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Need to Strengthen the Bridge between the Water and Energy Professionals: An Example from Sri Lanka

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ABSTRACT Sri Lanka, a developing island in the Indian Ocean, is attempting to effectively utilize the available natural resources. Though the Upper Kotmale Hydro-power Project planned by energy authorities was submitted for approval as the best option, the project was to affect several scenic waterfalls. After a critical evaluation of various project alternatives, water and other professionals indicated that an option which claimed to have almost no effect on waterfalls would probably be the best option. This gave rise to a conflicting situation that resulted in a delay in project implementation. The work presented is a discussion of the evaluation of environmental impact assessment, highlighting the need to bridge the gap between energy, water and other professionals.

Introduction

Sri Lanka is an island in the Indian Ocean between latitudes 5° 55′–9° 50′ N and longitudes 79° 42′–81° 52′ E. The climate in Sri Lanka consists of two main seasons, namely rainy and dry. Rainy seasons experienced by the country are due to the north-east and south-west monsoons. The country is divided into three main zones based on rainfall, the wet, intermediate and dry. The wet zone, covering the central hills and south-west of the country, averages 2500 mm of rainfall, mostly throughout the year, while the remaining two-thirds of the country in the north, east and south-east stays comparatively dry, averaging 1500 mm. Most of the island receives plenty of rain and hence is equipped with lush green vegetation. Sri Lanka is blessed with beautiful landscape, tropical fauna and flora and warm weather. However, it is a developing country having limited natural resources, which are categorized as not so economically attractive. In its striving for economic development the nation is trying to effectively utilize available natural resources. Water flowing down central mountains is one such resource and the potential energy of this water has been effectively used to generate electricity for Sri Lanka’s economic activities.

The power-generating system of Sri Lanka is predominantly based on hydropower, which has produced over 90% of total demand in the recent past. However, more recently, with the hydropower sources becoming scarce, and the demand for energy increasing, the government of Sri Lanka has stepped up efforts to strengthen its energy base. One remaining hydropower project
identified in the overall hydropower programme to be implemented in the near future is the Upper Kotmale Hydropower Project (UKHP). This project, which sought implementation in 1994, targets the generation of sufficient power in the early 2000s to meet the growing energy demand of the nation. It is proposed to locate the UKHP in the central, mountainous zone of the island at an altitude of 700–1200 m above mean sea level. The project, which consists of six tributary diversion facilities, is proposed as a 150 MW power generation scheme supplying 532 GWh annually to the national grid. The UKHP proposes to divert water above seven scenic waterfalls. It has aroused significant concerns not only because of its efforts to overcome the energy crisis but also because the project would cause the near-disappearance of major waterfalls remaining in Sri Lanka. In two previous hydropower development efforts, the country had forgone two of its most beautiful waterfalls, namely Laxapana and Victoria. Hydropower-generating reservoirs at the top of these waterfalls continue to deprive the public and the foreign tourists visiting the central hills who once enjoyed their breathtaking beauty.

Though electricity-generating authorities claimed that the UKHP was identified as the best of a number of options, the environmental authorities declined to grant clearance, citing an insufficient consideration of project alternatives. It was pointed out that the quantity of water that could be harnessed was undervalued and hence other project alternatives appeared unattractive due to the lowering of benefit to cost (B/C) ratios. A variant to an alternative proposal submitted during the public participation process of environmental clearance was identified as competitive, although power benefits from that were lower. The UKHP could not get off the ground in time without environmental clearance, which insisted on a better study of alternatives, though the power authorities claimed that adequate efforts to study many alternatives had been made. The tug of war that delayed implementation finally passes on to the poor in the country because any delay seriously affects the economic development activities, which are heavily dependent on the reliability of the power supply. In order to escape from the nightmares of poverty, Sri Lanka needs to bridge the gap between the energy, water and other professionals.

Sequence of Events

The energy authorities requested environmental clearance for the implementation of the UKHP under the National Environmental Act No. 47 of 1980 from the Secretary of the Ministry of Irrigation, Power and Energy (MIPE) on 11 October 1994. The MIPE, being the project-approving agency, approved the implementation of the project. The concurrence requested by MIPE in February 1995 for this was declined by the Central Environmental Authority (CEA). In March 1995, the energy authorities made an appeal to the Ministry of Transport, Environment and Women’s Affairs (MTE&WA) under the National Environmental Act against the decision of the CEA. This appeal was dismissed by the MTE&WA in August 1995. Subsequently, the MTE&WA granted liberty for the Ceylon Electricity Board (CEB) to seek approval for the project with a study of an omission in the previously submitted environmental impact assessment report (EIAR). The energy authorities submitted an addendum to the original EIAR in July 1996. Environmental clearance to this project was again declined by the CEA in December 1996. Energy authorities logged an appeal with the
MTE&WA in January 1997 and a hearing was conducted in June 1998. At the end of the appeal in July 1998, the MTE&WA allowed the implementation of the UKHP subject to strict adoption of proposed mitigatory measures. A non-governmental agency thereafter filed an application in the Court of Appeal. The case was settled in July 1999 on condition that a hearing by the ministry would be granted to the petitioner within 3 months, and that the energy authorities would ensure that no steps would be taken to commence actual work of the project until the expiry of the said period. Following the hearing, the appeal for the energy authorities to implement the UKHP was allowed on 27 August 2000.

The UKHP

The UKHP proposes to divert waters above seven scenic waterfalls, namely the Upper and Lower Ramboda Falls, Puna Falls, St Clair's Falls, Devon Falls, Pundalu Falls and St Andrew's Falls (Figure 1). Though the master plans of the recent past indicated the UKHP to be an electricity-generating project with a capacity of 248 MW to generate 809 GWh annually, the project submitted by the energy authorities for environmental approval was of reduced capacity. This reduction of capacity had been cited as the result of optimizing the project and devising mitigatory measures to ensure the sustenance of the environment. The main features of the project are a 34 m high reservoir at Talawakele above a major waterfall named St Clair's Falls, a 12.8 km long tunnel to the powerhouse and diversion tunnels conveying water from the other waterfalls. The UKHP showed a good economic internal rate of return (EIRR) of 10.38% and a marginal B/C ratio of 1.04. This project option is commonly known as the Talawakele option of the UKHP.

Alternative Proposal

The Sri Lankan government requires all projects to obtain environmental clearance prior to implementation. The EIAR of the UKHP Talawakele proposal (CEB, 1994) was also opened for public participation as per national environmental regulations. During this period the Central Engineering Consultancy Bureau (CECB), a semi-governmental agency considered to be one of the reputable agencies comprising experienced water professionals, submitted an alternative proposal. This proposal, the Yoxford/Lindula alternative, indicated the possibility of harnessing 595 GWh of annual energy with an installed capacity of 182 MW by constructing reservoirs in a different arrangement and at different locations in the same area as the UKHP Talawakele proposal (CECB, 1994). This scheme proposes to construct two reservoirs at Yoxford and Lindula, the reservoir at Yoxford being 65 m high and 255 m long, while at Lindula a smaller one of 35 m in height would store approximately $1.1 \times 10^6$ m$^3$. According to long-term power estimates, the reservoir at Yoxford is to generate 320 GWh of energy with an installed capacity of 100 MW and the Lindula is expected to generate 250 GWh of energy with an installed capacity of 80 MW. This alternative also proposes a tunnel to divert water from Goraka Oya to the Yoxford reservoir while generating an additional 20 GWh/year. A small-bore tunnel is proposed to augment St Clair's waterfall with water through Pundalu Falls and the diverted water is expected to generate 5 GWh/year. The cost estimate for this alternative is US$322 million (CECB, 1994).
Figure 1. Project location and the associated stream network of the UKHP.

The alternative proposal (the Yoxford option), citing different tapping points from the same sources, claimed that this arrangement would save all waterfalls affected by the earlier Talawakele option except for a minor one. This alternative appeared attractive and competitive but lacked the depth and details for a comparative analysis. Since the project proponent, the CEB, had not looked at this alternative when presenting the recommended option, the environmental authorities indicated the necessity of an adequate study of project alternatives.
Table 1. Comparison of UKHP options in the addendum

<table>
<thead>
<tr>
<th></th>
<th>Talawakele</th>
<th>Yoxford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed capacity (MW)</td>
<td>150.0</td>
<td>170.0</td>
</tr>
<tr>
<td>Annual energy (GWh)</td>
<td>531.9</td>
<td>490.1</td>
</tr>
<tr>
<td>Present value of costs (US$\times 10^8)</td>
<td>256.8</td>
<td>421.3</td>
</tr>
<tr>
<td>Present value of benefits (US$\times 10^8)</td>
<td>267.3</td>
<td>266.9</td>
</tr>
<tr>
<td>B/C ratio</td>
<td>1.04</td>
<td>0.633</td>
</tr>
<tr>
<td>EIRR (%)</td>
<td>10.38</td>
<td>6.21</td>
</tr>
</tbody>
</table>

Hence the environmental clearance was not granted. This decision was not favourable for the energy authorities since it implied significant time and financial requirements for a further study of many alternatives. The energy authorities appealed against the decision and as a result were requested to study the Yoxford alternative. In 1996 the energy authorities submitted an addendum to the EIAR of 1994 which included the study of the said alternative.

The UKHP Addendum

The CEB, the proponent of the UKHP, submitted an addendum to the earlier proposal, which carried a comparison of the UKHP Talawakele proposal and the alternative (CEB, 1996). The addendum indicated that the Yoxford option could generate only 490 GWh of annual energy, had a B/C ratio of 0.633 and an EIRR of 6.21% (Table 1). Though the installed capacity of the Yoxford option was high, the annual energy was lower than the Talawakele option. Both options showed similar quantified benefits but the Talawakele option would be less expensive to construct. The Yoxford option indicated that the cost of the project would be much larger than the benefits. The addendum also indicated that the construction of a dam at Yoxford as in the alternative was not geologically favourable. This, along with a few changes to the addendum, indicated a lower energy potential from the Yoxford alternative. On the basis of the results of this study, the project proponent did not consider the Yoxford alternative proposal as viable. Results in the addendum were significantly different from those of the alternative proposed at the time of public participation and this created a conflict situation that called for an independent evaluation of project alternatives submitted by the energy authorities.

Evaluation

The addendum showed that the Talawakele option had a B/C ratio marginally over unity. Results of the addendum indicated that it was not feasible to implement the Yoxford alternative, which had a B/C ratio of 0.633. The Talawakele option, even with a 5% increase of project costs, would reach a break-even situation, thus questioning the justification of the project implementation. The estimated project cost of the Yoxford alternative had increased by nearly US$100 million in the addendum when compared with the alternate proposal at the public participation stage. A multidisciplinary technical evaluation committee (TEC) comprising members from independent organizations external to the CEB or to the environmental authorities was appointed by the
environmental authorities to evaluate the UKHP and the addendum. Water specialists in the TEC had to critically look at the computations with regard to the quantification of water, since the bulk of the benefits from a hydropower project are from water. The evaluation studied: (1) the use of streamflow data and the rating curve used for data conversion; (2) the method of incorporating spill over losses and a water diversion in a system water balance; (3) the cost increase due to the cofferdam construction; and (4) the possibility of a run of river (ROR) weir instead of a dam at a poor geological location.

Streamflow Data

Estimates of power availability for all project alternatives had been based on measured streamflow data of the Department of Irrigation pertaining to the period 1981–92 (CNEC, 1994; CEB, 1996). Streamflow measurement records available for the study area indicate that the above period has had a significantly low streamflow when compared with the rest of the period (Figure 2). Rainfall time series for the project area also indicated a similar reduction during 1960–70, prompting the idea that the 1981–92 streamflow depletion might only be part of cyclical behaviour, and indicating that a careful hydrological study is required to arrive at realistic flow estimates. Though the minimum value of 11.7m³/s, taken for computations in the project report, would provide a safer, conservative situation, justification of conservative values in the UKHP study does not appear as logical since lower benefit estimates may lead to B/C ratios of less than unity for certain project alternatives, thus pushing such projects to the not-feasible category. Therefore representative streamflow data values need to be established through an analysis using the entire duration of available data. A visual observation of the rainfall and streamflow time series suggests that a representative average flow at the gauging point would be above the simple mean of 15.0m³/s for the entire time series between 1951 and 1991. The TEC recognized that even with this average value taken for computations, hydropower benefits from both UKHP options considered in the addendum would show an approximate increase of 32%.

Rating Curve

The conversion of stage readings to quantity of flow was another concern of the TEC. The UKHP study by the project proponent included flow gauging during the initial study period by establishing a gauging station at Talawakele. The final design report of the UKHP (CNEC, 1994) shows a comparison of the rating curve established by the Irrigation Department (ID) in 1981 with the rating curve established for the final design report (Figure 3). It shows that the ID rating curve gives rise to lower flow values than the rating curve from the gauging station developed during the UKHP study. The EIAR indicates that the computation of benefits had been based on the ID rating curve and hence they were about 9–10% lower than with the other rating curve. The addendum indicates that the use of the ID rating curve for computations is due to the fact that it leads to conservative values. Though it is felt that project-specific measurements should be more reliable than measurements performed earlier, water specialists felt that further verification of the rating curve is prudent to establish realistic streamflow values. In this connection it is important to note that non-consider-
Discharges before June 1954 were estimated from Morape records. Those from July 1954 to September 1981 are revised data. The ones from October 1981 to present are ID original records.

Figure 2. Streamflow measurement records used for environmental impact assessment. Source: Ceylon Electricity Board.

ation of the rating curve established using streamflow specifically measured for the project warrants a better justification because any lowering of benefits would affect economic indicators. Such lowering may also lead a certain project to possess a B/C ratio greater than unity, while pushing another to a ratio less than unity, thus negating the chances of a fair competition.

Spill-over Losses
In the addendum, energy that could be harnessed by the proposed reservoir at Yoxford is less than was anticipated in the alternative submitted by the CECB.
It was observed that the loss of energy was partly due to spill-over losses. Spill-over losses are anticipated when inflows are far more than the water for turbines and available storage in the reservoir. Information made available to the TEC indicated that these estimates for the Yoxford alternative were based on a monthly water balance, whereas the analysis for the Talawakele option had been carried out on a daily basis. Though water balance aggregated over longer periods provides adequate information for planning, shorter intervals would provide a detailed view of performance. An exercise for a comparison of performance would require a similar approach for all alternatives. Since the comparison deals with two environmentally sensitive alternatives, evaluators recognized that a water balance of the system should have been carried out at a higher time resolution compatible with water release schedules for power generation and environmental enhancements.

Pundalu Oya Diversion

Comparison of alternatives in the UKHP addendum indicates that the proposal to divert Pundalu Oya to augment St Clair’s waterfall in the Yoxford option has been rejected, since the diversion tunnel is meaningless. Details provided in the addendum and subsequent discussions with power authorities indicated the lack of a reasonable study prior to reaching this conclusion. The alternative by the CECB (1994) proposed not only to augment the St Clair’s waterfall by this diversion but also to generate electricity at the tunnel outlet. As such this diversion should be analysed through water balance using a systems approach whereby the power generation capability of the project and the project costs could be compared both with and without the Pundalu Oya diversion.

Feasibility of Yoxford Dam

The addendum to the EIAR had studied the dam proposed and evaluated the construction of dam, powerhouse and associated infrastructure in the CECB
alternative. One of the key features is the inclusion of a cofferdam for the construction of a tailrace outlet which is below the full supply level of the Kotmale reservoir. The proposed cofferdam in the addendum is 30 m high and amounting to about 100 000 m$^3$ in volume. The cost estimate increase for civil works of the addendum show that an approximate estimated cost of US$87.5 million is required for the construction of the cofferdam (Wijesekera, 1999). The alternative proposal of the CECB (1994) did not include the necessity of a cofferdam. During subsequent discussions facilitated by the environmental authorities, the TEC learned that this approach to construct the tailrace outlet was different to that of the alternative. The CECB indicated the possibility of eliminating a cofferdam by executing the construction of the powerhouse via an access tunnel, using a natural rock face as a cofferdam. Since a huge cofferdam construction as proposed in the addendum inevitably increases the cost of the Yoxford option, it is necessary to evaluate the merits of alternative construction methods.

Another key feature in the addendum was that detailed site investigations had revealed the technical non-feasibility of the Yoxford dam construction due to very poor geology of the proposed site. The addendum said that it was impractical to construct the tailrace and powerhouse as stated in the CECB proposal because of poor geology (CEB, 1996). The addendum had concluded that further consideration of the Yoxford option was not warranted due to these reasons.

Since poor geology was identified as a significant constraint, the evaluators of the TEC recognized that the Yoxford proposal with a dam at Talawakele should not be used for any rational comparison.

Project Variants

The main rationale for the comparison of the UKHP Talawakele option with the CECB alternative is that the latter would not affect the waterfalls as much as the UKHP but would generate comparative amounts of energy. As such the inability to construct a dam at Yoxford alone could not be considered sufficient to ignore the alternative proposal. In this context, it is prudent to investigate possibilities of achieving the best option within the concept proposed in the CECB alternative.

Since it is not possible to construct the Yoxford dam at the geologically poor location as suggested in the CECB proposal, one variant would be an investigation of suitable dam sites in surrounding locations to suit the concept of the proposal.

Another variant to the Yoxford dam in the CECB proposal could be the consideration of a run-of-river scheme instead of a 65 m high dam at the geologically poor location. This would need the investigation of both the technical feasibility and the power generation capability of a lighter structure at the geologically poor location.

Reports submitted by the project proponent, other meetings and discussions did not point to studies of these variants. Evaluation by the TEC needed to recognize the want of further studies of alternatives or variants because the project was aiming to overcome an energy crisis in the near future. Any decision warranting a further study would prolong the project implementation. Therefore
the evaluation required a critical approach because, unless such an approach is adopted, the time and money spent for further work due to a poor decision would be harmful to the status of Sri Lanka's economy.

ROR Variant

Investigating a project variant at the stage of EIAR evaluation is not an easy task because, according to law, the TEC has to rely on data either provided by the proponent or obtained during meetings arranged by the environmental authorities. A document submitted during the environmental impact assessment appeal (CEB, 1995) provided a study of a few options, including an ROR scheme at Yoxford but without any diversion. This information was related and hence could be used for the study of the Yoxford variant within the framework of the alternative proposal. Comparison of proposed dimensions in both the ROR weir and the storage reservoir at Yoxford showed that a weir would be about 10% of the dam in size and the energy contributions indicated that a weir could produce about 90% of the annual energy available from a dam at Yoxford as proposed in the addendum (Wijesekera, 1999). As such, a cursory look at a possible variant of the UKHP Yoxford ROR option indicates that the ROR variant, when compared with the dam studied in the addendum, would significantly reduce the costs while marginally lowering the available power.

Adjusted Estimates

Energy and cost estimates of the UKHP and Yoxford options were compared using the findings. Energy estimate revisions considered the streamflow fluctuations, rating curve adjustments and availability of effective head for ROR generation. Project cost estimate adjustments were done to suit the construction of the ROR weir and the powerhouse (Wijesekera, 1999). These probable energy estimates, computed using adjusted streamflow data and a project ROR variant, indicated that the Talawakele option could harness approximately 752.2 GWh/year while the Yoxford ROR and Lindula system could harness 660.1 GWh/year. Since a major conceptual disparity could not be observed between the Lindula scheme proposed by the CECB and the addendum, the cost estimate for the addendum was kept unchanged.

Considering the reduction in dimensions, estimates of the dam construction costs were reduced to 10% of those for the dam. After evaluating construction methodology it was taken that the cofferdam costs could be reduced at least by 75%. The evaluators identified that adjusted cost estimates for the Yoxford ROR option were US$279.2 million, against US$256.8 million for the Talawakele scheme.

Benefits and Costs of Alternatives

Estimated annual energy from each alternative was used for the computation of project benefits, and estimations were carried out in a manner similar to those of the addendum. The basis of computation of project benefits in the addendum is through a comparison of alternative energy generation options by either coal or gas turbines. Keeping the alternative energy proportions at the same level of
the addendum, benefits for the Yoxford ROR option were computed for the adjusted estimates (Wijesekera, 1999). The present worth of benefits computed, assuming a discount rate of 10% and a project life of 50 years after a construction period of 5 years, showed that the B/C ratio of the Talawakele option increased to 1.4 while that of the Yoxford ROR variant also increased to 1.25 (Table 2). A sensitivity analysis to identify the effect of a scenario with a benefit reduction of 10% and a cost escalation of 10% showed that in such a situation the Talawakele and Yoxford ROR alternatives would reduce their B/C ratios to 1.14 and 1.02, respectively.

The evaluation by the TEC deliberately avoided the inclusion of hard-to-quantify benefits in the analysis. Therefore benefits from preserving the scenic beauty of waterfalls, the biodiversity of the environment, income from tourist attractions and the consequences for riparian rights, etc. were not taken into account. However, an idea of the present worth of benefits that would arise from the preservation of waterfalls can be computed by comparing both project alternatives. Benefits and costs of both options show that if the present worth of other benefits arising from keeping the waterfalls were to reach US$43 million, the Yoxford ROR option would even out with the Talawakele option. In the case of a 10% cost increase and a 10% benefit decrease, the Yoxford ROR option approaches an almost break-even condition. However, tagging a value of US$114 million for waterfalls under this condition would increase the B/C ratio of this option to a value of 1.4, which is equal to the estimate for the Talawakele option. From another point of view, if the Yoxford ROR option falls behind by 10% from the projected benefits, and gives rise to a lowering of weir and cofferdam costs by only 25% and 50%, respectively, while leaving the other costs unchanged, then the value of unquantified benefits associated with waterfalls would need to reach US$112 million to be even with the Talawakele option.

Summary

(1) Streamflow estimation for project evaluation was found to require accurate assessments rather than conservative estimates due to the environmental competitiveness of the alternatives. Evaluation from a critical point of view increased the annual energy potential of the UKHP Talawakele option to 752 GWh and showed that the Yoxford ROR variant could generate about 660 GWh. Evaluation of hydrological information indicated that a realistic analysis would yield approximately a 41.5% increase in water yields from those in the addendum.

(2) Water balance computations are necessary to carry out comparisons of water use. Such computations need to consider rational selection of time resolution to show the influence of affected system changes. Use of such an approach
would have assisted the computations relating to spill-over losses and the Pundalu Oya diversion presented in the UKHP addendum.

(3) Cost of the cofferdam construction estimated in the Yoxford/Lindula option has a significant impact on the viability of the alternative and hence needed a careful evaluation. The evaluators recognized the possibility of lowering the cofferdam construction costs via an alternative approach.

(4) Evaluation of the UKHP Talawakele option and the Yoxford/Lindula ROR variant indicated that both projects appear to have B/C ratios greater than unity even at a situation where benefits decrease by 10% and costs increase by 10% from the revised estimates. The revised estimates indicate that if the hard-to-quantify benefits associated with waterfalls are worth more than US$43 million then the Yoxford ROR variant becomes attractive. Various possible worst-scenario cases lead to a value of US$114 million as the threshold value. These values need to be compared with Sri Lanka's development and conservation concerns prior to making a decision either to implement the Talawakele option or to extend the work of the EIAR to cover the issues raised in the study.

(5) Evaluation by the TEC, which was carried out within a limited time using data available through recognized sources, provides planning guidance. If a similar evaluation had been done for the project at early stages then more conclusive values could have been obtained, probably preventing conflicts and saving time and money. Considering the issues raised, it is important to periodically engage independent water and other professionals to work with the project designers to carry out critical evaluation at least in the case of major development projects.

(6) If national authorities tag a competitive price for the waterfall-associated benefits then the project will require sufficient finances to carry out further studies and this may cause difficulties. Usually, at the time of preparing final project documents such as the EIAR, financial allocations for project design are almost exhausted and this will create an opposition to commencing new studies, thus creating conflicts.

Discussion

(1) Benefits and costs are the key to evaluation of a project. However, all benefits from a project and especially environmental benefits are shown as being difficult to quantify. This needs a very thorough assessment of quantifiable benefits or costs because of the need to assess different project alternatives that lead to different degrees of environmental benefits. Evaluation of the UKHP indicated that a critical assessment would prevent the suppression of environmentally friendly alternatives, whereas a conservative assessment might not provide a fair opportunity. The values tagged to waterfalls to abandon the UKHP and implement the ROR variant are considered as highly competitive by many. Many expected the energy authorities to give adequate consideration to the ROR. Energy managers could be seen clinging onto a proposal that maximizes energy benefits, whereas independent water and other professionals indicated the need for a more critical assessment. Therefore project designers should look at national assets in a challenging way rather than carrying out project formulation in a traditional, conservative manner.
To avoid uncertainties in data such as those relating to streamflow, in concepts such as water diversion, in water balance for spill-over losses or in construction methods, water and other professionals will need to carry out careful sensitivity analyses to identify the effect of uncertainties. This was a clear omission in the EIAR of the UKHP. Such computations would have enabled a clear identification of sustainable alternatives demanded by the present-day public.

In formulating energy projects such as the UKHP, project proponents and designers need to possess the vision to identify and study potential project variants in a rational manner. It would save a significant amount of time and energy, which are of immense value to a developing country such as Sri Lanka. Therefore it is essential that energy professionals recognize the need of competent water and other professionals for appropriate design of energy projects. The present work clearly indicates that when formulating hydropower projects, energy professionals need to utilize experienced and competent water professionals who are unbiased. The water professionals could be either in the team itself or external.

Incorporation of staged evaluations for the project would avoid last-minute identification of project alternatives. Unveiling of the ROR alternative and the independent assessment by water professionals was done at a point of time when a significant quantity of resources had been exhausted for the analysis of alternatives. A point of view is that, though the ROR option was attractive, the energy managers did not have the ability to restart the process, probably due to lack of time and money. Under such circumstances a deadlock situation is not a surprise. Therefore every attempt needs to be taken to surface the key alternatives at the right point of time. Periodical exposure to other professionals and the public would facilitate better project formulation, probably leading to fewer conflicts arising due to exhaustion of financial resources.

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