The Lom Pangar dam project (Cameroon) Fruitful collaboration between the consultants in charge of the dam design and of the environmental and social assessment

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Introduction

The Lom Pangar dam is under construction in the upper Sanaga river basin (Cameroon). The owner is Electricity Development Corporation (EDC), a state-owned company. The project has been planned in order to optimize the yield of the several hydropower plants located on the Sanaga River. It includes a 45 m high dam creating a 6 billion cubic meters reservoir, 540 km^2 in area. It also includes a 30 MW power plant and a 105 km long transmission line. The dam and reservoir are located in a sensitive forest and savanna area, in a poorly developed part of the country.

The Lom Pangar project is, to the authors' knowledge, the first large dam project in Africa whose construction works are financed by the World Bank through an IDA credit since the World Commission on Dams (1998-2000). Given its context, the Lom Pangar project is associated with substantial environmental, social and reputational risks.

During the preparation phase of the project, the Government of Cameroon carried out an environmental and social impact assessment (ESIA) which led to the completion of an environmental and social management plan (ESMP) and a resettlement action plan (RAP). The environmental and social documentation was produced in compliance with the World Bank and other donors policies.

During the detailed design study, a close collaboration was organized between Tractebel Engineering (France) / Coyne et Bellier, the consultant in charge of the dam design, and the consortium ISL Consulting Engineers/Oréade Brèche/Sogreah, in charge of the environmental and social documentation preparation. Frequent exchanges between the two teams helped preparing a better project in both technical and socio-environmental perspectives. This collaboration fruitfully carried on, the consortium Tractebel Engineering (France)/Coyne et Bellier - ISL Consulting Engineers having been hired to carry out the supervision of the dam construction works, with the assistance of Oréade Brèche.

The paper focuses on the contributions of the social and environmental assessment to the dam design and worksite organisation, and on the contributions of the project to conservation of biodiversity, living standards of local populations, and culture history.

1. Background

1.1 The electricity sector in Cameroon

Taking into account the commissioning of the gas power plant in Kribi (216 MW) in early 2013, over 60% of Cameroon's electricity is produced by the hydroelectric plants in Song Loulou (384 MW) and Edea (263 MW) on the Sanaga river, and by the Lagdo plant (72 MW) on the Benoue.

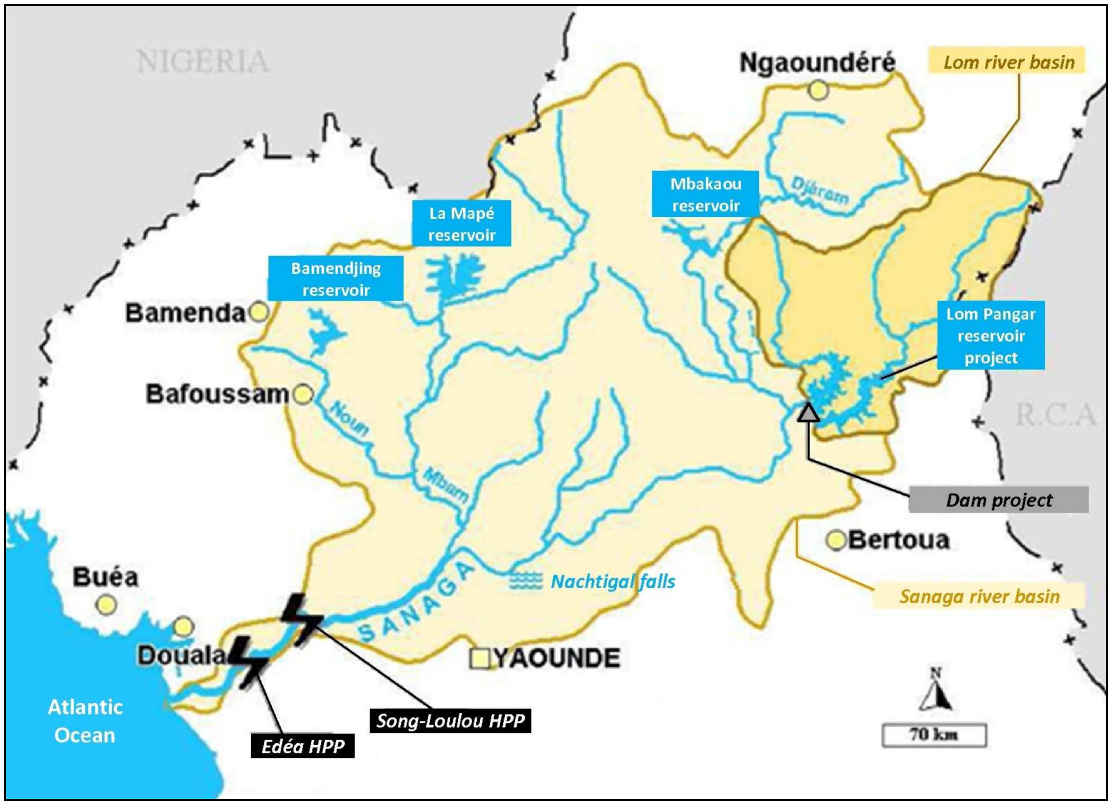

Fig. 1. Map showing the Lom Pangar project within the Sanaga hydropower system.

The development of Cameroon's hydroelectric potential, the second largest in Africa behind the Democratic Republic of Congo, started with the progressive deployment of the Edea plant between 1954 and 1958, then its extension in 1970. The Song Loulou and Lagdo plants were both commissioned in the 1980s. Alongside the development of production capacities, the three reservoir dams in Mbakaou, Bamendjin and La Mapé were progressively brought into service in 1970, 1975 and 1988, in order to increase the water flow of the Sanaga river during the dry season, thereby increasing the guaranteed power production at the Song Loulou and Edea plants.

Nonetheless, starting in the middle of the 1980s and until the early 2000s, Cameroon had to deal with a severe economic crisis, which led the Government to enact the structural adjustment policy proposed by the Bretton Woods institutions. It was obliged to: i) postpone planned strategic investment in the energy sector, in particular hydroelectric facilities, and ii) privatise the production, transport, distribution and sale of electric power. The privatisation of Sonel led to the creation of the company AES-Sonel in 2001.

Due to the postponement of the investment, Cameroon’s power production system can not cope since the early 2000s with the growing demand of the public sector and industry, causing frequent load shedding during the dry season. The economic cost of this energy shortage is estimated at 1-2% of the annual Gross Domestic Product, or about CFA 1,000 billion over the 2002-2011 period.

Faced with this energy crisis, the Cameroon government has made the expansion of the country's electricity production capacity a national priority and has drawn up an Energy Sector Development Plan for 2030 (ESDP 2030), in which the choice of hydroelectric power is a suitable long-term solution whatever the development scenario.

1.2 Lom Pangar reservoir dam

The Lom Pangar dam project is located in the Eastern province on the Lom river, approximately 4 km downstream from the confluence with the Pangar, and 13 km upstream of the confluence with the Djerem. It is an extension of the development of the Sanaga electric power production system and its main purpose is to significantly increase the hydrological regulating capacity of the catchment area. The project will increase the minimum water flow at Song Loulou from 600 to 950 m^3/s, thereby ensuring an additional guaranteed power of 120 MW to the Song Loulou and Edea plants, and also to supply water to future hydropower facilities, including the Nachtigal hydroelectric plant.

The Lom Pangar dam, which has a maximum height of 45 m, is a mixed-type dam composed of a central concrete structure with embankment wings and a saddle dam. Its 540 km² reservoir offers an active storage capacity of 6 billion cubic metres (km^3) at normal operating level (672.7 m NGC). The project also features the construction of a dam toe powerhouse which in time will be equipped with four generator turbines, each with an individual power rating of 7.5 MW, and a 105 km long 90 kV transmission line connecting the plant to the Eastern Network at Bertoua substation.

1.3 History of design and environmental studies

The Lom Pangar site was identified in 1980 during a general programme to inventory the hydroelectric resources of Cameroon. The design studies were initiated in 1990 and self-financed by Sonel, before its privatisation. A full geological and geo-technical reconnaissance campaign was carried out in 1992, followed by a feasibility study for the dam and plant in 1993, simulation work on the Sanaga system in 1995 and basic design studies also in 1995. A preliminary Environmental Impact Assessment (EIA) was carried out in 1997 and 1998. The basic design studies were updated in 1999, but the detailed design study, which should have been done after this update, was not launched due to the privatisation of Sonel, initiated in 1999.

A detailed environmental and social impact assessment (ESIA) composed of 25 thematic studies and a management plan, was carried out in 2004-2005 by the consortium ISL/Oréade Brèche/Sogreah, based on the the basic design updated in 1999.

A new updated version of the basic design was completed in 2006, integrating part of the recommendations contained in the ESIA 2005. The detailed design was then prepared by Coyne et Bellier, a draft being submitted in February 2007.

On the basis of the ESIA 2005 and the 2007 detailed design and on the observations of the Ministry of Environment and Protection of Nature, the independent panel of experts and the international funding agencies, additional studies (reservoir capacity optimisation, large primates population viability, environmental study of the access route) were required to meet the highest international standards. These studies were carried out in 2007 and 2008 and led to frequent exchanges and a close collaboration between Coyne et Bellier in charge of the project design and the consortium ISL/Oréade Breache/Sogreah in charge of the social and environmental studies.

Following those additional studies, the detailed design was updated in 2009 and the final version was published in April 2010. In parallel with the finalization of the dam engineering studies, environmental and social studies resumed in late 2008: at the request of the international funding agencies and in particular the World Bank, the Environmental and Social Assessment (ESA) and the resettlement action plan (RAP) were updated and reformulated to fully comply with their requirements. The final documents were edited in early 2012 after integration of the observations of the different stakeholders.

The call for tenders for the dam construction works was launched in August 2010, following a pre-qualification process that led to the selection, after notice of no-objection from the international funding agencies, of five Chinese companies, one Italian company, one Brazilian company and one French company. The works contract was awarded in May 2011 at the Chinese company China Water and Electric Corporation (CWE) and was put into effect in September 2011.

1.4 Requirements for the environmental and social studies

The environmental and social assessment process was conducted in accordance with:
- the national legal, regulatory and institutional framework, and in particular the Environmental Management Framework Law (Law n°96/12, 5 August 1996);
- the World Bank safeguard policies requirements, along with the ones of the other main donors (Agence Française de Développment – AFD, European Investment Bank - EIB, African Development Bank – AfDB).

The World Bank safeguard policies triggered by the Lom Pangar project are: Environmental Assessment (OP/BP 4.01), Natural Habitats (OP/BP 4.04), Forests (OP/BP 4.36), Pest Management (OP 4.09), Physical Cultural Resources (OP/BP 4.11), Involuntary Resettlement (OP/BP 4.12), Safety of Dams (OP/BP 4.37).

The safeguard policies requirements that are beyond national laws and decrees were identified and included in the environmental and social assessment process in order to fully comply with the donors' policies and allow for project appraisal.

2. Contributions of the social and environmental assessment to the project design

2.1 Contributions to the dam design

Optimisation of the reservoir storage capacity

The 2006 update of the basic design studies included an active storage capacity of 7 km^3, at a normal operating level of 674.50 m NGC. At the request of the financial contributors, an economic and environmental optimisation assessment of the reservoir storage capacity was carried out by ISL/Oreade Brèche.

The optimisation assessment for the active storage capacity of the Lom Pangar dam was based on fine modelling of the Sanaga river basin. All the hydrological data available were taken into account. The assessment shows that management of the Sanaga river must be optimised to be able to analyse the optimisation of the storage capacity appropriately.

From a hydraulic standpoint, simulations show that increasing the storage capacity from 5 km^3 to 6 km^3 will increase the guaranteed 90% water flow during low water level periods by 5 to 10%, therefore increasing the guaranteed power available on the Sanaga plants. Increasing the capacity from 6 to 7 km^3 only increases this water flow by 1 to 2%. We can therefore identify a significant hydraulic efficiency for the increase from 5 to 6 km^3 but only a marginal one for the extension from 6 to 7 km^3.

From an economic point of view, the optimisation of the storage capacity was done in an effort to minimise the cost of meeting the energy demand of the South Interconnected Network for the 2005-2030 period. The components taken into consideration are:
- Investment costs to meet demand on the basis of the ESDP 2030;
- Network operation costs, including fuel expenditure for thermal units along with operating and maintenance spending;
- Cost per tonne of carbon generated by greenhouse gases by the thermal plants and by the Lom Pangar reservoir;
- Cost of environmental measures according to the reservoir capacity.

The results of the optimisation in the median economic development scenario with the assumptions of the ESDP 2030 produce an optimal capacity slightly below 6 km^3.

The assessment highlights a high sensitivity of the optimal capacity in relation to the value per tonne of CO2 (equivalent), with the optimum changing from 6.6 to 5.1 km^3 when the cost per tonne of CO2 (equivalent) is increased from €5 to €15.

The other economic parameters taken into consideration have a less significant influence:
- a 33% increase in fuel costs pushes the optimal capacity from 5.7 up to 6.0 km^3;
- doubling the environmental flow from 25 to 50 m^3/s lowers the optimum capacity from 5.7 to 5.3 km^3;
- the use of a "wet" hydrological time series (1960-2003) also lowers the optimum capacity from 5.7 to less than 5.0 km^3.

Furthermore, the economic assessment highlights the high sensitivity of the results to the energy demand assumptions: the most pessimistic scenario would produce a storage capacity below 5 km^3 whatever the cost associated with greenhouse gases.

The environmental costs have been integrated into the economic assessment. Nonetheless, this approach does not take into consideration the wider environmental impacts. Specifically, the impact on the tail end of the reservoir area on the Lom river is sensitive to the choice of the normal operating level.

The assessment highlights a clear difference in the operation of the reservoir according to the selected capacity. Full refilling is effective four years out of five for a 5 km^3 capacity but less than one year out of two for a 7 km^3 capacity. A 7 km^3 reservoir entails hence severe restrictions on the tail end of the reservoir area on the Lom river, where agricultural land will be lost by the local populations and inefficiently valued by power production. The measures necessary to maintain the living standards of the 1,600 people affected are not easy to implement.

For the intermediate capacity of 6 km^3, the impact of the drawdown on the tail end of the reservoir area persists, but is limited as the tail end is located near Mbamjock/Taparé and the number of directly-affected inhabitants is lower.

Optimisation of the spillway design

As part of the Environmental Impact Assessment, the risks associated with the dam were analysed. This analysis led to the recommendation, which was supported by the panel of independent experts, to add a fusegate to the spillway as its initial design featured only radial gates.

An uncontrolled emergency spillway equipped with a fusegate was designed on the right bank of the controlled service spillway, serving to compensate for the non-opening of one of the four planned radial gates, increasing the discharge capacity in extreme flood conditions by about 20%. The fusegate crest allows also to define physically the normal operating level, 672.70 m NGC, resulting from the optimisation of the active storage capacity.

It was also decided to retain the dam crest level at an elevation of 677 m NGC, thereby offering an additional flood control volume of one billion m^3 and increasing the hydrological safety of the dam by as much.

Re-oxygenation weir

Experience feedback on large storage reservoirs in equatorial zones and the specific assessment of the forecasted quality of water done as part of the 2005 Environmental Impact Assessment demonstrated the need to foresee a downstream weir to reoxygenate the water turbinated through the powerhouse (environmental flow) during the annual filling period of the reservoir, corresponding to the wet season.

The construction of a re-oxygenation weir is now part of the project. It will be located on one of the rocky weirs marking the river topography between the dam and the confluence with the Djerem. The site location is to be optimised, in order to restrict the length of the river reach between the dam and the weir, and to limit the negative impact of the weir on the hydroelectric production of the dam toe powerhouse.

The purpose of this structure is to produce a minimum concentration of 5 g/l within the flow range of 0 to 100 m^3/s.

Nevertheless, most of the outflow will be discharged during the dry season through the regulating gates located at the bottom of the dam. The aeration of the flow will then be insured by flip buckets allowing for dispersion of the water jets and extensive contact with the surrounding air.

Abandonment of fishway option

Prior studies demonstrated the high risk of anoxic conditions in the reservoir due to the minimum operational level, defined as 649 m NGC, which could be reached every ten years in light of the regulating character of the dam, as well as the predominance of a fish reproduction strategy in the Sanaga river network that essentially features lateral migration (and not downstream - upstream) to breeding zones, tributaries or the flood plain. These results led to abandon the option of creating a fishway.

2.2 Contributions to the worksite organisation

Access route

As part of the Environmental Impact Assessment, the site access routes were studied. Four possible routes were analysed and compared using a multi-criteria approach. The Bertoua-Belabo-Santalo-Mansa-Deng Deng-Site solution was retained due to the multiple advantages it presented compared to the other possibilities. It avoids the direct Bertoua-Deng Deng road which is surrounded by numerous villages. It bypasses the Deng Deng National Park and provides an optimal solution in terms of cost of works and deadlines.

Location of camp facilities

The camp facilities for Contractor management and workforce were shifted from the left to the right bank of the Lom river, to ensure the separation of the work site from the villages located on the left bank close to the Deng Deng National Park. A temporary bridge will be used to cross the Lom during the construction work. A control barrier will be located in Ouami, between Deng Deng and the work site access point.

Location of rock quarry

The quarry initially intended to supply aggregates for concrete, filters, drains, rockfill and riprap was the Kouma dome located on the left bank downstream of the dam. This quarry is located on land inhabited by large primates and is now part of the Deng Deng National Park. Another quarry, located upstream of the dam and mostly situated below the reservoir's normal operating level, has been identified and selected, thereby minimising the environmental impact.

Environmental and Social Conditions of Contract

All contractors participating in work relating to the Lom Pangar project shall respect the organisational and technical obligations specified in the Environmental and Social Specifications appended to the Tender documents. These obligations are based on ISO 14001 (Environmental Management System) and OHSAS 18001 (Health & Safety), as well as on commonly observed construction best practices concerning the environment.

3. Project contributions to conservation of biodiversity

The dam, its associated infrastructures and the reservoir are located in the heart of the Deng Deng forest, which spreads over 500,000 hectares. In light of the direct and indirect impacts on this zone, during both the construction and operational phases, the project has led to the creation of the Deng Deng National Park, the extent of which should reach 60,000 hectares by the end of the dam construction phase. Beyond the traditional roles attributed to a protected area, in the context of the Lom Pangar project, the Deng Deng National Park has a more specific, double purpose:

- Constitute an environmental compensatory measure in proportion to the natural habitats destroyed by the project and in particular, those flooded by the reservoir. This objective includes the effective protection of the ecosystems and biodiversity of the Park, especially through rigorous control of encroachment on forest for agricultural lands, illegal felling of trees, poaching, etc.
- Ensure viability of large primates populations (notably gorillas and chimpanzees) by protecting their habitats in the Deng Deng forest, which are close to the dam construction zone, its access routes and a portion of the transmission line.

Furthermore, in order to ensure suitable control of all impacts of the Lom Pangar project on the Deng Deng forest region, the administrative zones of the area were revised, to structure the forest space according to the foreseeable evolution of usage, by (i) permitting local populations to use the designated forest areas in a sustainable manner, and (ii) maintaining biodiversity in the Forest and in particular the large primate populations. Specifically, the revisions concerned the following points: adaptation of the Deng Deng National Park boundaries, creation of the Belabo communal forest area, modification of the boundaries of the Forest Management Unit 10 065, creation of an agricultural forest area, creation of the Deng Deng Community Forest.

The management of the reservoir and impacts downstream of the dam on water quality, down to the Sanaga estuary, represents a major environmental issue for the Lom Pangar project, especially during the operational phase. In addition to the water oxygenation systems featured in the structure itself, in order to control these impacts the project foresees:

- a forced drawdown for the first three years to limit the decomposition of organic matter in an anaerobic medium;

- the production of Social and Environmental Conditions appended to the dam operations and reservoir management manual, setting out the social and environmental specifications for day-to-day operations and exceptional operations of the power plant and the dam;
- various monitoring programmes concerning: (i) the hydrology of the catchment area, (ii) the quality of the water in the reservoir and downstream of the dam through its confluence with the Djerem, (iii) the development of invasive species in the reservoir, (iv) net greenhouse gas emissions.

4. Project contributions to restoring/improving the living standards of local populations

The Lom Pangar project will have an economic impact on approximately 1,600 households, 400 of which will have to be physically resettled. Relocation and resettlement plans have been prepared for the project sites, in accordance with World Bank safeguard policy OP 4.12 on involuntary resettlement. These plans provide information on: (i) the populations affected, (ii) the legislative context, (iii) the methods used to identify Persons Affected by the Project (PAPs), (iv) the methods and objective of consultations with PAPs on the issues surrounding loss of property, compensation and resettlement, (v), the proposed resettlement and compensation project, (vi) the methods used and schedule of resettlement and compensation, (vii) the institutional organisation for deployment of these plans, (viii) the cost of compensation and resettlements, (ix) assistance to vulnerable people, (x) external and internal monitoring of the plans, (xi) the independent audit system.

The project represents an opportunity for social and economic development for the Eastern region of Cameroon, but will also have negative impacts on populations inhabiting its area of influence. The project therefore features several measures which intend to attenuate the negative impacts on the local economy and living conditions, and to ease the load on local infrastructures and services caused by the relocation of populations under the project.

The influx of people attracted by the construction works is likely to have a durable effect on the sanitary situation of villages surrounding the project site. The project features measures to maintain or improve the sanitary profile of populations in the area of influence of the Lom Pangar project both in the construction phase and operation phase. These measures include:
- the drilling of wells, the construction of stand pipes and draw wells in fifteen villages;
- the ramping up of health infrastructures: renovation of health care centres, enhancement of regional hospital equipment;
- the completion of epidemiological and sociological surveys;
- the production of sanitary maps.

The project features the flooding of a part of the gold resources in the Lom valley and it is essential that the gold mining activities that will follow upstream of the reservoir when the dam is brought into service do not cause chronic pollution of the reservoir, notably due to the presence of mercury. In light of these facts, the project intends to accompany the development of this activity through i) the development of mining techniques that respect the environment, ii) the structuring of the local mining sector, iii) support for professional reconversion.

Although the fishing sector is not highly developed, it will be permanently affected by the project, for two reasons: the transformation of a river environment into a lake environment and the risks of stratification and anoxia in the reservoir during the operation phase. The project will therefore offer direct assistance to fishermen affected by the operation of the dam. Moreover, fish stocks and fishing activities will be monitored before, during and after construction of the dam, to enable us to understand the actual impact that the reservoir will have and to adapt supervision of the fishing activity throughout the life of the dam.

For agricultural and animal breeding sectors that will see their most fertile land either temporarily or permanently submerged, the project will provide aid to develop agricultural and breeding activities elsewhere in order to restore the living standards of the directly-affected populations. This support will concern the improvement of production yields and the introduction of high added-value cultures when the soils enable it.

The seasonal flooding of the tail end of the reservoir will cover roads and commercial routes, including the traditional breeder migration routes, all of which the populations living to the north of the Lom are strongly dependent on. In light of these impacts, the project plans to restore the continuity of the main economic routes by the construction of a major bridge crossing the Lom at Touraké, which is currently served by a small ferry.

The consultations carried out throughout the preliminary design phase demonstrated a strong demand for local populations to benefit from the energy generated by the Lom Pangar project. To this end, a rural electrification project has been integrated into the project in order to help improve the quality of life of a large part of the populations affected. In particular, the project concerns the electrification the villages along or close to the high voltage transmission line. This component of the project includes the extension of the low voltage distribution network and the connection of households to the network.

5. Project contributions to culture history

The inventories carried out at the time of the preliminary design work revealed the presence of many archaeological sites, with strong cultural, historical and scientific value, indicating traces of ancient human life in the Lom valley. Therefore, in accordance with the requirements of World Bank safeguard policy OP 4.11, the project features the completion of full inventories and safeguard digs on all land affected by the work and the reservoir prior to the reservoir being filled, in order to conserve a representative sample of the artefacts and to safeguard pertinent historical data. The initial results of the archaeological digs are of great interest, as they provide new information on the origins of iron production in sub-Saharan Africa, a subject that remains hotly debated within the scientific community. In fact, it was recently suspected that the very ancient use of iron (3000 - 2500 BC) could be identified in the North West region of the Central African Republic.

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