IMPACT ASSESSMENT CASE STUDIES FROM SOUTHERN AFRICA

PRE-FEASIBILITY STUDY FOR THE POPA FALLS HYDRO POWER PROJECT: PRELIMINARY ENVIRONMENTAL ASSESSMENT
Aims of the Project

The Popa Falls Hydro Power Project was proposed by NamPower in the context of rapidly growing demand for electrical power in Namibia and the SADC Region. In 2003 the demand in Namibia was 350 MW and growing, driven largely by developments in the mining sector. At that time Namibia received approximately half its power from Ruacana Hydro Power Station on the Cunene River and most of the balance was imported from South Africa. However, the demand in South Africa was starting to outstrip supply and their surplus for export was diminishing. The project was also intended to improve supply to the north-east of Namibia where, amongst other things, extensive irrigation projects along the Okavango River were proposed. Popa Falls Hydro Power was to feed some 20 MW into the national grid.

Brief description of the development and alternatives considered

Popa Falls is a series of rapids on the Okavango River in Namibia, upstream of the Okavango panhandle and Delta. It is close to the new Bwabwata National Park (to the east of Popa Falls), Popa Falls Game Park, and Mahangu Game Reserve downstream.

Of great significance are the islands and riverine forests immediately upstream of the Falls, which are some of the last remnants of riverine forest on the Okavango River in Namibia. The islands in particular are relatively undisturbed.

A gated weir of over 9 m was proposed near Divundu to provide the pressure head needed to generate power. The weir was necessitated by the fact that the Okavango River in Namibia has such a low gradient with no big falls. Popa Falls itself is only a rapid of 2 – 4 m high, depending on the flow rate at different times of the year.

Figure 1: The photo shows the riverine forests and islands about 2 km downstream from the limit of inundation near Andara. These forests represent some of the last remnants of such riverine forest on the Okavango River in Namibia. Much of this habitat would be destroyed.
Brief description of the development and alternatives considered

Several alternative sites for the weir were identified as shown by the red lines in Figure 2. Site option 1 was Popa Falls itself, which was ruled out as it would destroy the main tourist attraction, affect at least three tourist establishments, and impact on an important breeding and feeding site for rock pratincoles. Sites 2 and 3 were also considered too close to the tourist establishments and may have had structural implications for the bridge at Divundu.

The preferred site was Site 5, some 3.3 km upstream from the Divundu Bridge. This site provided the greatest potential for hydro power generation. A weir 9.75 m high would create an impoundment 10 km long, reaching to just below Andara Mission Hospital. The weir would inundate about 8.1 million hectares, which was about 5.2 million hectares more than the area occupied by the natural channels.

The inundation would cover mostly natural habitat, but also some crop lands and homesteads.

Figure 2: Locality map showing the five alternative sites for hydro power generation in the vicinity of Popa Falls.
Brief description of the development and alternatives considered

The project would be designed as a ‘run-of-the-river’ scheme so that no water was diverted out of the river channel. Instead, turbines would be located in the weir itself, alternating with sluice gates. The weir would be operated at ‘full supply level’ most of the time with water flowing 300 mm over the top of the weir and the rest passing through the turbines and sluice gates. ‘Tops gates’ would be used to keep the level constant at the full supply level. However, during part of the low flow season, the level would drop below the full supply level because of lower river discharge, and power generation would decline.

At an early stage the need to ensure the uninterrupted passage of sediment through the weir was identified as an environmental prerequisite – this being ecologically important for the Okavango Delta. Two options were considered to move sediment through the impoundment – sluicing or pumping. Sluicing involved opening all gates for 4 to 6 weeks each year during the peak flow season, thus increasing flow velocities in an attempt to remobilize sediment that had been deposited. No power could be generated during sluicing. The second option was to capture the sediment as it entered the head of the impoundment and pump it via a 10 km pipeline to be released below the weir.

The sluicing option would result in a volume of the order of 20 million m$^3$ of water being released over a few days as the weir emptied, then the same volume would be held back again to refill the weir 4 to 6 weeks later. This would obviously have a major impact on the hydrograph, and it was impossible to achieve this within the natural

Figure 3: The preferred location for the weir (Site 5) is shown by the red line. This is just upstream from Divundu. River flow is from left to right. The flat landscape necessitates a long weir which would result in extensive inundation. Some mahangu fields as well as natural habitat would be lost, and many dwellings would have to be relocated.
Brief description of the development and alternatives considered

Variability of the flow regime. A year’s accumulation of sediment would also be discharged below the weir over 4 to 6 weeks. The implications for the redistribution of that sediment downstream needed to be better understood, particularly as sandbanks downstream are breeding grounds for African skimmers.

The sediment pumping option was far less disruptive to the natural flow of water and sediment and was therefore preferred for environmental reasons. The technical feasibility of achieving this was not confirmed.

Although hydro power generation is relatively clean and pollution free, there would be impacts on water quality and temperature, and shallow water habitats with rapid flow would be replaced by deep water, sluggish flow and lower oxygen levels.

The project would create very little direct employment and would have only a small stimulus effect on related services such as markets and raw materials. In fact the greatest potential of the area was for tourism, which requires very little power.

Inundation of the impoundment would necessitate relocation of many peoples’ homes. The natural resources on which their subsistence lifestyles depend would also be adversely affected – fertile soils next to the river, wood, and possibly fish resources.

Access would be via the existing tar road known as the Trans Caprivi Highway, and existing gravel roads to potential sites. Powerlines would be required to link the power plant to the national grid at Rundu. The exact route was not assessed at this pre-feasibility stage.

Alternatives to the project

Over several years NamPower had investigated several alternatives for generating or sourcing power. These included:

- A 20 MW (maximum) wind generation plant near Lüderitz was found to be not viable;
- A 800 MW gas fired plant at Oranjemund – Kudu Gas, but the gas is expensive;
- Baynes Hydro Power Project – a much larger project on the Cunene River, under consideration;
- Several small hydro power plants along the Orange River;
- A coal fired station at Walvis Bay;
- Construction of a 220 kV powerline through the Caprivi to Livingstone, which would supply 200 MW to Namibia. Presently under construction;
- Greater use of renewables such as solar water heaters – potentially saving 3,5 times more than the output of Popa Falls.
- Green architecture, energy efficient buildings and many other demand side measures have proved to be effective elsewhere in the world.
Environmental setting

Biophysical environment

Vegetation
Outside of the weir basin the vegetation is Kalahari woodland – dry, broad-leafed woodland which would not be significantly affected by the project. However, the impoundment would drown much of the last remnants of riverine forest between Andara and the weir site. This includes much of the extensive forested islands, where several Namibian Red Data listed species of plants are known to occur. Small areas of fringing reedbeds and papyrus would also be drowned. Downstream of Popa Falls is the start of extensive floodplains that form the transition to the Panhandle of the Delta. Extensive reed and papyrus beds are found there.

Fauna
A high faunal diversity occurs in the study area. Ten species of frogs, eight species of reptiles and 18 mammal species are dependent on the wetland habitats. Many of these species are of national conservation concern.

The area from Andara to Mahangu supports more bird species than any similar sized area of Namibia...
Environmental setting

(450 species) including at least 21 Red Data listed species. This includes the wattled crane which is considered to be globally threatened.

Fish are important ecologically and for human subsistence. A high diversity occurs in this area, including a number that require specialised habitats. The rocky rapids between Mukwe and Popa Falls support more than 10 species of such habitat specialists, which require fast flowing well oxygenated water and would be unlikely to survive in an impoundment.

Water & sediment

Virtually all the water in the Okavango River comes from Angola. The mean annual discharge is about 10,000 million m³, but it is highly variable with a range of 6,000 – 16,400 million m³. Most of the variation is accounted for by the annual flood discharge. Despite the natural variability, the rise and fall of the water level is very slow at Divundu, typically about 2 cm/day and up to 7 cm/day in the flood season.

The permeable nature of the soils, distance from the source of rainfall, and low gradient of the river mean that water takes months to arrive from Angola. Water quality is always very good, with very low concentrations of dissolved solids (25-42 mg/l), and low levels of suspended sediment (below 0.01% silt- and clay-sized particles at Rundu). This is due to the nature of the catchment, of which more than 90% is covered in Kalahari sand which yields very low levels of clay, silt or soluble material. The bulk of the river’s load is fine sand (0.25 – 0.4 mm) which is transported as bedload, not in suspension.

Figure 5: Bedload transport (left) downstream of Divundu Bridge two weeks after the flood peak in April 2003. The sand is stirred up around rocks due to locally higher velocities, but within 100 m it settles and thereafter proceeds to move as bedload. The fact that the bed (at 3 – 4 m deep) is so clearly visible proves that there is very little suspended sediment. The view to the south over Popa Falls (right) shows submerged sandbars below the falls. Organic matter (dark ‘shadows’) has accumulated on the downstream side of the bedforms. Sandbanks such as these further downstream are important breeding sites for African skimmers, while rock pratinoles breed on the falls and similar rocky outcrops in the river during the low flow season.
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Environmental setting

Socio-economic environment
A narrow riverine margin is fairly densely settled due to the presence of water, more fertile soils, fish, reeds, timber and other natural resources. Grazing of cattle and goats is also important. These people live a subsistence lifestyle, with some cash incomes from pensions. Employment opportunities are very limited

EIA process

The EIA was a preliminary study which was appropriate at the pre-feasibility stage, but it complied with the Environmental Policy of Namibia. It also went well beyond what would normally be expected of a preliminary EIA. This was due partly to NamPower’s urgency over the project, and partly due to the fact that a number of serious environmental concerns were raised, requiring more information to allow NamPower to make an informed decision about whether or not to proceed with a full feasibility study.

Public participation was started at an early stage in order to ensure that concerns were taken into account in the development of the project proposal. The public participation programme was carried out in both Namibia and Botswana. In Botswana, this was done by a Botswana based environmental consultancy to ensure that Botswana’s interests would be as well represented as Namibia’s. The project was advertised in the press and radio, and known interested and affected parties were contacted directly. Public meetings were held in Windhoek, Maun, Xaxanaka (with a group of scientists), Divundu and Rundu. Information sheets were distributed, minutes were kept and a summary of issues and concerns from all the meetings was circulated to registered I&APs. The concerns raised by I&APs centred mainly around the following key issues:

- Extent of inundation of the impoundment and consequent flooding;
- Impacts on the natural hydrograph, with secondary ecological impacts;
- Loss of water reaching the Delta, e.g. from evaporation and seepage;
- Impacts on water quality;
- Incompatibility between demand for irrigation and hydro power generation;
- Sediment being trapped in the impoundment, and methods to remove it;
- Fine sand carried down the river is integral to hydraulic functioning of the Delta, prevention of a build up of salts, and consequent ecosystem renewal;
**EIA process**

- Potential erosion downstream, especially of sandbars where birds breed;
- Destruction of riverine forest in the impoundment area;
- Altered habitats for many organisms resulting in local loss of species, including Red Data species,
- Disruption of sediments and benthic organisms / invertebrates in those sediments;
- Reduced inundation of floodplains downstream if sediment is impounded, with consequences for fish breeding and all floodplain species of fauna and birds;
- Fish migrations impeded by the weir;
- Sustainability of hydro power generation as more water is abstracted upstream in Angola and Namibia, and climate change reduces flow.

Overall, the public in Namibia and Botswana considered that the benefits of 20 MW of power were far too small to be worth the known environmental impacts and potential ecological risks. Both the natural and socio-economic impacts were considered likely to outweigh any benefits. Moreover, the benefits would be confined to Namibia, while the adverse impacts would extend also to Botswana.

Events at the public meeting at Divundu made it difficult to gauge the opinion of the people living closest to the project. The local chief sat himself at the consultants’ table in front, and after the presentations, he stood up and told the meeting that they must support the project! Not surprisingly most local people were reluctant to voice any objections. In hindsight, we also realised that it was difficult for local rural people with low levels of education to anticipate what issues they would encounter. They needed far more detailed information than could be provided at the pre-feasibility stage, e.g. how many homesteads would be relocated, who would lose their fields etc.

Consultations were held with authorities in Namibia and Botswana by means of letters and meetings.

Specialist studies were conducted at a level appropriate to a preliminary EIA. These included desktop study and fieldwork, covering the fields of flora, fauna, avifauna, aquatic ecology, and sediment transport. Consultations were also held with other knowledgeable people in the area and the Okavango Delta.

Other activities contributing to the EIA were:

- An extensive literature review, including a large body of studies on the role of sediment in hydrological and ecological functioning of the Delta. This information led to the judgement of sediment impoundment as a fatal flaw.
- An aerial digital laser survey and mapping was conducted by Water Transfer Consultants and was used to determine the extent of inundation.
- A helicopter flight by the environmental scientist and botanist/ornithologist was valuable in understanding the impoundment area, as the flat landscape provides few vantage points.
- Fieldwork for site-familiarisation by the environmental scientist and specialists.
**EIA process**

Two important studies of sediment transport were carried out simultaneously during the flood peak in April 2003. These studies were done in order to resolve debates about the manner and magnitude of sediment transport. Bedload transport is notoriously difficult to measure. Scientists from the Universities of Stellenbosch and the Witwatersrand collaborated using different methods (bedload sampling and high resolution bathymetry) to establish a relationship between mean flow velocity across the channel and bedload sediment discharge. Using long term historical records of flow and flow velocity it was possible to estimate the total sediment discharge per year – approximately 70,000m$^3$/year.

All of the above-mentioned inputs to the EIA process were used to identify potential impacts, and South Africa’s Checklist of Environmental Characteristics (DEAT, 1992) was used to ensure comprehensiveness in impact identification.

The identified impacts were then assessed to standard criteria: nature of impact, extent, duration, intensity, probability of occurrence, confidence in predictions made, and significance for a decision about the project. Potential mitigation measures were proposed and in some cases also assessed (e.g. for sluicing). Further research was recommended in a number of specialist fields, including a comprehensive cost benefit analysis of socio-economic issues in Namibia and Botswana.

**Main environmental impacts & issues**

**Positive**

The preliminary EIA considered the benefits of the project to be as follows:

- To generate 20 – 23 MW and feed this into the Namibian supply grid;

- Some transmission costs for alternative ways to get power to north-eastern Namibia would be avoided;

- The benefits of the project were found to be comparable with the Kudu Gas project, and slightly cheaper than imports from South Africa or Zambia.

Overall the benefits to Namibia were small, and the benefits to the local people insignificant.
Main environmental impacts & issues

Negative
The more significant negative impacts were found to be:

- Sediment (mainly fine sand, but also clay and detritus) would be deposited, starting at the inflow to the impoundment. This would result in erosion of the downstream channel, reduced over-bank flooding, and consequent ecological impacts on fish breeding and floodplain species.

- If sluicing was practised it would have a major impact on the hydrograph. Therefore, sediment pumping was the only method of moving sediment to downstream of the weir, but this was not a tried and proven solution.

- Failure to ensure that most of the sediment was passed through the impoundment would have negative impacts on the Okavango Delta. There, sediment deposition is one of the key ecological drivers of channel renewal. Briefly, when major channels become choked up (historically about every 100 years), water gets redistributed to new parts of the Delta. Former floodplains dry out, peat burns down, scarce nutrients get recycled, salts that have accumulated in islands get leached out to deeper levels, and ecosystem renewal occurs. Preventing sediment inflow to the Delta would cause serious long lasting ecological change in the Delta.

- Destruction of large areas of intact riverine forest on banks and islands would occur in the impoundment area. These are the last extensive remnants of such forest in Namibia, and support one of the country’s highest concentrations of biodiversity. Several species of Red Data birds and plants would be lost, and possibly also other animal species.

- Aquatic habitats in the impoundment would be altered from rocky rapids to deep still water environments with a sandy floor. This would have negative impacts on several specialised species of fish and invertebrates.

- Fish migrations would be interrupted. Fish bypasses have often been found to be ineffective.

- To the extent that fish populations are reduced, there would be a negative impact on subsistence livelihoods.

- Some of the crop lands with the most fertile soils would be inundated, and dwellings would have to be relocated.

- Incidence of diseases such as bilharzia and malaria often increase in impoundments as ecological balances are upset and the host organisms increase.

- Conservation planning initiatives in the area would possibly be threatened.
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Main environmental impacts & issues

Cumulative
Impacts of the project together with other impacts on the river would include:

- A small loss of water, due to evaporation and seepage, would be added to losses from abstraction for irrigation and domestic supply, and climate change. Water loss would also reduce the transport of sediment to the Delta,

- Decreased water quality due to decomposition of detritus in the impoundment and reduced oxygen levels, would be additional to the impacts of increased nutrient loading from irrigation and urban development upstream.

The study recommended a full cost-benefit analysis, including all costs and benefits to the environment. It found that the biophysical impacts and related socio-economic costs would outweigh the very modest benefits of the project. Also, the distribution of costs and benefits would not be equitable, as subsistence livelihoods in the dam area would be negatively impacted, yet these residents would experience very little of the project’s benefits.

Decision-making process

Following the pre-feasibility study, NamPower made a decision to shelve the Popa Falls Hydro Power project. The reasons given were:

- The 20MW that could be generated was very small,

- The costs of sound environmental management were likely to be very high, and

- The hydromatrix turbines were not ideal for the desired application.

The Preliminary Environmental Assessment played a significant role in the decision making process. The sediment studies made a twofold contribution:

- Firstly, by confirming the fact that the sediment load is transported mainly as bedload, it became apparent that sediment would be deposited at the head of the impoundment and it would be very difficult to move it through the impoundment by sluicing. This cast serious doubt on the sluicing option.
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Decision-making process

- Secondly, it provided an estimate of the volume of sediment that would have to be pumped through the impoundment – a fact that had both technical and cost implications.

However, it was not only the sediment issues that influenced the decision. All the known impacts, especially within the impoundment area, when taken together, indicated that the impacts of the project would be more negative than positive. For most of the serious impacts in the impoundment area, no mitigation would be possible.

The Ministry of Environment & Tourism made very little contribution to the EIA process, and in the end issued an Environmental Clearance for the project to proceed to a full EIA.

The EIA was externally reviewed by the Southern African Institute for Environmental Assessment (SAIEA) in Windhoek and the CSIR in Pretoria. Both reviews commended the study for going way beyond what was normally expected from a preliminary EIA. The quality of the study enabled NamPower to defend a decision to shelve the project.

Main elements of excellence in this EIA

The EIA process contributed significantly to a scientific understanding of sediment transport on the Okavango River in Namibia. This contribution was acknowledged by the Directorate of Water Affairs. The specialist scientific contributions were also vital to this improved understanding.

In particular, the field studies proved that the dominant mode of sediment transport is bedload transport – just as it is in the Delta. This makes the Okavango River extremely unusual in the southern African and even in a global context. Most rivers carry a high proportion of their sediment load as silt and clay, which can be carried in suspension, creating the potential to flush out small-volume impoundments by sluicing. Removal of fine sand by this method, however, is very unlikely to be successful. This has very important implications for the engineering approach to the problem of sediment impoundment.

Very good long term hydrological records provided by the Directorate of Water Affairs were also essential to making good assessments of impacts relating to the flow of the river.

An extensive literature review by the author, and the concise specialist reports, improved Namibia’s understanding of the biophysical functioning of the Delta. Scientific knowledge from earlier research in Botswana was communicated across the three basin states, including Angola, via various forums including OKACOM (the international basin committee). Furthermore, this knowledge was communicated in layman’s terms, so that it was accessible to decision-makers who do not necessarily understand technical and scientific content.

The comprehensiveness of the study and attention to detail was a very strong aspect of the study – going beyond what would normally be required of a preliminary EIA.

An extensive public participation programme was very valuable in identifying some of the potential issues at an early stage. It was also very important that it was just as comprehensive in Botswana as in Namibia – since Botswana had more to lose if the worst case scenarios materialised.
Lessons learnt

Conducting the public participation early in the planning process was queried by some people at the public meetings on the basis that not enough information was available at that stage. However this approach proved valuable in that issues and concerns were identified early enough so that they could be investigated during the EIA process. Introducing public participation much later would also have deprived the EIA process of the benefit of public knowledge about the affected environments.

In communal contexts it is often difficult to solicit the views and concerns of rural people. The public meeting at Divundu was only partly successful in achieving this. The fact that the chief told people to support the project made it difficult for local people to express concerns. In hindsight it would have been better to use local consultants who speak the language to conduct surveys informally amongst the local people. This would have eliminated the risk of the meeting being ‘hijacked’ by the local chief or other influential members of the community.

In this case a preliminary EIA was sufficient to provide enough information to enable decision-makers to make an informed decision about the project. A full EIA and feasibility study could have been commissioned thereafter (at considerable cost) and it would have added valuable quantification of many of the impacts that were identified, but it may not have added much to the decision-making process.