sheet" approach is unacceptable as it ignores the typical mismatch between the distribution of the gains and losses of a project across different societal groups'.

What, then, are the ground realities in the case of Nepal? What are the outcomes in terms of equality/ inequality when large hydropower plants are implanted upon local communities vis-à-vis the distribution of resources—financial and natural (of land and water)? This paper attempts to link in answers to these questions focusing on patronage relations in the Kali Gandaki (KG) 'A' project area. Before unfolding the research assumptions to these questions, the following section will briefly explain the concepts of patronage.

The anthropology of patronage (clientelism)

The interplay between relational inequalities and distributional inequalities[1] can be studied within the framework of patron-client relationships. Patronage (used interchangeably with clientelism, a term used by anthropologists) is important because it links the strata based on class, ethnicity and class together, especially in the political process[2]. The word 'patron' is derived from the Spanish *patrón*, a person of power, status, authority and influence, while the client is economically and politically weaker (Hall 1977:510). Landé defines a patron-client relation as 'a vertical dyadic alliance; i.e., an alliance between two people of unequal status, power or resources each of whom finds it useful to have as an ally someone superior or inferior to himself' (1977:xx). In such a relationship, the superior member is the patron and the inferior member his client. In addition to unequal status, influence and a relationship based on reciprocity, Powell (1970) adds that patron-client relationship rests on a face-to-face contact between the two parties. Significant amount of research on clientelism were conducted around peasant societies by anthropologists and political scientists (see Swartz 1968; Lemarchand and Legg 1972; Scott 1976; Schmidt et al 1977; Popkin 1979). Later works on patron-client relations focussed on a wider political, historical and contemporary global coverage (see Eisenstadt and Lemarchand 1981; Roniger and Günes-Ayata 1994). Patronage and clientelism existed, according to these researchers, in the absence of strong states but then stealthily crept into development processes. In Nepal, there have been no specific attempts to study patronage, although Bista (1991) wrote extensively about *chakari*, a manifestation of clientelism. Like Bista, other social and political scientists often incorporate patronage and clientelism within a wider work on social or political development.

In this paper, the politics of patronage in the KG 'A' site will be explored through the concepts of patronage used by Scott (1976) and Popkin (1979) mainly because of the commonality of 'rural' settings, inclusive of highly structured patronage relations amongst social groups. John Scott (1976), in the *Moral Economy of the Peasants*, captures the dynamics of motivations of people that sustain relational and distributive inequalities. Scott argues that peasants and elites are moral and less calculating in pre-capitalist settings. He believes that the justification of any hierarchy of status and power implies the creation of role obligations that carry moral weight. The subordinate groups accept inequalities because their patrons provide social and material guarantees in return for labour, services and loyalty. Patrons provide these guarantees under scarcity of labour and competition from other patrons. Their mutual interests bind patrons and clients together. They develop a normative framework on this basis. Patrons who do not adhere to this subsistence ethic are exploitative and unjust. When patrons opt out of this frame, peasants resist and rebel because the moral contract is broken. For Scott, stratification originates from capitalism and the entry of markets.

Popkin (1979), on the other hand, made a competing rational political economy thesis in his examination of village economy and politics in pre-colonial Vietnam. He argues that individual choice and decision-making form the core concepts on why groups of individuals decide to adopt some norms while rejecting others. Subordinate groups act in their individual self-interest even without markets and will opt out of a clientelistic relationship on assessing their own individualistic goals. Popkin's political economy approach argues that norms are malleable, renegotiated and shifted in accordance with considerations of power and strategic interactions among individuals. The assumption is that a peasant is concerned with his/her own and his/her family's welfare and security, thereby being self-interested and rational.

In terms of the effects of development projects on patron-client relations, however, the two approaches of Scott and Popkin make two different predictions that are taken into account here. Both predict different outcomes of miniaturization and proletarization (the social consequences of the project). Development projects will benefit patrons more because these have the political capital necessary to establish relationships with project staff. Following Scott's and Popkin's approach, it is hypothesized that *there will be a 'trickle down' effect: the clients will also profit, since the patrons will hand some of the benefits to their followers*. Alternately, *through development intervention, new patronage relations will form linking the development state and locals in new ways to create new dependencies*. Taking Popkin's rationality argument, it is also hypothesized that '*the long term consequences of project intervention, should ideally, be less social hierarchy, less reliance on patronage clan and lineages, less patriarchy, more individual and geographical space mobility*'.

Methodology

A brief conceptual framework adapted from Stern, Ostrom et al (2002:452) to correlate the variables is put forward to further the hypothesis. Given the ecological and social complexities of dam intervention, this framework helps explain and explore the causality of relationships for meaningful theoretical propositions. It tries to explain how social inequalities and patronage politics influence the individual's access to information and decision-makers and how the inequality of access determines the distribution of compensation and other resources controlled by the dam project.

Dependent variable: Outcomes

Outcomes are the dependent variables, which are of importance to the resource users who may be affected by interventions and resource conditions and usage. To examine this variable, inequalities were measured or observed based on the delivery, benefits and distribution of financial compensation resulting from

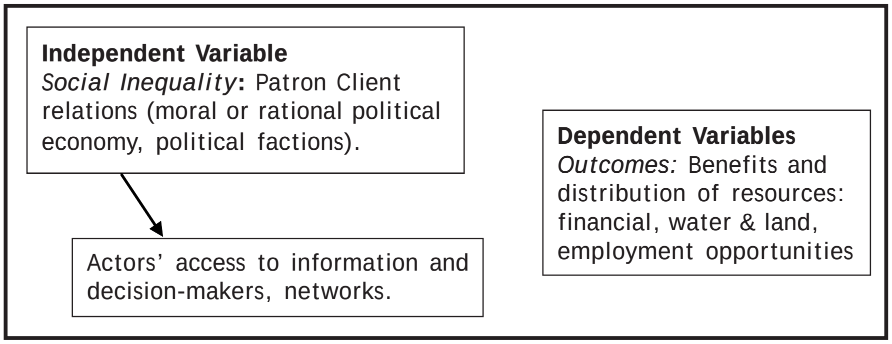

Figure 1. Conceptual Framework (adapted from Stern, Ostrom et al 2002)

loss of land. Additionally, the benefits from project employment, income generation projects and recruitment of labour in the project site during construction and post construction phases were also examined.

Independent variables: Social inequality (patron-client relations)

The hypothesis is concentrated on social structure variables and the various relationships through information access and political networks. Patron-client relations and factionalism based on political patronage were pursued as the independent variable.

Research methods

The research took a case study approach focusing on the local population affected by the 144 MW Kali Gandaki 'A' dam project, Nepal's largest hydropower plant (to date). The collection of secondary data and field research took place between September 2002 and July 2003. Time was allocated to collect project-related information, conduct empirical fieldwork, input data, and write field notes. Semi-structured interviews were conducted with relevant experts and personnel from the capital Kathmandu and the Nepal Electricity Authority (NEA)[3], the main implementing organization. The two most affected villages of Mirmi, where the dam is located, and Beltari, with the powerhouse, both in the central Nepal district of Syangja, were taken as field sites. People who lost a major share of their land to the project came from these two villages. Members from the higher Bahun (Brahmin) caste, the ethnic Magars, and the lower caste groups of Damai, Sunuwars and Kamis, were all interviewed as they were all affected by the KG 'A' project. To gather relevant data on issues of environmental equity of natural resource sharing (mainly the river), interviews were carried out among the Bote fishing communities downstream along the 50 km river loop and upstream of the dam.

A major part of fieldwork was spent conducting qualitative ethnographic research. The intense community antagonism towards researchers at this stage did not allow for quantitative research. They were suffering from a 'survey burnout' as the project continuously monitored them for about eight years. Therefore, to attain a true picture of the intervention, responses and outcomes and to build up confidence with local respondents, qualitative research became the key method. In addition, key informants (local people as well as current and former project officials) were the major sources of information. After some confidence was built up, an eight-page questionnaire was administered to 108 households that constituted 50% of those most affected in terms of land loss. These families were categorized by the project as seriously project-affected families (SPAFs) and project-affected families (PAFs).

General extent of the Kali Gandaki 'A' dam intervention

In the case of hydropower intervention in Nepal, the law assigns the right over water exclusively to the state. Similarly, in the case of private property, the law of eminent domain[4] allows the state to acquire private property against compensation only in the public interest. Both private and *guthi*[5] lands were acquired in the case of the KG 'A' project. NEA acquired about 53.7 ha (1054 *ropanis*[6]) of land and 57 houses for the access road to the dam and powerhouse sites. A further 148.62 ha was acquired (of which 94.2 ha was private and *guthi* lands) for the main facilities that include the dam, the powerhouse and the project office sites. In addition, 13 houses, 20 cowsheds and one water collection pond were acquired. Out of the total compensation amount of NRs 30.43 million (US$ 0.54 million) of compensation, almost 95% (NRs 30.24 million) had been disbursed (KGEMU 2002).

In terms of resettlement in the KG 'A' project, there were no cases of homelessness. Sixteen Bote (an indigenous fisher community) households whose lands and houses had been earlier appropriated were considered for resettlement. Resettlement was novel to this project, as it did not exist in past hydropower

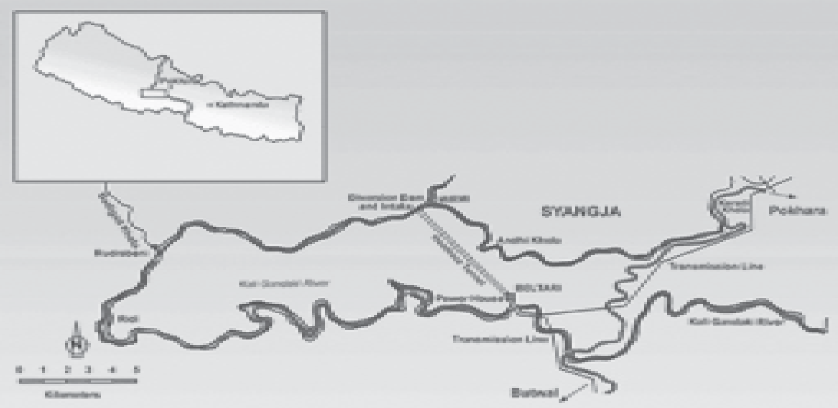

Figure 2. Map of the Kali Gandaki 'A' Hydroelectric Project site (source: *The Nepali Times,* Kathmandu, #176, 26 December 2003)

compensatory packages. Cash compensation was the main mode of compensation for land acquired by the NEA. Land for land was not an option. An acquisition, compensation and rehabilitation plan (ACRP) was developed as a pre-project document following the process established in the Land Acquisition Act of 1977 of Nepal. In accordance with the same Act, the chief district officer led a Rate Fixation Committee. Market prices of the area, government rate and gradations of land were the three determining factors used to set compensation rates (KGEMU 2002). Land compensation rates changed three times because the existing rules and laws did not match real land valuations and negotiations took place between local leaders and the compensation committee.

Compensation processes required that all those whose lands were appropriated had to produce land title papers to receive the compensation. All individuals who lost 50% or more of legally registered land and/or their living quarters were declared as SPAFs (263 families in total) and those losing less than 50% of land were categorized as PAFs (1205 families in total). The same criteria were applied for land acquisition for both the road access and the main facilities (dam, powerhouse and offices). The average land-holding size of an affected family was .46 ha to 1.5 ha; often equally divided between irrigated and non-irrigated land.

As part of the mitigation strategy of the Environmental Impact Assessment Plan, at least one person from the affected families was to be provided employment in the project. The Kali Gandaki monitoring unit provided a list of these families to the contractors for job employment. As of May 2001, a total of 2,132 persons were employed in the project of which 1,012 (47.45%) were from the local area. Altogether, individuals from 94 SPAFs and 190 PAFs were employed in the project.

Empirical evidence to theoretical proposition

Patron-client relations commonly found in the KG 'A' areas manifested mainly through three patronage systems: traditional money lending patronage systems, caste based patronage and political patronage, based on political affiliation. In a nascent democracy,[7] political party leaders are chosen at ward and regional levels forming crucial patrons linking them to the state. According to Pfaff-Czarnecka (2000), political parties are often viewed as best suited allies to the state, which increasingly interferes or provides for the people. In the KG 'A' areas, political leaders as well as government officials—members of Village Development Committees (VDCs) and the District Development Committee (DDC)[8]—played important roles as intermediaries between their followers and project interventionists especially before the dam intervention. However, during the project construction period, competition, especially for employment, grew. Apart from political leadership, social and village elders formed the core of the hierarchical informal institutional structure within the village.

Both hypotheses on clientelism were confirmed in the study as clients benefited mainly through patronage politics. In the case of the Kali Gandaki 'A' intervention, as prominent political party and village leaders lost the major share of their land, it made a crucial difference in the determination of outcomes. Compensation was low in the first acquisition process, that of the access road. Once the patrons (high caste or ethnic group leaders) formed a proper base of knowledge and with their own interests, they raised voices and negotiated with project officials, state bureaucrats and formed alliances to set a higher amount of compensation suited to the changed land economy after the project intervention.

As for the project officials, they could capture the local elite. Project officials relied on the influence of local social and political leaders at the beginning of the project period, particularly to mediate with the whole community. This worked for some time. In the whole process, clients or poorer people benefited through their leaders and patrons, both social and political. However, akin to Popkin's assumptions, the slow invasion of a cash economy and the patronage of influential officers started to break this influence. It was mostly through the local VDC or DDC leaders, political parties or elites that families and individuals started to channel influence to gain employment and other benefits.

One of the first dismantling of local power channels resulted from the new-found alliance between local leaders and project officials. The self-interest of leaders led to the decay of previously existing loyal relations of political and social patronage. Clients opted out of their loyalties to their patrons, especially political leaders, to forge their own alliances with NEA officials, contractors and state bureaucrats, thus supporting Scott's moral economy argument. Alliances with the intervening actors were built particularly to provide jobs for their family members. A majority of the respondents (60%) said that they have a direct relation with project staff rather than through political or social affiliations. Project officials and outside contractors often took over the role of the 'patrons'. With these alliances grew a new set of relationships, not necessarily fully reciprocal but nonetheless with some reciprocity in the form of trust and loyalty to the project itself. While some respondents who gained fully from the project emphasized their loyalty and positive attitude to the dam intervention, others who had not received continued support, particularly in the form of jobs from officials, feel a sense of betrayal. Individualistic gains were found to be more common, supporting Popkin's political economy argument.

The hypothesis that the long-term consequences of a project intervention would ideally, be less social hierarchy, less reliance on clan and extended family, less patriarchal and more individual and geographical space mobility were also partially confirmed. In the most affected villages of Beltari and Mirmi, large clans and patronage systems existed. After the loss of land in these villages, cooperation and cohesion among members were found to be weak, as pointed out earlier. In the presence of scarce resources and with competition, most of the respondents identified with their own immediate nucleated family rather than the larger extended family or clan. The provision of cash as compensation is one of the main reasons leading to this fraction. While earlier elder patriarchs had total control and it was often difficult to divide land easily between brothers, after land acquisition it was easier for family members to take their share of the cash and opt out of the extended family. The situation remained similar in all Bahun, Magar and Bote families. This partly supports Scott's thesis that peasants insured themselves socially through reliance on own kin and friends rather than the state (for example, DDC/VDC members).

Similarly, old forms of political control (parties) and patronages disappeared; individualism was on the rise. Project officials and contractors weakened the position of the local social and political leaders through petty contracting, thus tilting support towards them as local communities distrusted their leaders. This led many individuals to develop new relationships, especially with project officials and contractors of the project, thus supporting Popkin's rationality argument.

Conclusion

Despite the implementation of policies and laws, relationships between the local powerful people and dam project interventionists shaped outcomes towards the former's favour, especially under scarce resource constraints. Linkages within and to the corridors of power (both new and old patronage) were important to access employment or project benefits. Participatory and interactive institutional processes need to be developed further, particularly by the implementing agency, in order to lower unequal outcomes.

From the study, it was concluded that the moral economy approach is well-suited in areas with active functioning agrarian structures. Scott's moral economy provides insight into peasant life with strong land-labour relations and sustenance based on the subsistence ethic. In the KG 'A' sites, after almost a decade of project interventions and the entry of a wider set of national and international actors, new institutional arrangements had crept up. Markets had broadened, particularly with the additional road network, and the cash economy tilted eventually in favour of Popkin's rational economy model. One lesson is clear: that old forms of patronage will metamorphose into new ones and power relations will continue to play a major role especially in development interventions in rural areas. Developing transparent policies and programmes are one way of enhancing equality of outcomes amongst various social and gender groups. Otherwise, the intricacies of power within social relationships may hamper progress and equitable solutions at the local level.

Kavita Rai *is an anthropologist working in the area of energy for sustainable development. The research was carried out in fulfillment of her PhD dissertation, entitled* Dam Development: The Dynamics of Social Inequality in a Hydropower Project in Nepal *(Rai 2005). The data in this article are derived from field research carried out in 2002-2003 on the Kali Gandaki 'A' Hydroelectric Project.*
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The article summarizes two theoretical concepts and results of the research.

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End notes

1. Béteille (1983:1) differentiates between relational and distributional inequality. Relational

inequalities are inherent in relations amongst people. Some are deemed superior, and others subordinate, with the division of people into categories along caste, ethnic, class and gender lines. Distributional inequalities, however, concern disparities in the distribution of material resources such as income and wealth.

2. Patron-client studies conducted since the mid-60s have shown interesting insights into political life in rural communities.

3. Nepal Electricity Authority (NEA), created on 16 August 16 1985, is responsible for planning, constructing, operating and maintaining all generation, transmission and distribution facilities in Nepal's power system both interconnected and isolated.

4. Eminent domain is defined as 'the power of a nation or a sovereign state to take or to authorise the taking of private property for public use without the owner's consent, conditioned upon the payment of compensation' (Bhattarai 2001:52).

5. *Guthi* land grants, are religious endowments (Ramirez 2000a) or for social charity purposes; e.g. public schools and hospitals (New Era 1988).

6. 1hectare land equals 19.6 *ropani*.

7. Nepal became a multi-party democracy in 1990.

8. The Village Development Committee (VDC) is the lowest administrative political unit at the village level, and at the district level is the District Development Committee (DDC) working between parliament and local bodies. Committee members often have an affiliation to a political party.

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Maximizing Benefits from Hydropower: A Nepal Case

Janak Lal Karmacharya

Abstract. Hydropower development is the only development activity that yields multiple benefits and, in many cases, can be an effective agent for poverty alleviation. Apart from being a source of renewable and clean energy, to stabilize the supply of electricity, it helps provide year round irrigation resulting in the increase in the cropping intensity and changing cropping pattern, and it reduces both deforestation and greenhouse gas (GHG) emissions. Nepal has adopted a policy of Integrated Water Resources Management (IWRM), by which hydropower projects are developed in conjunction with irrigation, flood control, water supply and navigation components whenever feasible. As an agriculture dependent country, Nepal should maximize the irrigation benefit, by providing year round irrigation through storage projects developed for peak energy generation. Nepal has planned to provide year round irrigation to 67% of the total irrigated area by 2027. Electricity from hydropower projects currently contributes only 1% of energy need, whereas fuelwood contributes 68%, and fossil fuels 8%. Development of hydropower not only helps reduce deforestation, reported at the rate of 0.7% per annum, but also helps reduce GHG emission by substitution of imported fossil fuels. The annual fossil fuel import bill for Nepal 2004/05 was about 310 million USD. Nepal could benefit substantially if consumption of petroleum products were replaced by hydropower. Where the Clean Development Mechanism (CDM) is effectively used to address the impact on climate change, hydropower gains significance in contributing positively to climate change.

Key words: Hydropower, IWRM, maximization of benefit, poverty alleviation, growth, Nepal

No other source of energy other than hydropower can deliver multi-pronged benefits. The development of hydropower can ensure energy security, provide food security and health security and, in addition, preserve environment, reduce greenhouse gas emission and create recreational facilities. It can also provide access to the sea for a land-locked country. With the world wide recognition, from World Summit on Sustainable Development to Bonn and Beijing Renewable Conferences through Third World Water Forum, that hydropower is the clean and renewable source of energy, the exploitation of hydropower is going to be a major activity to meet the Millennium Development Goal.

One of the important benefits that come out of the construction of dams for hydropower generation is flood control. In many cases, this benefit cannot be quantified in its totality; it is, however, a significant one as it saves precious life and resources. The construction of a storage hydro project, if properly executed on the basis of mutually agreed concept, can be instrumental in maintaining peace between transboundary countries.

Socio-economic set-up of Nepal

Nepal is one of the most populated mountainous countries in the world with the population density of 167 people per square kilometer. Basically it is a country based on an agrarian economy with about 80% of population engaged in agriculture. This sector contributes 38% to the national economy, which translates into 2.48% in agricultural growth, whereas non-agricultural growth is registered at 10.44%. The heavy pressure is on agriculture and natural resources to support the growing population. The annual per capita GDP is estimated at USD 248. The human Development Indicator stands at 0.504. The life expectancy at birth is reported to be about 61 years and infant mortality is recorded at 69% in 2001. The proportion of electrified households is 40%.

The government has set a target of achieving annual economic growth of 8.3% by 2016/17, out of which 5% growth is projected in the agriculture sector and 9.7% in non-agriculture sector. The population below the poverty line will be reduced to 10%, with the growth reduced to 1.5%. About 1700 thousand hectares will be brought under irrigation by the same year. Nepal is a land locked country, a factor that dominates the development scenario.

Water resources use in Nepal

Nepal is a land limited but water rich country. Its 6,000 rivers generates 224 billion cubic meter of surface run-off annually, which translates into more than 9,000 m^3 of water per capita. This is far more than internationally recognized norm of 1,750 m^3 per capita. However, because of the spatial and temporal variation in the availability of water, a few months and a few areas of the country are still water deficit. The uniform distribution of water over its territory is essential to avoid water stress situation This objective is met through adoption of Integrated Water Resources Management. The major components of integrated use are hydropower, irrigation, water supply and flood control and, to lesser extent, inland navigation, recreational use and fisheries.

Hydropower – the way to poverty alleviation

The rivers of Nepal with glacier, snow and monsoon feeding coupled with steep gradient, are estimated to have the potentiality of generating 83,000 MW of electricity. With the load factor of 52%, this translates into 1,500 kWh per capita of electricity for the present population. If this potentiality is fully exploited and sold at an average rate of six cents per kWh, the resulting revenue generated will be to the tune of 23 billion USD per annum. Out of this theoretical potentiality, 43,000 MW have been proven to be technically and economically attractive through sound engineering studies.

In view of the importance of hydropower development for the overall economic development of the country, the Nepal Government has put specific emphasis on the implementation of its National Water Plan (NWP). This plan envisages generating 2,100 MW by 2017 and 4,000 MW by 2027. This, however, is a substantially downgraded target of 4,080 MW in 2017 and 11,568 MW in 2027. This was considered necessary to meet the value added requirement in the water and electricity sector to generate 6.5% economic growth. In the High Growth Scenario, with the assumption that the load factor will improve by 10% and operational expenses will drop by 10% due to economy of scale of plants, the projected generation is envisaged to be 6,275 MW in 2017 and 25,234 MW in 2027.

In comparison to the identified hydropower potentiality, the domestic electricity market of Nepal is very limited. Without entering into the export market, the benefits from hydro generation cannot be maximized. In the regional market, hydropower is going to play a significant role in addressing concern for energy security. The South Asia region is marching towards unprecedented economic growth. However, the supply of energy has been stumbling block. To face this challenge, Bangladesh, India, Pakistan and Sri Lanka are vigorously pursuing measures to diversify their traditional energy supply mix. Because of the high volatility of the oil market and the uncertainty associated with it, the role of hydropower assumes great significance. Hydropower, being capable of generating cheap and reliable peak energy, contributes to the stability of the system by stabilizing the supply frequency. This additional advantage of hydropower has led to the appreciation of the need to develop a Hydroelectric Master Plan for the South Asia Region encompassing India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, the Maldives and newly entered Afghanistan. The objective of such a master plan is to facilitate an integrated planning mechanism to identify the hydropower sources that would meet the power needs of the region at an affordable cost. This will also help maximize the benefit from hydropower development and rationalize utilization of hydro resources. It will also bring hydropower to the center stage of the Regional Power Pool, envisaged to be created in the South Asia Association for Regional Cooperation (SAARC) framework.

Nepal and India have been traditional power exchange countries. To sustain India's rate of GDP growth requires considerable addition of electricity. The electricity deficit in India, particularly the peak deficit, is significant at 18%. Hence, the Government of India has allowed a premium on the peak power in the vicinity of 50% of base electricity tariff. As reported earlier out of the 43,000 MW 0f proven capacity of Nepal, 22,000 MW will come from storage plants. Development of these schemes will maximize the benefit of Nepal Hydropower. In view of the mutual benefits to both Nepal and India and the need to mobilize private financial resources, India and Nepal have initialed a bi-national Power Trade Agreement. The proposed electric power agreement allows the governmental, semi-governmental and private enterprises of Nepal and India to enter into agreements for power trade. Agreeing parties may determine the terms and conditions of such agreements, including the quantum and parameters of supply, point of delivery and the price of supply. Such wide provisions in power trade agreement will facilitate the cross border flow of electricity during periods when each country needs the power. The time, location and duration of need are different in the two power systems. This introduces complimentarity in supply, thus maximizing the use and, therefore, the benefit of the hydropower.

Hydropower contributes to meeting both water and energy needs, including water for irrigation and drinking water. It usually works with a wider group of disciplines, to maximize hydropower's contribution to sustainable development.

Irrigation – insuring food security

As earlier mentioned, Nepal is basically an agriculture country with its contribution to the economy standing at 38% of GDP. Nepal has 2.64 million hectares of cultivable land, of which only 1.76 million ha (66%) are irrigable. Irrigation facilities are available only for 60% of irrigable land, though less than one third of that land has round-the-year irrigation facility. This limited facility for irrigation and resulting unsatisfactory cropping intensity resulted, in 2003, in the production of 7.2 million tons of agricultural product—hardly sufficient to meet the minimum requirement of the nation.

The Nepal Government has embarked upon the plan to increase the total year-round irrigated area to 49%, the cropping intensity to exceed 140% in year-round irrigated areas, and irrigation efficiency to 35% by 2007. The corresponding figures for the year 2017 are 64%, 164% and 45%, respectively. By 2027, the targeted corresponding figures are 67% year-round irrigated area, an average cropping intensity of 193% and an irrigation efficiency of 50%.

The cost of implementing the plan, which may result in achieving the above target, is significant. In the short term (i.e., by 2007), the investment requirement is USD 293 million; in the medium term (2017) USD 1,405 million; and, in long term (2027), the figure goes up to USD 1,904 million. This totals USD 3,602 million over the next 20 years (at the 2003/04 price level). Raising this level of financial resources is a daunting task. The sector cannot generate enough money itself to finance the programme. The collection of water tariffs has a very poor record. Improvement has been envisaged with the target of achieving irrigation service contribution to 30% of operation and maintenance cost of the irrigation system by 2007, with further improvement in 2017 by increasing the figure to 45%, and eventually reaching the figure of 75% by 2027. This means that even for operation and maintenance, the irrigation system will not be self sustained, not to mention capital investment. It is here that the necessity to develop hydropower for multipurpose utilization assumes significance. Fortunately, the resource generation capacity of this sector is satisfactory and if the capital costs are shared between irrigation and power in a multipurpose development it will not only help address the problem of the irrigation sector but will also maximize the profits from hydropower development. Nepal has a number of projects that can meet this objective, such as Bagmati, Kankai, Sapt Kosi, Sunkosi, Karnali Bheri-Babai, Mahakali, etc.

Flood control - reducing human suffrage

One of the significant benefits that a dam construction gives is the flood control. This advantage becomes more important in the area where flash floods occur or the rivers are fed with monsoon rain. In Nepal floods usually occur because of the monsoon precipitation, glacial lake outbursts, cloud outbursts and coincidence of monsoon with increased base flow from snow and glacier melt. The damage and loss of living beings and assets are tremendous. There are many trans-boundary rivers that traverse from Nepal through India to Bangladesh causing extensive damage in multiple countries. One of Nepal's eastern rivers, the Kosi, is called 'the sorrow of Bihar', a populace state in northern India, because of the trail of devastation it leaves in Bihar every year after monsoon. The well documented damage caused by floods in Bangladesh in 1988 presents a grim picture, where loss of 2 million tons of crops, about 172,000 livestock and destruction of 1,990 kms of embankment, 283 kms of canals, 3,000 kms of national roads and 10,000 kms of rural roads were reported. In Nepal the flood events of 1974, 1978, 1985 and 1987 were significant in terms of damage inflicted on the national economy. Studies conducted so far have identified about thirty reservoir sites in Nepal. The total effective water holding capacity of these reservoirs created by storage dam has been estimated to be about 77 billion m.

Nepal is divided into five hydrological regions: Mahakali River Basin, Karnali River Basin, Gandak River Basin, Sapt-Kosi River Basin and Southern River Basin. The holding capacity of each of these basins is given in Table 1.

The storage capacity constitutes[3] almost 70% of total monsoon flow. Multipurpose and optimal utilization of these water resources by constructing high dams will not only help mitigate floods but also help augment dry season flow by storing water in the reservoir to release during the dry season, thus improving irrigation potentiality and the mitigation

BASIN	HOLDING CAPACITY OF RESERVOIR (million cubic meters)	HOLDING POTENTIAL OF MONSOON RUNOFF (%)
Mahakali	6,040	43.2
Karnali	34,243	123.7
Gandak	17,830	55.1
Sapta Kosi	13,760	44.6
Southern River	5,221	92.9

Table: 1 Holding capacity of reservoirs in each basin

of floods. However, to ensure the investment to implement such scheme, hydropower is the one component that alone can generate revenue. This kind of multipurpose development helps maximize the benefits of hydropower.

Drinking water and sanitation – insuring health security

Nepal is water rich. However its surface run-off heavily depends upon the monsoon, which is limited to four months a year. Although it is a small country with an area of 144,000 km^2, the spatial distribution of run-off is uneven. Therefore the inter-basin transfer of water is necessary to meet the water needs of all regions of the country. Inter-basin transfer requires construction of dams to divert the water to water conveyance system.

Drinking water and sanitation services are basic needs of the population. At present around 50% of population has access to these services. By 2007, this service will be extended to 80% of population It is envisaged that by 2012, 90% population will have access to water supply and basic sanitation facilities. 100% of the population will have these facilities by 2017. However; people will have to wait until 2027 to receive high quality services in these areas.

The main source of water supply has been surface run-off, which either has to be stored during the monsoon season and used in dry season or pump from groundwater. Due to the lack of storage hydropower projects, municipalities are relying heavily on groundwater extraction with an adverse impact on water table. Provision for drinking water in the storage hydropower schemes or installation of powerhouses in drinking water schemes, where inter-basin transfer is executed, not only maximizes the benefit of hydro schemes but also helps lighten the financial burden of drinking water projects. Provision of safe drinking water also ensures the health security of the population

Hydropower and cost of imported energy

Nepal does not have any fossil fuel reserve nor coal mining. Technological development of the country does not allow development of nuclear power. The development of alternative energy such as solar or wind is also limited due to the cost involved in such development. Hence, for all commercial energy needs, Nepal has to depend either on imported fossil fuels or indigenous hydropower. The industrial, transportation and urban household energy needs are predominantly met by imported fuel. Hydropower has been exploited only in a limited quantity because of the lack of investment.

Meanwhile, the importation bill of fossil fuels is rising, not so much because of an increase in demand but because of skyrocketing prices. The demand on petroleum products has remained more or less at the same level, largely because of political instability, which has contributed to a slow down in economic activities and, to some extent, to the increase in hydropower generation. However, the price of petroleum products has more than doubled in the past decade (see Table 2). The costs are given at the price level of July 2006.

In a small economy such as Nepal, pressure on the foreign currency reserve, because of the petroleum products bill, is substantial. It is here that the importance of hydropower development plays a vital role not only in terms of lessening the pressure on foreign currency reserves, but also in ensuring energy security against uncertainty in supply as well volatility in oil market prices.

The Nepal Rastra Bank, the central bank of Nepal, has reported a record foreign currency deposit of about USD 2 billion this year. The nearly USD 300 million fuel importation bill per annum is a substantial chunk of the foreign currency saving.

YEAR	IMPORTED QUANTUM IN KL	AMOUNT IN USD
1999/00	877,856	121 million
2000/01	941,914	190 million
2001/02	896,324	241 million
2002/03	890,609	312 million
2003/04	879,455	313 million
2004/05	n/a	291 million

Table 2: Importation of fuel and fuel bill of Nepal

Topographically, Nepal is brick shaped with east-west prolongation and north-south width presents a narrow strip with elevation differences of more than 8,000 m within a narrow width of about 200 kms. If Nepal develops a transportation system run by electricity generated from hydropower, it can save substantial portion of petroleum product importation bill of USD 138 million. This is 23% of annual export. A transportation system that could bring about this benefit could be based on hydroelectricity driven east-west railway networks, north-south cable cars and inter- and intra-city tramways and trolley buses. The introduction of such systems will derive maximum benefit from hydropower, and change the face of nation. As an additional benefit it will also drastically reduce dependency on the third country, which Nepal has to rely upon, being a land-locked country. Such a hydroelectricity driven transportation system would also greatly enhance national security.

Environment and additional benefit from hydropower

World climate change has been a phenomenon of global concern. One of the major agents of climate change has been the greenhouse gas (GHG) emission by various power generating plants. After the Kyoto protocol signed by 134 countries, it has been the obligation of the each signatory country to help reduce the emission of GHG within a certain period. Globally it is expected that GHG emissions will be reduced by 2010 by 10% from the present level. To meet this international obligation, a new kind of trade—Carbon Trade—has started through Clean Development Mechanism (CDM). Hydropower, being not related with the emissions-related environmental concerns and being the cleanest source of power generation, not only helps the environment but also generates revenue by entering into this trade, thus maximizing the benefit. Across the southern border, coal- and gas/diesel-fired thermal plants are the main sources of power generation. A World Bank study of the neighboring state of Bihar, India, estimates the emission at levels of 1.23 kg/kwh of carbon dioxide, 7.2 kg/kHz of nitrogen monoxide, and 8 kg/kwh of sulphur monoxide. Nepal's 10 medium and big hydropower plants have the generating energy capacity of about 40,000 GWh. Assuming that these 10 hydropower projects will displace a mix of coal-fired and liquid- fuel thermal plants with similar emission levels, the 40,000 GWh combined annual generation would reduce GHG emission by 680 million tons. With the prevailing average rate of USD 5, the trade would generate about USD 3.4 billion per annum. If these developments were translated into reality, it would not only help meet the global target of reducing GHG emissions but also contribute to the national economy, not only of Nepal but also of neighboring countries.

Hydropower and poverty alleviation

In a country which is hydropower rich, poverty alleviation hinges on the development of this resource. The potential impact is astonishing in a small country with no competitive source on income generation. In Bhutan, for example, a country of about half a million population, the development of hydropower has been dramatically changed by the construction just two hydropower plants with combined capacity of 1,380 MW. As a result, it is expected that the per capita income will go up from USD 760 to 1,320. In Nepal, the impact of hydropower development may not be that dramatic, but it has been established that the hydropower sector is the driving sector in economic development and a major resource to alleviate poverty. A macro-economic study has concluded that in order to eradicate absolute poverty in households, the country needs to register 8% economic growth rate. This will help to bring the level of percentage of population below poverty line to 10% and by 2027 there will be no household in absolute poverty. No other sector of economy other than hydropower is in a position to help attend to this goal, as the required quantum of 25,000+ MW by 2027 that need to be developed to achieve this target is ready for exploitation at short notice, and the market is available. Thus, the solution of poverty alleviation is closely linked with hydropower development in Nepal.

Wrapping-up

Based on the recommendation and statement of Third World Water Forum on Water and Energy, some pertinent observations can be made:

- Water and energy must be integrated as far as possible to maximize the benefit of hydropower development. Multipurpose infrastructures offer the advantage of shared cost and benefit.
- Hydropower contributes to meeting both water and energy needs.
- Hydropower with storage reservoir is the most flexible energy technology in terms of power generation; it can generate power exactly when it is needed, providing back-up for intermittent sources such as wind power and allowing thermal plants to operate at their best efficiency, thus further reducing greenhouse gas emissions.

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IRR: An Operational Risks Reduction Model for Population Resettlement

Michael M. Cernea

Abstract. The construction of hydropower dams and of other types of projects must plan also for the relocation of populations living in the project area, a process fraught with risks and difficulties. This paper describes an analytical, diagnostic, predictive, and planning tool for such projects, developed by the author, named the Impoverishment Risks and Reconstruction (IRR) model. Derived from knowledge and lessons of many previous projects, this model can serve as predictor of risks and problems that will be encountered in forthcoming projects, and be used as guide in applying strategies to counter, overcome or mitigate these risks. Among these are the eight basic risks of impoverishment faced during displacement and resettlement, such as: 1) Landlessness; 2) Joblessness; 3) Homelessness; 4) Marginalization; 5) Food insecurity; 6) Increased morbidity and mortality; 7) Loss of access to common property resources; and 8) Community Disarticulation. Further, the counter-risks strategies and measures are 'modeled', to help early risk-elimination or risk-reduction actions.

The IRR Model is being used internationally. It was applied also in studies for Nepal's Kali Gandaki project to monitor implementation and impacts, to explore what measures and management strategies can be employed against the common risks in resettlement, and to assist those affected in overcoming land or house loss and in deriving benefits from the project.

Key words: Risk model, resettlement, displacement, impoverishment, reconstruction

This paper concisely describes a theoretical model of development–induced displacement and resettlement processes: the *Impoverishment Risks and Reconstruction* (IRR) model. This model is a conceptual and methodological tool apt to perform several essential functions in support of analytical and operational development work. This instrument enables project planners to focus from the outset on the poverty issues that are at the heart of involuntary resettlement. It does not add new tasks on top of the existing ones in preparing projects entailing resettlement. Instead, it saves efforts and increases effectiveness by (a) moving risk discovery upstream in project preparation, and (b) by helping reduce displacement, guiding early risk-elimination or risk-reduction actions.

The main such functions for which the model can be employed are:

- a predictive function, to anticipate the main impoverishment risks involved in forced displacement and resettlement;
- a diagnostic function, to help assess in the field the content and the intensity of each major risk, in a given project's context;
- a planning and problem-resolution function, to guide the design of counter-risk measures and their incorporation in resettlement planning, for either preventing or mitigating risks; and
- a research function, to serve as methodology in the scholarly analysis of resettlement impacts and to guide monitoring and evaluation studies on resettlement processes.

As a theoretical model, the IRR also makes the linkage between the conceptual apparatus used in the analysis of displacement processes, on the one hand, and the theory of poverty, impoverishment prevention and poverty reduction, on the other side.

Knowledge has forewarning power. The research utility of the IRR Model results from using the knowledge about past processes, which is accumulated, 'packaged' and synthesized in the model. This research utility also comes from its ability to guide data collection in the field and to coherently aggregate disparate empirical findings along key variables. In the practice of planning or executing projects, the use of the IRR Model can help prevent, or at least mitigate and gradually reverse, the impoverishment risks embedded in development projects that involve involuntary resettlement.

Theoretical modeling in resettlement research has been made possible by the vast body of empirical findings generated worldwide by numerous researchers about the adverse consequences of forced displacement. The accumulation of empirical data enables us to reveal basic regularities within a multitude of similar and comparable processes. In forced displacement, *the dominant regularity is the* *impoverishment of most resettlers*. This impoverishment is deconstructed and explained in the IRR Model, which also outlines the key reconstruction strategies to counteract impoverishment.

The IRR Model has been formulated in the early 1990s (Cernea 1990) and has been considerably refined since (Cernea and McDowell 2000). During recent years, the model has been widely discussed in the development literature (e.g., see Mathur and Marsden 1998; Mahapatra 1999) and has become the leading conceptual model in resettlement research.

Basic concepts

At the core of the IRR Model are three basic concepts: *risk*, *impoverishment* and *reconstruction*. The related aspects of risks in development and risk-related social behavior can be addressed with a set of more specific, narrower and focused risk concepts such as: risk-exposure, risk aversion, risk prevention, risk taking, risk reduction, risk reversal, risk coping, and others. The theoretical underpinnings of the *Impoverishment Risks and Reconstruction Model* are informed by sociology, economics, anthropology and ethics—more specifically by concerns for equity, human rights and social justice in development, rather than by economic efficiency alone.

Resettlement needs and trends

Involuntary population displacement results from the imperative need to build modern industrial and transportation infrastructure, expand power generation and irrigation, implement urban renewal and enhance social services—schools, hospitals, water supply. Nonetheless, by its adverse effects, forced population displacement remains a social pathology of development, and the first efforts must always be to avoid displacement wherever possible. Unfortunately, however, increases in population density, tight land scarcities and growing socio-economic needs will maintain resettlement as a continuous companion of development. During the last two decades of the twentieth century, the magnitude of forced population displacements entailed by development projects was estimated at about 10 million people annually, or some 200 million people over two decades. Currently, in the first decade of the new century, the size of development-caused displacement is estimated at about 15 million people annually. This clearly indicates the global dimension of this social pathology.

Decapitalization of resettlers

In developing countries (to which this article mainly refers) forced resettlement carries severe *risks of impoverishing the uprooted people*, many of who are very poor even before displacement. Socio-anthropological research currently documents that resettlement operations tend to cause the decapitalization and pauperization of vast numbers of resettlers. They lose capital in all its forms: natural capital, man-made physical capital, human capital and social capital. Eliminating or mitigating such impoverishment risks and improving resettlers' livelihoods is incumbent upon governments, agencies and private-sector corporations responsible for projects that cause forced-displacement.

Poverty reduction policies

If development's fundamental objective is to reduce poverty and promote growth, then development policies must attempt, among other goals, to minimize resettlement occurrences and (when resettlement is unavoidable) to carry out impoverishment-free relocation.

This paper argues that the orientation towards reducing the *existing* poverty must go hand in hand with efforts for *preventing the onset of new processes* of impoverishment. Development itself is not free from risks and adverse impacts. Such risks of potential impoverishment regularly surface in development projects that require involuntary resettlement, and sometimes in other projects as well. If project planning and execution fail to anticipate the potential risks, and to prevent them from becoming reality, severe problems in resettlement operations will inevitably occur. This is why the socio-economic and moral principles embedded in poverty reduction policies must be translated in targeted actions oriented against adverse impacts and against new impoverishment processes.

In project practice, resettlement plans (RP) are required as mandatory in most internationally assisted projects. However, they are far less frequently mandated by governments of developing countries in projects they finance from domestic sources alone. Therefore, the requirement for explicit, adequately financed and culturally sensitive RPs must be generalized in all countries.

The currently used analytical and planning tools are often not sharp and flexible enough to lead to differentiated and effective responses to risks. Improving the analytical methodology for regular risk assessment is therefore indispensable and should result in the formulation of *specific* risks management actions.

Usefulness of IRR in planning

Applying the IRR conceptual template to the circumstances of each development project has several advantages:

- it ensures—most importantly—that no major risk to resettlers is overlooked during the feasibility analysis of planned developments;
- it prompts planners to distinguish the different *intensity* of each risks (high risks from low or moderate risks, in a given project-context), rather than treating all risks uniformly; and
- it demands a *pro-active risk-reversal* orientation in project design, planning, financing and implementation.

The deconstruction of the impoverishment process into a template of eight basic risks permits the mobilization of proportionate resources for the highest risk or against the risks affecting larger numbers of people, while allocating less to risks with lower incidence or intensity in a certain context. In practice, this differential approach may vastly increase equity by rationalizing resource allocation. *Early risk analysis* may also conclude that in some projects one or another of the IRR Model's risks is not likely to occur. It can also reveal some locally specific risks that are not part of the template but need to be addressed.

The major risks of impoverishment

The IRR Model captures impoverishment not only in terms of 'income-poverty', but also in terms of losing employment opportunities, shelter, health, nutrition, education or community power.

The modeling of main risks results from deconstructing the multifaceted displacement process into its essential and most general risks of, namely:

1. Landlessness.
2. Joblessness.
3. Homelessness.
4. Marginalization.
5. Increased morbidity and mortality.
6. Food insecurity.
7. Loss of access to common property.
8. Social (community) disarticulation.

Each of these is briefly presented below. Further, we will point out how the IRR Model is to be turned on its head to help derive counter-risk strategies and to match project measures against each of these eight basic risks.

1. *Landlessness*. Expropriation of land needed for the project's 'right of way' removes the main foundation on which many people build productive systems, commercial activities and livelihoods. Often land is lost forever, sometimes it is partially replaced, and only seldom fully replaced or fully compensated. This is the main form of decapitalization and pauperization of the people who are displaced. Both natural and man-made capital are lost.
2. *Joblessness*. Loss of wage employment occurs both in rural and urban displacement. People losing jobs may be landless agricultural laborers, service workers or artisans. The unemployment or underemployment among resettlers may linger long after physical relocation. Creating new jobs for them is difficult and requires substantial investment, new creative approaches and relying more on sharing project benefits.
3. *Homelessness*. Loss of housing and shelter may be only temporary for many people, but for some it remains a chronic condition and is felt as loss of identity and cultural impoverishment. Loss of dwelling may have consequences on family cohesion and mutual help patterns if neighboring households of the same kinship group get scattered. Group relocation of related people and neighbors is therefore preferable over dispersed relocation.
4. *Marginalization*. Marginalization occurs when relocated families lose economic power and slide down towards lesser socio-economic positions: middle income farm-households become small landholders; small shopkeepers and craftspeople lose business and fall below poverty thresholds. Economic marginalization is often accompanied by social and psychological marginalization, expressed in a drop in social status, in resettlers' loss of confidence in themselves and in society.
5. *Increased morbidity and mortality*. The vulnerability of the poorest people to illness is increased by forced relocation, as it tends to be associated with increased stress, psychological traumas, and the outbreak of parasitic and vector-born diseases. Serious decreases in health levels result from unsafe water supply and sewage systems that transmit epidemic infections, diarrhea, dysentery, etc., and may lead to higher mortality rates among children and the elderly.
6. *Food insecurity*. Forced uprooting diminishes self-sufficiency, dismantles local arrangements for food supply and, thus, increases the risk that people will fall into

chronic food insecurity. This is defined as calorie-protein intake levels below the minimum necessary for normal growth and work.

7. *Loss of access to common property*. Poor farmers loose access to the common property assets belonging to communities that are relocated (e.g., loss of access to forests, water bodies, grazing lands, etc.). This type of income loss and livelihood deterioration is usually overlooked by planners and remains uncompensated.
8. *Social disarticulation*. The dismantling of community structures and social organization, the dispersation of informal and formal networks, local associations, etc., is a massive loss of social capital. Such disarticulation undermines livelihoods in ways not recognized and not measured by planners, and results in disempowerment and further pauperization.

The risks discussed above affect non-uniformly various categories of people: rural and urban, tribal and non-tribal groups, children and the elderly, or, in river based projects, upstream and downstream people. Research findings show that women suffer the impacts of displacement more severely than men. Host populations are also subjected to new risks, resulting from increased population densities and competition for resources

How to reverse risks and reconstruct?

Before displacement actually begins, the social and economic risks of impoverishment are only potential, possible risks. But if preventative counteractions are not initiated, these potential hazards convert into actual, dire impoverishment processes.

Robert K. Merton has insightfully observed that the prediction of an undesirable chain of events may become a 'self-destroying prophecy' (Merton 1979) if people respond adequately to the prediction. It follows that a risk prediction model becomes maximally useful not when it is confirmed by adverse events, but rather when, as a result of its warnings being taken seriously and acted upon, the risks are preempted from becoming reality, or are minimized. The prophecy destroys itself, and the consequences announced by the model do not occur or occur in a limited way.

The internal logic of the IRR Model as a planning tool suggests that in order to defeat its impoverishment prediction it is necessary to attack the looming risks *early on* during the preparation of a development project. In the same way in which it deconstructs the process of displacement into eight major risks of impoverishment, the IRR Model also deconstructs the process of resettlement and reconstruction into a set of definable *risks-reversal activities*, able to lead:

- from landlessness to land-based resettlement,
- from joblessness to reemployment,
- from homelessness to house reconstruction,
- from marginalization to social inclusion,
- from increased morbidity to improved health care,
- from food insecurity to adequate nutrition,
- from loss of access to restoration of community assets and services, and
- from social disarticulation to rebuilding networks and communities.

These strategic directions for reconstruction indicate that the IRR Model is not just a predictor of inescapable pauperization: on the contrary, it maps the way to restoring and improving the livelihoods of the displaced. Like in the case of other models, the components of the IRR Model can be acted upon and influenced through planning and resource allocation, in order to diminish the impact of one or several risks.

Risk-reduction through policy measures

Development knowledge teaches us that measures to reduce risks can be taken both at the project level, and at the policy level. For instance, policies that keep the costs of energy too low tend to encourage overconsumption and tolerate waste, thus leading to constructing more dams or thermal plants, with entailed displacements risks. This suggests that the risks of resettlement can be diminished also through better demand-management policies. Ultimately, the interlocked risks inherent in displacement can be controlled when governments adopt broad national policies for safety nets and risk reversals. Single means—for instance, cash compensation—are insufficient to alone counterbalance all risks. Compensation needs to be supplemented with special investments directed to the resettled communities, and with sharing with the resettlers a part of the benefits generated by the project that displaces them. Without substantial financing, no sound and sustainable resettlement is possible.[1]

Maximum safeguarding is achieved when involuntary displacement is avoided altogether. This is the response to risks that should be considered first and foremost. Recognizing risks upfront and their financial implications is often a powerful stimulus to search for an alternative that will eliminate the need for displacement or cut down its size. This is technically possible in some cases, for instance, by changing the site of a dam or by re-routing a highway around (rather than through) a village. Many other technical options can be found through creative search.

Social research on resettlement has indeed identified specific risk management strategies that can be employed against the common risks in resettlement, to prevent landlessness, joblessness, higher morbidity, etc. In turn, social research on *voluntary* settlement schemes and on patterns of self-management *after relocation* has documented effective approaches, some replicable in involuntary resettlement, that can help those resettling to new lands to overcome the risks and difficulties of resettlement.[2]

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End notes

1. For a more detailed argument, see Cernea 2007.
2. For empirical documentation on the impoverishment risks and impacts, as well as on results of risks reduction measures, please consult the recommended readings (see References).

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Legal and Policy Environment for Private Sector Participation in the Power Sector in Nepal

Anup Kumar Upadhyay

Nepal is bestowed with immense hydropower potential. Of the total theoretical potential of 83,000 MW only about 43,000 MW is techno-economically feasible, out of which storage projects constitute about 49% and the remaining 51% are run-of-river projects. However, with increased demand for system regulation and new export opportunities opened, peaking storage plant capacities could be significantly increased.

Nepalese hydropower projects have mostly been non-consumptive and are located in the hills. With the development of hydropower, a few cases of adverse effects in utilizing water for consumptive purposes have been documented. To deal with them, laws and regulations are being constantly updated and reviewed.

National water resources strategy

Realising that the development and management of water resources should be undertaken in an holistic and systematic manner aimed at the sustainable use of the resources ensuring conservation and protection of environment, Nepal has adopted the National Water Resources Strategy. This Strategy provides the country with a directional guideline of water resources development over the next 25 years. In order to translate the key outputs identified by the Strategy into concrete action plans, a National Water Plan has recently been adopted by the government. The Plan has set some targets to be fulfilled in a stipulated time frame. The main highlights of this Plan are summarized as follows:

Targets by 2017

- Up to 2,035 MW hydropower electricity is developed to meet the projected domestic demand at base case scenario, excluding export;
- 50% of households are to be supplied with Integrated Nepal Power System (INPS) electricity, 12% by isolated (micro and small) hydro systems, and 3% by alternative energy; and
- Per capita electricity consumption of 160 KWh will be achieved.

Targets by 2027

- 4,000 MW of hydropower is developed to meet the projected domestic demand at base case scenario, excluding export,
- 75% of the households are to be supplied with INPS electricity, 20% by isolated (micro and small) hydro systems and 5% by alternate energy,
- Per capita electricity consumption of over 400 KWh will be achieved, and
- Nepal exporting substantial amounts of electricity to earn national revenue.

Hydropower development policy

The Government is pursuing water resources development in Nepal from three different approaches. Firstly, to develop small and decentralized hydropower projects to meet the local demands in remote and isolated regions of the country. Secondly, to develop medium sized power projects to meet the national demand within the national grid including surplus for export, and to develop local capacity. Thirdly, large-scale multi-purpose projects to meet the regional demand for food, energy and flood control. With this vision, the Government has adopted the Hydropower Development Policy of 2001 for attracting both local and foreign investment. The following are the main highlights of this Policy:

Objectives

- To generate electricity at low cost by utilizing the water resources available in the country,
- To link electrification with the economic activities,
- to render support to the development of rural economy by extending rural electrification, and
- to develop hydro power as an exportable commodity.

Management of investment risk

- No nationalization of Projects.

- Exchange facility (*to repatriate*).
- Government land on lease.
- Water rights.
- Government may be a partner in storage project.
- Transfer of project.
- Export of electricity.

Provision for internal electricity market

- For private sector operated hydropower projects with capacity up to one MW and not linked to the grid, the independent power producer (IPP) may sell and distribute the electricity by determining the tariff rate of the electricity on its own.

Provision relating to visa

- Non-tourist visa and work permit shall be provided to the investor of hydropower project, his/her authorized representative and necessary foreign experts, skilled manpower and their families as provided for in the agreement until the construction and operation of the project.

Government agencies in the power sector

The following are the main agencies for development in the power sector:

- Ministry of Water Resources (MOWR).
- Water and Energy Commission Secretariat (WECS)—planning and policy research.
- Department of Electricity Development (DOED)—licensing, facilitation, promotion, compliance monitoring, project study.
- Nepal Electricity Authority (NEA)—public utility for generation, transmission and distribution of electricity.
- Electricity Tariff Fixation Commission (ETFC)—tariff setting.

Moreover, for the promotion of hydropower projects, the DOED has been designated as 'One Window' under the MOWR, with these responsibilities:

- Issuance of survey and project licenses,
- Providing concessions and incentives,
- assistance in importing goods,
- assistance in obtaining land, and
- assistance in obtaining permits and approvals.

Licensing procedures

The Electricity Act of 1992 has set following time limits for the issuance of licenses:

- Survey license issued within 30 days.
- Period of such license up to 5 years.
- Project license issued within 120 days.
- Period of such license up to 35 years.
- Public consultation before issuance of project license.

Application process for generation/ transmission/distribution

Application process for hydropower projects from 100 kW–1,000 kW

- For a project with capacity in this range no license is required. However, the proponent needs to submit project related information to the MOWR through the DOED. In addition, he/she has to submit desk study report, (topographic map, area of distribution, number of beneficiary, information of other water use, boundaries of survey area, recommendation from VDC/municipality/ work schedule; Letter of Interest for the Power Purchase Agreement, financial evidence).

License application process for hydropower projects>1,000 kW

For the devlopment of projects with the capacity more than 1000 kW, the proponent has to obtain:

- *Survey License*
  - To study generation, transmission, distribution survey of a project.
- *Operation License*
  - Production License (for construction and operation of a production facility),
  - Transmission License(for construction and operation of a transmission),
  - Distribution License (for construction and operation of a distribution facility).

Supporting documents required to obtain generation/transmission/distribution license

The proponent will be granted Generation, Transmission, or Distribution License with the submission of following documents:

- *Feasibility Study Report, including:*
  - detailed description of the project,
  - description of related transmission line to evacuate power, and
  - approved IEE/EIA Report from concerned Ministry.

- *Detail Financing Plan, including:*
  - estimated cost of the project,
  - financial capability of the investors of the project,
  - commitment of the financial institutions to be involved directly in the project,
  - percentage of liability of investor, and
  - equity and debt ratio.

- *Power Purchase Agreement*
- *Other Requirements*
  - Certificate of registration,
  - memorandum of article,
  - memorandum of association,
  - industrial registration certificate,
  - PAN (permanent account number), and
  - details of technical capability.

Steps to be taken by the proponent after obtaining generation/transmission/ distribution license

Once the proponent obtains the Generation, Transmission, or Distribution License he would have the following obligations:

- Start construction work within 1 year,
- Complete financial closure within 1 year of license issued date,
- Submit bi-annual progress report until construction is completed,
- Testing and commissioning,
- Start commercial operation,
- Pay royalty (Production licensee).

Marketing electricity

For the sale of electricity, two types of markets, domestic and export are available. In order to sell the electricity, the proponent does it through a Power Purchase Agreement (PPA) with the NEA.

For the export of electricity, bi-lateral arrangements exist with the neighboring India. The following are the provisions of the current power exchange arrangement:

- presently about 50 MW,
- agreed in principle to increase to 150 MW,
- 132 kV links available at two points, and
- 220 KV additional links identified.

Status of licenses issued

By June 2006, the number of licenses issued to developers by the Government of Nepal, including NEA-operated projects, is as follows, by category:

Survey License for Generation	230
Transmission Survey	57
Distribution Survey	12
Generation	19
Transmission	19
Distribution	1
Generation, transmission and distribution (including NEA old plants)	18

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Underground Space for Infrastructure Development and Engineering Geological Challenges in Tunneling in the Himalayas

Krishna Kanta Panthi

Abstract: Being topographically steep and consisting of many rivers originating from the glaciers of the Himalaya, Nepal is gifted in water resources. As a developing country, Nepal needs to accelerate to develop its crucial infrastructures for the economic prosperity of the nation. This is achievable by developing the enormous hydropower potential available, making short and efficient roads through the steep mountain topography, extracting mines for various purposes, and providing cost effective solutions for the storage facilities. These developments are not possible unless tunnels and underground caverns are used.

Due to tectonic activity, however, the rock mass in Nepal and across the Himalayan region is somewhat different in their engineering behaviour. These differences in mechanical behaviour are mainly caused by a high degree of folding, faulting, shearing, fracturing and deep weathering. As a result, severe instability problems associated with this complex geological setup have to be faced during tunnelling. This is the major challenge to be addressed in a scientific manner in order to make tunnel option more cost effective, feasible and safer.

This paper delineates the possible areas where tunnels and underground caverns are needed and may play an important role in the socio-economic development of the nation, discusses the major geological challenges faced while tunnelling, and briefly describes methodologies to be used for analysing geological uncertainties.

Key words: Himalayan geology, tunnelling, Nepal

The Himalayan region in Asia covers an area of about 594,400 km^2, of which Nepal occupies approximately 25%. Nepal extends east to west about 890 km and has a width ranging from 150 to 250 km. Within this very short width, the altitude varies greatly, from about 100 m above sea level at its southern border to its maximum of 8,848m above sea level (Mt Everest) at its north, giving a very rough terrain and steep mountainous topography. Because of the great elevation difference over a very short distance, the climatic conditions of the country also vary greatly. The higher Himalayan range (above 3,500m) in the north has an alpine climate and is mostly covered by snow and ice. The climate changes to mild and warm at the Mahabharat range (lesser Himalayan range) and to sub-tropical hot weather at the deep valleys, the Siwaliks (Churia) and the Gangetic plain (Terai).

The increasing population trend and rapid urbanization is augmenting pressure and is a major challenge in the economic development of Nepal. The main economic resources of the country are water resources (energy, irrigation and drinking water), agriculture, tourism and agro-tourism based industries. Maximum utilization of these resources is inevitable, and is only possible by developing infrastructures such as hydropower schemes, irrigation systems, road networks, drinking water systems, etc. Development of all these infrastructures demands the utilization of underground space like tunnels and underground caverns.

This paper discusses the possible areas where tunnels and underground caverns are needed and may play an important role in socio-economic development of our nation, the major geological challenges faced while tunnelling, and methodologies useful for analysing engineering geological uncertainties.

Need for tunnelling in Nepal

The use of underground space is not new in this country. The early miners used underground caverns and tunnels of small dimensions to extract ore and minerals such as copper, iron, lead, cobalt, nickel and different types of coloured stones. However, modern and institutionalized tunnelling started with the excavation of tunnels and an underground powerhouse for the Tinau Hydroelectric Project located near the town Butwal. Since completion of the Tinau Project in the early 1970s, approximately

75 km of tunnels have been excavated.

There are principally four areas where tunnels and underground caverns are needed in Nepal. They include: (a) water conveying tunnels, (b) transport tunnels, (c) mining and (d) food storage facilities (Panthi 2004). For the time being most of the tunnelling is focused on hydropower, and to some extent in mining and irrigation.

Hydropower and tunneling

Being snow fed and very steep in their gradient, most of the major rivers originating in the Himalaya have considerable potential in hydropower generation. In particular, those rivers originating from the elevation above 3,500m are perennial. For this reason, Nepal has been gifted with considerable hydropower potential (see Figure 1).

Nepal has so far managed to develop only about 560 MW hydropower energy, and approximately 40% of the total population has access to it. Apart from domestic requirements, fast developing India could be an important hydropower energy market for Nepal, since India is experiencing a shortage of energy with ever increasing energy demand. It is estimated that by the year 2013 almost 220,000 MW installed capacity of electrical energy is required in India to cope with very rapidly growing economy. Today, the installed capacity of electrical energy in India is approximately 148,000 MW and hydropower contributes only 30,000 MW. Moreover, India is one of the major countries in the world that contributes considerably to global emissions of carbon dioxide. Consequently, the hydropower potential that exists in the Nepal Himalaya could be an environmentally friendly alternative energy source that could help fulfil not only the energy demands of India, but also help in reducing the carbon emission to the world (Panthi 2004).

As can be seen in Figure 1, a number of possible hydropower projects have already been studied in different river basins of Nepal and are ready for the materialization. A study carried out by Nepal's Water and Energy Commission Secretariat (WECS) of the Ministry of Water Resources (MOWR) indicates that more than 850 km of tunnelling needs to be done to develop already planned hydropower potentials in Nepal. Thus, tunnelling requirements for the development of Nepal's hydropower is enormous.

Transport and tunnelling

A balanced, coordinated, well-managed and efficient transport system is a precondition for the sustainable development and economic growth of a country like Nepal. Except for the southern flatland and some inner valleys, there are many limitations for the development of good air and rail transport in Nepal. Thus, the most suitable mode of transport is an efficient road network. The development of such road network will make it possible to link different parts of the country and commercial hubs, contributing largely to the nation's economic and social development (Panthi 1998).

At present, a total of approximately 20,000 km of road have been built in Nepal, of which 29% are blacktopped with fair to good quality, 25% are gravel surfaced, and the remaining are earthen surfaced. The present situation of road networking is unsatisfactory and poses a considerable demand on the need for improving the existing road system. Connecting the mountainous part of the country with good quality roads to the southern flat Gangetic plain (Terai), where high level of economic activity exists, is very much needed. Such North-South running highways will play an important role in linking Nepal with the fast growing economies of neighbouring India and China.

The Himalayan region as a whole is affected by a constant tectonic uplifting as well as downcutting effects by several river systems. The action of tectonic activity and the monsoon on the predominantly fragile and deeply weathered rock mass of the Siwaliks and lesser Himalaya make steep mountain slopes highly unstable and erosion prone. Many rock and soil slope failures occur during the monsoon season along the road cut slopes, not only obstructing the transport movement, but also creating considerable human and property damage. Figure 2 shows an example of the Prithivi Highway, which is the only reliable gateway to capital city, Kathmandu, from the rest of the country.

As shown in Figure 2, a major rock/soil slide started to develop in July 1999 at Krishnabir, located 83 km west of Kathmandu. The slide was further aggravated during the monsoon of 2000 with a massive movement of the slope, and is still active in every monsoon. According to Regmi and Sitaula (2003) almost 360 hours of complete road closure occurred during the two monsoon periods in 2000 and 2001 as a result of this slide, and similar closures are routine in every monsoon period.

Based on the Nepalese Government's Tenth National Plan (NPC 2003), special attention should be placed on regional and sub-regional cooperation for the integrated development of the transport sector in South Asia. The standard of major east-west and north-south highways, must, therefore be improved so that these highways can be converted into regional commercial routes with high rates of return. The Tenth Plan also emphasizes the minimization of investment costs as well as of environmental degradation during design, construction, maintenance and rehabilitation of such road systems.

The quality target set by the government for major highways is only possible to achieve if road tunnels are introduced on the highways running through mountainous parts of the country. The introduction of such road tunnels will not only reduce the road length, but also make it possible to avoid the areas that are very steep and vulnerable to slope failures and risk of rock falls. An example of such an undertaking is the planned Kathmandu–Hetauda direct link, with approximately 60 km road length including three road tunnels with total length of 8 km. If this road project is implemented, it will shorten the existing 224 km long route to only 60 km, making it the shortest connection from the southern flatland to Kathmandu and north to Tibet, China (Panthi 1998).

Other infrastructures and tunneling

The other areas of infrastructure development where tunneling is required in Nepal are irrigation, water supply, mining and storage facilities. Even though there are many possibilities for excavation of tunnels and underground caverns in these areas, very little has been done so far, excluding a few kilometers of tunneling for irrigation and mining. The introduction of underground storage caverns, for example, may help in the reduction of electrical energy.

Even though the possibilities for the development of tunnels and underground caverns are great in Nepal, many uncertainties and challenges exists in this field due to the complex geological setup of the Himalaya.

Engineering geological challenges in tunneling

For economically viable tunneling, it is crucial to have a method characterized by cost effectiveness and flexibility to adopt in changing ground conditions, and by accuracy in the prediction of rock mass quality during planning. The design phase decision in selecting tunnel alignment and predicting the rock mass quality and rock support requirement has direct influence on the overall cost and time requirement of any tunneling project. See Figure 3.

As can be seen in Figure 3, as soon as the rock mass quality decreases (higher class), there is a dramatic increase in rock support cost. For example, for very poor (class 5) and exceptionally poor (class 7) rock mass quality, the rock support cost can be more than 250 and 350%, respectively, of the excavation cost.

The past tunneling experience in Nepal shows that the accuracy of planning phase geological investigations for underground works has often been rather poor. In addition, the compressional tectonic stress regime in the Himalaya has resulted in intense deformation of the rock mass, making it highly folded, faulted, sheared, fractured and deeply weathered. This complex geological setting has caused considerable stability problems (uncertainties) and is a great challenge for successful tunneling. The geological uncertainties for underground openings are related to two major factors: non-geological and geological. See Figure 4.

The non-geological factors are connected to the level of skill and expertise gained by experience and the interpretation and decision making skills during the planning and construction phases of tunnelling projects. The ability to evaluate and tackle the stability issues during planning and construction and the tools, methods and technologies used in that process have great significance, since erroneous interpretation may result in the loss of millions (Panthi 2006).

The geological factors are related to the geological complexity of the region. As can be seen in Figure 4, complexity is represented mainly by four engineering geological characteristics that have caused major stability problems during tunnelling in Nepal. These are: (a) weak rock mass quality, (b) high degree of weathering and fracturing, (c) rock stresses, and (d) groundwater effect. The major geological uncertainties and challenges that have been faced in tunnelling in Nepal are briefly summarized below.

Rock mass quality

Among the most distinct inherent properties of the rock mass in the Himalaya is the strength anisotropy (schistocity) caused by the preferred orientations of mineral grains or directional stress history. The bedding and foliation that exist in the sedimentary and metamorphic rocks of Himalaya have made them highly directional concerning strength and deformability. As a result of this directional behavior with respect to strength and deformability, many rocks in the region are highly incompetent. This directional behavior leads to a considerable reduction on the self-supporting capability of the rock masses while tunneling. Figure 5 is an example of tunnel collapse caused by this directional anisotropy of a typical Himalayan phyllite. Many such failures occurred on the recently constructed headrace tunnels of 144 MW Kali Gandaki ‘A’ Hydropower Project and on the 60 MW Khimti-I Hydropower Project in Nepal. The highly deformable rocks such as shale, slate, phyllite, schist and micaceous gneiss show such directional behavior and are weak bonded along the foliation plane.

Another major feature of the highly deformed rock mass of the Himalaya is frequent intercalation between different rocks and shear bands. Such intercalation is observed at interval of even less than 50 centimetres. See Figure 6.

In many occasions, thin bands of very weak and highly deformed rocks such as slate, phyllite, schists and sheared mylonites are intercalated within the bands of relatively strong and brittle rocks such as gneiss, quartzite and dolomite. These small bands of weak rock mass are squeezed and highly sheared within these stronger layers of rock mass (Panthi 2004); i.e., typical mixed face conditions. Being weaker in their mechanical characteristics and highly schistose, these shear bands lack sufficient bonding/ friction and have reduced self-supporting capability. This phenomenon of directional behaviour and intercalation of the rock mass in the Himalaya has resulted in severe stability problems during tunnel excavation.

Weathering and fracturing

In the Himalaya, fracturing is caused either by active tectonic movement or due to gravity effect. The combination of active tectonic movement and the region's complex climatic conditions (dynamic monsoon) lead to aggravated weathering of the fractured rock mass. Being formed from the process of fracturing, shearing and hydrothermal alteration, the fractured rock mass, weakness zones and fault zones provide an environment for weathering to intensify. Accordingly, the weathering effect may reach more than hundred meters below the surface. Tunneling in such environment needs to be carefully addressed concerning rock mass quality evaluation at the planning and implementation stages.

There are two main effects of rock weathering and fracturing with respect to tunnel stability in the Himalaya. The first is the immediate tunnel collapse during excavation, since the rock mass loses its cohesion (friction) and is unable to selfsustain even for a very short period until the temporary support is placed. Figure 7 shows an example of weathering-induced tunnel collapse that was triggered due to deep weathering at the pressure shaft on the Khimti Project.

As shown in Figure 7, a sink hole was formed all the way to the surface due to the collapse in this tunnel. Several such collapses were witnessed along the headrace tunnel and pressure shaft of Khimti project. The second effect is the condition that is produced by weathering for water inflow and leakage from the tunnels, since many open channels may be formed along the fractures in the rock mass.

Stress induced problems

The third major stability problem faced during tunneling in the Himalaya is stress anisotropy. Due to topographic reasons, most of the tunnel projects are constructed in the Siwaliks and lesser Himalayan zones, where highly deformed rocks such as shale, mudstone, siltstone, slate, phyllite, schist, schistose gneiss and highly sheared fault gouge and mylonites are present. In general, highly deformed rock mass have very weak rock mass strength, and tunneling through such rock mass may cause severe squeezing as soon as the overburden stress exceeds the rock mass strength. The severe squeezing has been observed even in relatively low overburden, where tunnels pass through highly sheared fault zones with extremely poor rock mass (Panthi and Nilsen 2007). An example of severe squeezing occurred in the pressure tunnel of Modi Khola projects and in the headrace tunnel of Kali Gandaki 'A'. See Figure 8.

The Modi pressure tunnel passes through highly sheared fault gouge, representing intercalation of highly sheared and decomposed schist mixed with completely crushed quartzite at an overburden of about 75 meters. The squeezing was so severe that the applied support of steel ribs and shotcrete was completely buckled and collapsed (HH 2001). In the case of Kali Gandaki headrace tunnel, squeezing occurred in many sections. Figure 8 right shows a section where more than 50 cm of horizontal convergence occurred at an overburden of approximately 450 m. In this tunnel that passes through highly sheared Himalayan phyllite, a maximum of up to 75 cm of tunnel deformation was recorded at a section with an overburden of approximately 600 m (NEA 2002; Panthi and Nilsen 2007).

Severe squeezing in tunnels is extremely difficult to tackle and is a major challenge in tunneling through the Himalaya rock mass. In fact, no universal solution exists that may be used to control instability caused by tunnel squeezing of such magnitudes. The most effective solution is to carry out uncertainty analysis in predicting squeezing in advance and increase the excavation size for compensating to the predicted squeezing and install sufficient support.

Inflow and leakage

The fault zones, sheared zones, fractured and weathered rock mass of the Himalaya are highly permeable and water bearing. Tunneling through such permeable zones always represent great difficulties and considerable challenges. Figure 9 shows examples of severe water leakage and inflow problems at the Khimti headrace tunnel and the Modi pressure tunnel. As can be seen in the Figure, the severity of the problems caused by inflow and leakage are huge in the Himalaya. In many occasions several weeks and months and a huge amount of resources were spent to control the inflow and leakage problems.

As seen in Figure 9 left, water leakage problems are not only limited to the excessive inflow during tunneling, but also are relevant for a tunnel constructed for conveying water, where there is a high risk of losing valuable water after the completion due to leakage (Panthi and Nilsen 2005). It is a great challenge to establish methods or tools for predicting

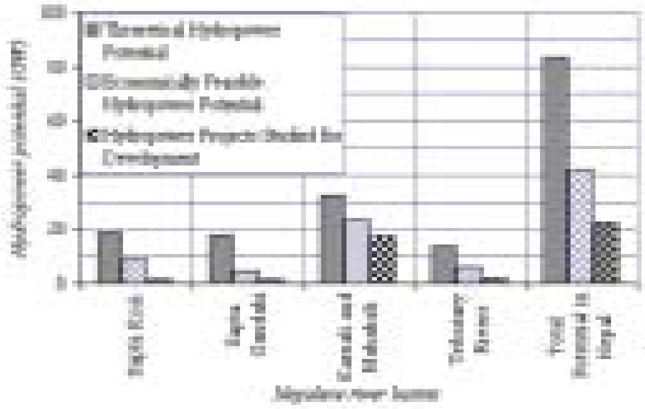

Figure 1. An estimated total hydropower potential of Nepal covering different river basins of the country (based on MOWR 2003)

Figure 2. A major slide at Krishnabir along the Prithvi Highway, 'A main gateway to Kathmandu Valley'. Slope protection works with gabion (left) and the extent of slope failure (right)

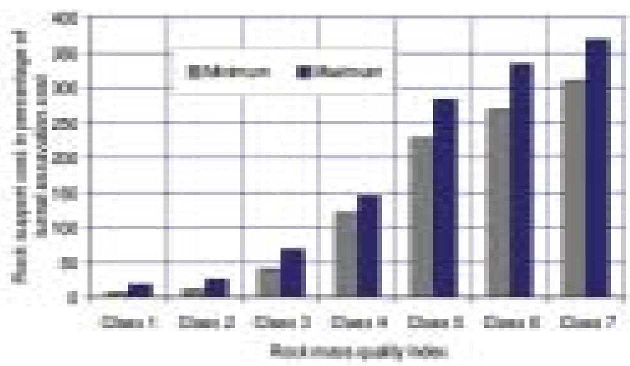

Figure 3. Approximate rock support cost for different rock mass classes (minimum and maximum for small and large section tunnels, respectively) (Panthi 2006)

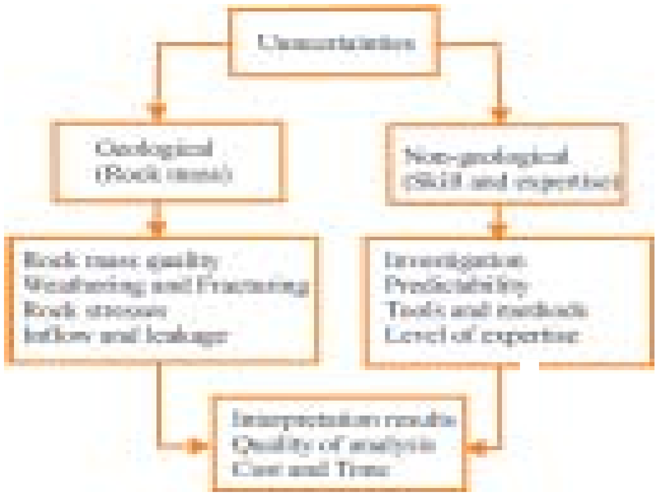

Figure 4. Two types of uncertainties for an underground opening.

Figure 5. Headrace tunnel collapse at Kali Gandaki 'A' Hydroelectric Project (left) and tunnel face showing thin foliation plane with very weak bond (right) (Panthi 2006)

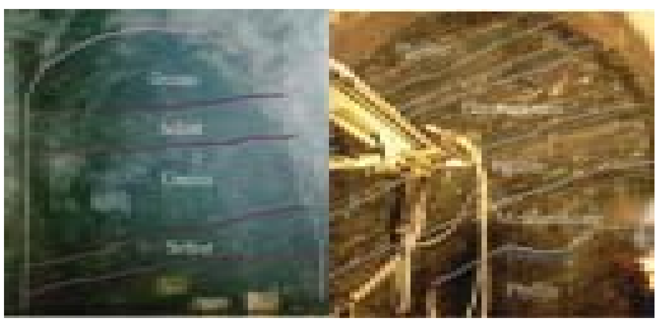

Figure 6. Intercalation between gneiss and schist at Khimti headrace tunnel (left) and intercalation between phyllite and metasandstone at Middle Marsyangdi headrace tunnel (right) (Panthi 2006)

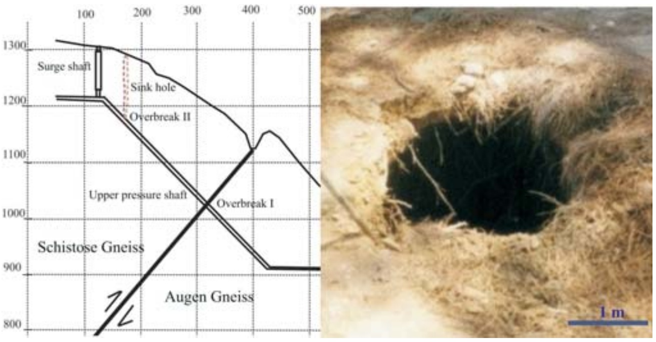

Figure 7. Cross section profile of the upper pressure shaft (dimension in meters) showing a tunnel collapse (left) and a sink hole of the same collapse that reached the surface (right) at Khimti Hydropower Project (Panthi 2006)

Figure 9. Water leakage from adit 2 of Khimti headrace tunnel after early water filling (left) and mass inflow of water mixed with debris from a shear fault at the pressure tunnel of Modi Khola (right) (right photo: Himal Hydro 1998)

Figure 8. Severe squeezing at Modi pressure tunnel (left) and Kali Gandaki headrace tunnel (right) (Photo: Himal Hydro 2001 and Impregilo SpA 1989)

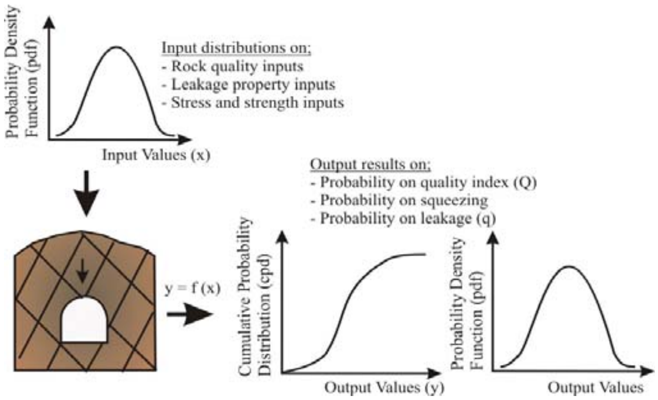

Figure 10. Principle sketch of Uncertainty and Risk Analysis Model for a tunnel project (Panthi 2006)

possible water inflow and leakage so that proper steps for tackling such problems may be considered in advance.

Methodology for uncertainty analysis

It is a fact that the key to success or failure of any tunneling project is the quality of the rock mass that the tunnel passes through and rock support measures that are applied during tunnel excavation. In this respect, accurate evaluation, analysis and interpretation of the rock mass quality play significant roles.

A major challenge therefore is to address geological uncertainties so that cost effectiveness and safer tunneling may be achieved. In this respect, the engineering geological uncertainty analysis methodology proposed by Panthi (2006) in evaluating uncertainty and risk associated with the rock mass quality evaluation, potential tunnel squeezing and possible inflow and leakage could be an alternative. The main focus of this methodology is a combined probabilistic and risk based approach. The main principle of this methodology is shown in Figure 10.

Instead of single point method of stability analysis for tunnels and underground caverns that is being generally used the proposed methodology gives much more reliable results.

Conclusion

The need for tunneling in Nepal, as in the Himalayan region in general, is enormous, particularly for hydropower development. Due to active tectonic movement and dynamic monsoon, the rock mass in the Himalaya is relatively weak and highly deformed, schistose, weathered and altered. Predicting rock mass quality, analyzing stress induced problems, in particular tunnel squeezing, and predicting inflow and leakage often have been found extremely difficult during the planning stage. Considerable discrepancies have been found between predicted and actual rock mass conditions, resulting in significant cost and time overrun for most of the tunneling projects. Finding innovative solutions for quantifying geological uncertainties and assessing risk are therefore key factors for cost effective and optimum future tunneling through Himalayan rock mass.

In this respect, a probabilistic approach of uncertainty analyses that the author has proposed in his PhD research (Panthi 2006) is believed will be appropriate to deal with the most important geological uncertainties reflecting Himalayan rock mass conditions. A geological uncertainty analysis model concept based on the software program '@Risk' should be applied for this purpose.

The proposed uncertainty analyses methodology includes rock mass quality evaluation based on the Q-system of rock mass classification, tunnel squeezing based on Hoek and Marinos approach, and analysis of water leakage through water tunnel. The degree of correlation between simulated results achieved by the '@Risk' model and values actually measured in the tunnel is discussed and the sensitiveness and effect of variations in the value of each input parameter and sensitivity of equations and methods used to analyze geological uncertainties are evaluated. The conclusion is that the proposed uncertainty analysis approach gives very promising results and has a great potential for analyzing tunnel projects in the Himalayan rock mass conditions.

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Investment in Hydropower Sector: Opportunities and Risks

Ratna Sansar Shrestha

It is remarkable that, during past one decade, domestic investors have invested US$75.5 million and foreign investors $233.6 million in the electricity generation business in Nepal. Similarly, $13.5 million was invested in buying shares in Butwal Power Company held by the Government of Nepal. Thus, in a span of one decade, the private sector has succeeded in mobilizing $322.6 million into the power sector. The details of the investment are as follows:

Project	Capacity in MW	Investment MUSD[1]	
		Local	International
Khimti	60	5.1	134.9
Bhotekoshi[2]	36	2.5	97.5
Syange	0.183	0.3	
Indrawati	7.5	22.1	1.2
Chilime	20	32.9	
Piluwa	3	4.4	
Chaku	1.5	2.1	
Sunkoshi	2.6	5.3	
Rairang	0.5	1.0	
Total	131.3	75.8	233.6

Table 1. Status of private investment in hydropower sectors

Opportunities

According to National Planning Commission, at the end of 9th Five Year Plan, 40% of the population in Nepal had access to electricity.[3] This means that 60% of the population still has no access to electricity, indicating that there is a solid market for electricity in Nepal. Further, it also needs no reminding that most of those who have access to electricity are facing severe load-shedding and the magnitude of which is likely to increase further in the near future. All this confirms that an abundant market for electricity exists within Nepal. If one is to include the potential export market of electricity to India then the size of the market increases by a magnitude.

The tremendous market for electricity manifests investment opportunity. In other words, the scope for investment in hydropower in Nepal is limitless. In this respect, it needs to be remembered that ramification of investment in hydropower sector is equity investment by the entrepreneurs with complementary debt financing[4] from financial intermediaries (FIs). It is not possible for an entrepreneur to implement a hydropower project just by making an equity investment. From this perspective, implementation of a hydropower project also depends on an entrepreneur's ability to mobilize debt funding. However, there are some major constraints in mobilizing funding from FIs for investment in a hydropower project, which are detailed below.

Market failure and portfolio mismatch in FIs

At present, Nepal is facing a market failure condition in its economy, high liquidity in the system leading to very low interest rates on deposits offered by FIs, while very few of them have experience with, or appetite for, long-term infrastructure projects, which are invariably capital-intensive. Projects needing long-term financing have been facing problems in securing finances. There are seven national level development banks mandated for long-term financing while a number of commercial banks are also financing long-term projects to an extent. However, the terms of the debt offered by these banks and their capital base are limited.

The market failure condition described above is due to the fact that their deposit base is of a short-term nature and it will be a portfolio mismatch for them to offer long-term loans. This condition is inhibiting FIs from assisting private developers in participating in the power sector development in the requisite way.

Lack of 'project finance' instrument

Project finance is specific mode of financing used by FIs under which the very project for which finance is being sought is accepted by FIs as collateral and no additional or external collateral is required for the purpose, thereby resulting in limited recourse to the institutions providing debt financing. This is also called non-recourse financing. In this kind of financing, the proponent does not need to lodge other tangible or intangible assets as collateral. However, FIs in Nepal do not 'like' project finance, and, therefore, a proponent is required to put a tangible or intangible assets of value higher than the debt amount to include a margin as collateral, or to furnish corporate or personal guarantee or third party guarantee or parent company guarantee, and so forth. Throughout the world, investors have not been financing front loaded projects, like hydropower, fully with their equity (even if they were capable), nor would it be prudent for them to be exposed to the assortments of risks just on their own. Project finance is a mechanism for sharing the exposure to such risks in the proportion of debt equity ratio. In order to encourage developers to participate in the power sector, FIs need to make available funding on 'project finance' basis.

Lack of 'due diligence' capability in FIs

Financing hydropower can not be compared to any other financing. In order for an FI to lend for hydropower projects, it will have to be able to understand the project intimately. Uniquely, the hydropower sector uses a number of disciplines, like civil, electric, and mechanical engineering, hydrology, geology, etc. Without contribution from each of these disciplines, it will not be possible to form an opinion about a project and to determine whether it is bankable or not. However, no FI in Nepal possesses this kind of expertise in house. Because of this constraint, banks have shown hesitation to invest in the power sector.

Another facet of the same problem is that FIs do not like the project finance instrument simply because they do not have the necessary 'due diligence' capability.

Central bank guidelines insensitive to power sector

Nepal Rastra Bank (NRB), the nation's central bank, has certain rules regarding provisioning in its guidelines to banks in Nepal. The NRB requires banks to make a 1% provision for 'good' loans; i.e., loans that are overdue by less than three month. Loans overdue by three to six months are called 'substandard' loans, and the provisioning requirement for such loans is 25%. Loans overdue by six month to a year are termed 'doubtful', and 50% is required to be provisioned for such loans. The provisioning requirement for loans overdue by more than one year is 100%.

In the power sector, the time overrun by one year is held to be normal (the Middle Marsyangdi Project was scheduled to be commissioned in 2004, but it is still under construction!). If banks started making 100% provision for their investments in the hydropower sector, they would become insolvent and would also adversely impact the power sector as well as the economy of the country.

Power development fund

In order to finance local Independent Power Producer (IPPs), the Government of Nepal established the Power Development Fund (PDF) with the support of the World Bank. With a start-up capital of US$35 million, the PDF intends to finance 60% of the cost of projects up to 10 MW and 40% of the cost of projects above 10 MW. The fund is administered by the Nepal Bangladesh Bank Limited, a private commercial bank in Nepal.

The PDF has yet to finance any project because the criteria for qualifying for PDF financing are too rigid for compliance by small IPPs. The criteria require prior clearance from the environment department to qualify for a loan. This usually takes more than two years. Developers cannot wait for such a long period. The resettlement issues are too stringent and are more relevant to large projects than to small projects. The proposal screening criteria are as per the international development agency guidelines, which is very time-consuming. The three-stage due diligence process of the PDF itself takes over 180 days. The purpose of establishing the PDF to help finance local IPPs has thus not been met due to the preconditions set down by the PDF. Recently, adding to the complications, the administrator (i.e., the bank appointed to administer the PDF) has been taken over by the NRB after declaring it troubled.

Risks

Financing a hydropower project is very heavily dependent on the prudent management of various types of risks. This involves identification of various risks associated with a project and assessment thereof. However, the most important step lies in arranging measures to mitigate such risks including an effective insurance program. Let us take a look at certain important risks from the perspective mentioned here.

Foreign exchange risk

A developer can borrow locally or from foreign institutions and the conditions with regard to security will be same. However, the borrower's exposure to certain risk will be different if the source of debt is overseas. There are mainly two types of risks that a borrower needs to be aware of while borrowing from a foreign lender.

A foreign exchange risk is inherent in foreign loans due to the fact that foreign currency tends to be relatively strong compared to Nepalese currency. This risk materializes with the devaluation if revenue is denominated in local currency while having to service the loan denominated in foreign currency. Similarly, this risk also does manifest in rising cost of imports. This risks can be mitigated by either (a) having the loan denominated in local currency, or (b) rate of revenue denominated in foreign currency. In the case of increase in the cost of imports an insurance coverage against cost escalation would mitigate this risk.

Repatriation risk

Another risk associated with foreign loan is 'repatriation risk'. This becomes of greater concern to a lender if it is not able to repatriate the proceeds of debt servicing. Generally, governments of development countries, in their quest to attract foreign investment, have enacted legislation guaranteeing repatriation. If such a guarantee is not available, either the lender will not make a loan or will make it subject to exorbitant rate of interest. In Nepal repatriation is guaranteed by the Foreign Investment and Technology Transfer Act of 1992 and the Electricity Act of 1992 for hydropower projects. A foreign equity investor is also subject to this risk.

Sovereign risk (country risk)

A foreign entrepreneur investing in Nepal is exposed to risk such as those associated with the government's credit worthiness, the possibility of confiscation, expropriation and nationalization (CEN Risk), changes in the local political environment and enforceability of contracts. These types of risk are known as sovereign and country risk. The Multilateral Investment Guarantee Association (MIGA), a member of the World Bank group, ensures against such risk for a fee. However, the availability of such insurance is limited only to foreign investors.

Interest rate risk

It is now time we also touched upon the concept of interest rate risk. Lenders offer two kind of interest: (a) floating rate and (b) fixed rate. Floating rate entails changes in the interest rate during the term of the loan, thereby introducing an element of uncertainty or risk for the borrower. Banks prefer floating rate as they need to be able to adapt to changes in financial market as well as cover their own exposure to the vagaries of changing interest rates (including bank rates). For a developer, fixed rate is the best way to mitigate this risk. However, banks tend to add a margin to the then prevalent rate to cushion their own risk.

Inflation rate

The real value of a unit of nominal currency tends to depreciate over time with inflation. Even hard currency is subject to this risk. Escalation in the rate of tariff is the only answer, short of trying to hold down the inflation with one's bare hands!

Legislative change risk

Here we are talking about the risk of changes in the country's laws that (a) increase rates and taxes or other expenses and liabilities, (b) reduce project revenues, or (c) reduce the value of the assets. Such changes adversely impact the viability of a project. Generally, an entrepreneur has to take such risk. However, it can also be mitigated by passing the impact through to the utility provided that the utility is amenable to such a pass through.

Market risk

It is common knowledge amongst engineers that energy requires a guaranteed market due to the constraints with regard, primarily, to storage and transmission. A simple way to mitigate this risk is to sign a long term Power Purchase Agreement (PPA) with the utility.

Revenue risk

A developer can have a long term PPA, but such a PPA may not ensure plant factor at a specific level if the utility accepts delivery of the energy at its pleasure, mainly in the case of a run-of-the-river type project lacking poundage. This means there will not be a guaranteed stream of revenue to the project in order for it to meet its financial obligations with regard to (a) operation, maintenance and repairs, and (b) debt servicing. A 'take or pay' type of PPA mitigates this risk.

However, with respect to both market risks and revenue risk, it needs to be noted that electric energy is already being traded in spot markets in Western Europe.

Payment risk

This risk emanates from the lack of creditworthiness on the part of the utility, the buyer of the energy. In many developing countries, state-owned utilities do not have established credit histories and also suffer from records of poor management, over-employment, high leakage (technical or otherwise), etc.

Developers are known to ask the government to issue a counter guarantee to cover the payment risk. This basically entails a government standing surety to the fact that the utility pays its dues to the developer in time, and in the case of a utility's failure to meet its obligations the government is required to promptly make payment to mitigate the delinquency of the utility. Now-a-days multilateral funding agencies like The World Bank take a dim view of a government issuing a counter guarantee. Having a letter of credit put in place by the utility with the IPP as the beneficiary is another way of mitigating this risk over the short term.

Construction risks

Time and cost overrun risks are one group of construction risks. Time overrun risk results in loss of revenue and may also raise the cost due to inflation. It also raises the total amount of interest during construction of the debt financing and may even attract penalties for late delivery of energy. Other construction risks are *force majeure* risk, socioeconomic/environmental risk, geological risk, performance risk, design risk, etc. One can arrange insurance coverage against such risk like CAR, TAR, EAR, professional liability, etc., including 'advance loss of profit insurance' that can be complemented by signing a 'fixed price' turnkey contract (or EPC contract) and incorporating a clause for imposition of liquidated damages on the contractor for delayed substantial completion or commissioning of the plant.

Hydrological risk

The 'take or pay' nature of the PPA guarantees that all energy produced by a plant, depending on the availability of water, irrespective of whether the season is dry or wet, shall be turned into cash. However, if there is no water to generate energy due to the change in the level of precipitation, climatic reason or change in the hydrology of the catchments area, then these projects are on there own. This risk emanates from the fact that seasonal rainfall patterns affect the amount of water available to a hydropower plant and generation may fall below contract levels in any season, thus threatening the revenue stream of such projects. Obviously, a dry year will be an unmitigated disaster for a hydropower plant. The most effective way to mitigate hydrology risk is to gather hydrological data for reasonable number of years in the past and design the project accordingly, after having selected a project with better hydrological potential as well as information.

Conclusion

There is no need to be frightened by the list of risks dealt with above, as most of the risk can be mitigated in some way or other. There is an old saying: 'no risks, no gain'. The entrepreneurship lies in taking risk and also being able to manage it. If an investor is able to do so then there is ample opportunity to invest in hydropower sector in Nepal. However, necessary measures must be undertaken to mitigate the constraints in financing power sector, described above.

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End notes

1. As these are ballpark numbers converted into US Dollars from Nepalese currency, there may be minor differences.
2. One of the main foreign equity investors in the Bhotekoshi Project has already sold its shares to an investor in Nepal.
3. The breakdown of this 40% has been given as: 33% covered by Nepal Electricity Authority, 2% covered by alternative modes of electrification, and 5% electrified in unexplained way(s). But according to the data published by NEA, its coverage is less than 25%.
4. The generally accepted debt equity ratio is 70:30.

Three Gorges Dam Project: An Introduction

Pranav Acharya

Abstract. The Three Gorges Dam Project (TGDP) on the Yangtze River in Hubei Province is touted as the long term solution to China's increasing energy and agricultural needs. TGDP, with a 1084 km^2 reservoir of 39.3 billion m^3 capacity, will be the largest multipurpose water conservancy project ever built in the world. The main structures of the project are dam, hydropower stations and navigation facilities. After studying fifteen alternative sites and approval of Environmental Impact Statement (EIS) in February 1992, the construction of the dam began in 1994 with an expected duration of 17 years.

Annual reduction of 40-50 million tons of coal consumption by providing 85 billion kilowatt hours of electricity, protection of 1.6 million hectares of agricultural land from floods and considerable improvement of navigation and tourism sector are the major anticipated benefits of TGDP. However, the proposed benefits put significant pressure on ecological and socio-cultural environment of the TGDP area. Relocation and resettlement of over 1.3 million local populations, inundation of several sites of historical importance, deforestation and loss of biodiversity including several endangered species of flora and fauna across a region of 58,000 km^2, increased sedimentation, water pollution and potential earthquake risks are the major adverse consequences of TGDP.

Key words: Three Gorges Dam Project (TGDP), environmental impacts, alternatives, resettlement, biodiversity, ecology, China

Project background

International advocates of hydropower have long argued that hydroelectric dams are a perfect example of 'renewable' or sustainable development, largely because of the use of water as their fuel and the fact that dams employ technologies that are non-greenhouse gas emitting (Sullivan 1999). In China, the government has adopted the hydropower development policy, in part, to stem the country's enormous dependence on coal and to avoid substantial increase in oil imports. The Three Gorges Dam Project (TGDP) is one of the several hydroelectric projects under construction that are touted as long term solutions to China's increasing energy and agricultural needs.

The concept of building a much controversial and optimistic dam across the world's third longest river, Yangtze (6300 km) in China's Hubei Province had its beginnings in the early 1900s, when the Chinese Supreme leader Sun Yat Sen suggested to build a dam at the Three Gorges in 1919. The advertised objectives of TGDP, apart from electricity production, is providing long-term solutions to the perennial problem of flooding on the Yangtze valley, which has caused the loss of thousands of lives and property over the past century and to improve navigation conditions in Yangtze river. For example, the major floods in the river in 1931 and 1954 caused 140,000 and 30,000 deaths, respectively, and disrupted the entire economy of the region for some time (ibid.:302-303).

The construction of the dam began in 1994, after the TGDP was voted on and passed by the National People's Congress in April 1992. The government has planned the construction work in three phases, starting from 1993 with expected completion in 2009.

After the completion, Three Gorges will be the world's largest dam ever built and the project will have three major components: a dam, a hydropower station and navigation facilities. The 181m high and 1.9 km long dam will create a reservoir of 1084 km^2, with an average width of 1.1 km expanding over 600 km. The reservoir will contain 39.3 billion cubic meter water and will be able to generate 18.2 million KW power. The official estimation of the project cost is about US$ 24.65 billion, which is debatable because the unofficial estimates claim that total costs will rise over US$ 75.0 billion.[1]

Proposed alternatives

From the 1950s, some alternatives to TGDP were considered, when the Chinese Government formally adopted the concept for flood control. Construction of smaller dams across the river, as an alternative of such large dam was discussed in the 1950s, arguing that China could not afford such a large scale and costly project. A small attempt was also taken to build smaller dams on Gezhouba, but was stopped because of technical problems and cost overruns. In 1980s also, alternatives of damming upstream and tributaries and lowering the dam height were proposed to mitigate the effects of inundation and resettlement to some extent. Finally, after the study on 15 alternative sites, the dam site for TGDP was finally determined at Sandouping because of its stable geologic condition and other favorable factors.[2]

However, the tragedy with the alternatives was that they were never taken seriously nor considered officially. Instead of looking for viable alternatives, concerns were raised addressing technical, social and environmental issues of TGDP.

Baseline studies before the project

The preliminary studies of TGDP started in 1950, when the Chinese Academy of Science began to study some of the environmental issues associated with the project. Preliminary findings were included in The Report on the Key Points of the Yangtze Valley Planning and in The Report on the Key Points of the Preliminary Design of the Three Gorges Project. The environmental issues began to take on high concern after the establishment of Yangtze Valley Water Resources Protection Bureau in 1976, which came up with an Environmental Impact Statement (EIS) of the TGDP in the 1980s. In addition, in 1984, the State Science and Technology Commission formally commissioned a study called The Studies on the Environmental Impact of the Three Gorges Project and Its Countermeasures, as one of the major components of the project's scientific research program. The environmental studies continued until 1991 through different agencies and the EIS was finished in December 1991, and then pre-examined by the Ministry of Water Resources in January 1991 and finally approved by National Environmental Protection Agency in February 1992.

In summary, the principal findings of the feasibility and environmental studies of TGDP concluded that the project objectives of flood control, hydroelectric power and navigation were significant benefits compared to some adverse environmental and social impacts.

Anticipated benefits

Hydroelectric power, flood control, navigation and tourism are the major sectors in which TGDP will benefit China. When completed, the dam will provide 85 billion kilowatt hours of electricity, approximately 10% of the country's total capacity as of 1993, thereby eliminating the annual burning of 40-50 million tons of coal in steam power plants (Sullivan 1999:303). This will help significantly in reducing the emission of green house gases like sulpher dioxide (SO_2) and carbon dioxide (CO_2), thus nullifying some effects of global warming.

It is projected that, normal pool level of dam with flood storage capacity of 22.1 billion m^3, will lessen the frequency of big downstream floods from once every 10 years to once every 100 years. This will help in saving the lives of 15 million people and protecting 1.6 million hectare of agricultural land from flood.[4]

The navigation capacities on the river will be improved and the economic benefits will include a decrease in shipping cost on the river by upwards of 40% and the ability of 10,000 ton ships to ply the smooth waters of the reservoir to inland cities, most notably Chongqing, Sichuan (Sullivan 1999:303).

In addition to these, the world largest man made dam structure, together with its landscape, will attract more tourists, which will ultimately uplift the economy of the area. This will also serve as a magnate for investment, especially in industry, in a region that has lagged behind the rest of the country.

Adverse consequences

Despite of its several positive impacts on Chinese economy, the TGDP has significant adverse impacts on the social and biophysical environments.

The costs of resettlement and environmental degradation will be enormous. Resettlement of 1.3 to 1.9 million people and the inundation of about 30,000 ha of river valley land in a rich orange growing region would cost more than one third of the total project cost. Resettlement will also create social disintegration and if it fails, many people will become reservoir refugees. In addition, the TGDP will, either completely or partially inundate two cities, 11 counties, 140 towns, 326 townships and 1,351 villages, which will create the huge problem of garbage, raising serious health concerns.[5] The reservoir will also submerge many archeological and cultural sites of national and global importance and valuable monuments of ancient history will be lost forever.

The dam will alter the natural environment, and the ecological effects will be devastating, across a region of about 58,000 km^2. Construction of the dam will affect the riverine ecosystem and the reservoir will create as many as 100 new islands causing significant habitat fragmentation, which will seriously affect many species of flora and fauna. Heavy logging and deforestation will further complicate the problem of habitat and biodiversity loss.[6]

In addition to these, the TGDP will affect endangered animal species, some of which are native to Yangtze basin. They include the giant panda, Chinese tiger, Chinese alligator, the Yangtze dolphin, the Chinese sturgeon and the Siberian crane.[7]

Finally, the TGDP will also cause the increase in local water pollution, increase in sedimentation deposition due to increased deforestation and soil erosion, and the potential hazards of earthquakes because of sudden storage of a heavy water load.

Ecological monitoring

Systematic tracing of environmental and ecological monitoring in the TGDP is required to mitigate the adverse ecological impacts. A properly implemented Mitigation Management and Monitoring Plan (MMMP), also known as an Environmental Management Plan (EMP), during construction and operation phase of the project is the backbone of ecological monitoring. The MMMP should formulate an authorized and comprehensive monitouring system for both biotic and abiotic components of ecology in the area before carrying out the field monitoring.

Long term ecological monitoring includes hydrological characteristics of the river (water flow, period, etc.), sedimentation in the reservoir (sediment load, deposition, etc.), water quality (dissolved oxygen), transparency, temperature, etc.), air quality (temperature, pollutants, etc.), aquatic biota (richness, migration patterns, adaptation, etc.), terrestrial flora and fauna (adaptation, effects of habitat fragmentation, isolation, etc.), and the related micro-ecosystems of tributaries and watershed.

The monitoring of these parameters is extremely important for implementing the proposed mitigation measures in a sustainable way. The ecological knowledge acquired through systematic monitoring will provide information for long term analysis and adaptive mitigation management approach.

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  Figure 4. Sketch of Uncertainty and Risk Analysis Model for a tunnel project (Panthi 2006)

  Figure 8. Severe squeezing at Modi pressure tunnel (left) and Kali Gandaki headrace tunnel (right) (photo courtesy of Himal Hydro 2001 and Impregilo SpA 1989)

  Table 2. Estimated total hydropower potential of Nepal (based on MOWR 2003)
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▸ <u>Examples of Reference styles by type</u> (for others refer to the *Chicago Manual of Style*)

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Offprints

- The corresponding author will receive 2 offprints. Be sure to include your a mailing address in correspondence.

The Bujagali Hydropower Project

An acute electricity crisis is impacting the livelihoods of millions of Ugandans and threatens the country's development.

Hospitals, schools, businesses, and residences suffer dailypower shortages, which have stunted Uganda's economic growth by an estimated one percent of the country's gross domestic product.

The Bank has approved US$360 million in loans and guarantees for the Bujagali Hydropower Project, an integral component of Uganda's strategy to close an energy supply gap that seriously constrains social and economic development in the country.

(Source: The World Bank)

The major hydropower projects of Nepal now in planning and study phases are briefly described below.

Chameliya Hydroelectric Project

Chameliya Hydroelectric Project is a six hour daily peaking run-of-river scheme with an installed capacity of 30MW and average annual energy generation of 184.21 GWh. The project is located at about 950 km west of Kathmandu in Nepal's Chameliya valley of Darchula District in the Far Western Development Region. Detailed design and tender document preparation were completed in December 2001 with grant assistance from the Korean International Co-operation Agency (KOICA).

The project's EIA study, as per the Environment Protection Rules of 1997, and final draft EIA report of the 132 kV transmission line alignment have been completed. In addition, the IEE study of the 35 km long 33 kV transmission lines, from Gothalapani of Baitadi to Balanch powerhouse site, for the construction power supply, has also been completed.

The project cost as per the detailed design report of December 2000 is 74.90 million USD, including the cost of constructing the 132 km long 132 kV transmission lines. The project is under construction with the funding of GoN and NEA.

Upper Tamakoshi Hydroelectric Project

Upper Tamakoshi Hydroelectric Project is a run-of-river type power project with daily peaking pondage. The Norwegian firm of Norconsult AS submitted a bankable feasibility study report of this project under the grant assistance of Royal Norwegian Government in May 2005. The headwork site of this project is located in Nepal's Dolakha District at Lamabagar VDC (Village Development Committee), with a power house in Gongar (Ward 5) of Lamabagar VDC.

This project has many attractive features such as:

- 300m high natural dam,
- good geology,
- high firm flow,
- very low sediment, and
- minimum environmental impact.

The project will make use of 820m gross head with the aim of generating a maximum output of 309 MW and an average annual energy of 1,737.7 GWh. According to the NEA's Generation Expansion Plan, this project should be commissioned by 2012 AD to meet Nepal's future demands for electrical energy. This project has very low specific energy cost and is planned to be implemented under a public-private partnership.

The EIA of this project has been carried out separately for generation and transmission. The EIA has identified many beneficial environmental effects such as fishery resources at intake pond, land reclamation, flood control at Lamabagar, community development works, employment opportunities and improve access etc. The adverse impacts of the project of this size are minimal and can be appropriately mitigated.

The estimated cost of this project as per the final feasibility report is 340 million USD, including access road and transmission lines. The unit price of energy is calculated as c. USD 2.6 kWh at present.

Recently Nepal Electricity Authority has made a contract with Norconsult AS, Norway and Lahmeyer International GmbH, Gerany (J/V) for detail design study of the project.

Issuance of Survey License

The Ministry of Water Resources of GoN has granted the survey license to Statecraft Norfund (SN Power) for the proposed Tamakoshi II and Tamakoshi III.

Tamakoshi II, a run-of-river type project has a capacity of 203MW and Tamakoshi III, a storage type, has a capacity of 275MW. SN Power has a plan to produce electricity from the proposed project by 2015 and will sell the energy to Nepal and excess energy to India.

West Seti Hydropower Project

The proposed West Seti Hydropower Project of 750 MW capacity is located in Far Western Nepal, on a loop of the West Seti river, approximately 82 km upstream from its confluence with the Karnali river. Initial power purchasing agreement has been made with Power Trading Corporation of India by Snowy Mountain Engineering Consultancy (SMEC), West Seti Hydroelectric Corporation Limited. Asian Development Bank has shown interest to invest in this roject

The main project features include:

- 195m high concrete face rock fill storage da-m and 1,989 ha reservoir,
- 10m diameter, 6.7 km long headrace tunnel,
- power station located 19.2 km downstream of the dam and 300m underground, housing five 150 MW rated turbine generator units, transformers and a switching station,
- 620 m long tailrace tunnel,
- re-regulation weir located 6 km downst-ream from the tailrace outlet,
- 100.3 km long 400 kV double circuit tra-nsmission lines, from the power station to Dhangadhi on the Nepal- India border,
- permanent access roads totaling 20.3 km.

Kulekhani III Hydropower Project

Kulekhani III Hydroelectric Project is located about 40 km south east of Kathmandu in Makwanpur district of Nepal. The proposed headworks site is located at Bhainse village development committee. The project will utilize the net head of 107m and a design discharge of 15 cumecs to generate 14 MW of peak power. A 4.5 km long headrace tunnel, surge tank and surface power house are the main components of the project. The generate power will be evacuated to Hetauda through the second circuit strung on the KL-II Hetauda existing 132 kV line and a 500 m long new 132 kV line.

The EIA study of the project has been approved by the concern ministry. The social and environmental impacts of the project are minimum with only 25 ha of agricultural land and a few households being affected. The project has been found technically, financially and environmentally viable NEA is planning to implement the project using its own financial and human resources.

The project cost is estimated at US $ 27060 million. The project will be commissioned to meet the peak demand of dry season by 2009 The annual energy output of the project will be 40.82 GWh. The detailed design of the access road and the bridge over the Rapti river is under process.

IHA Blue Planet Prize

The 5 MW Andhikhola Hydel and Rural Electrification scheme of Butwal Power Company of Nepal won the IHA Blue Planet Prize 2005 for excellence in socio-economic benefits and capacity buildings. IHA also named 185 MW Arrow Lakes and 16 MW Sechelt Creek in Canada's British Columbia Province for social, environmental and technical excellence.

ANNOUNCEMENTS

June 4–21: Training program on Hydropower Development and Management sponsored by International Centre for Hydropower. Location: Trondheim, Norway, Contact Email: mail@ich.no. More Info: www.ich.no.

July 23–26: *WaterPower* XV Location: Chattanooga, TN, USA. More Info: www.hcipub.com/wp/index.asp.

Aug. 12–18: World Water Week 2007 sponsored by Stockholm International Water Institute. Location: Stockholm, Sweden. More Info: www.worldwaterweek.org.

From 30 August: The Process of Social Impact Assessment sponsored by International Centre for Hydropower, Norway. Location: Internet – Online Training Course. Contact: mailto:lf@ich.no. More Info: www.ich.no, go to SIA2007.

27 Aug–13 Sept.: Training course on Hydropower and the Environment (HE2007) sponsored by International Centre for Hydropower. Location: Trondheim, Norway. Contact Email: lf@ich.no. More Info: www.ich.no.

Oct. 22–24: Hydro Sri Lanka: International Conference on Small Hydropower. Location: Kandy, Sri Lanka. Contact Email: lf@ich.no. More Info: www.hydrosrilanka.org.

Nov. 19–23: Training program on Hydropower Financing and Project Economy (HFPE2007) sponsored by International Centre for Hydropower. Location: Oslo, Norway. Contact Email: lf@ich.no. More Info: www.ich.no.