



Nile Basin Initiative

Regional Power Trade Project

Review of Hydropower Multipurpose Project Coordination Regimes

Best Practice Compendium
June 2008



SWECO 

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LIST OF ACRONYMS AND ABBREVIATIONS

ADB	- Asian Development Bank
AfDB	- African Development bank
BO	- Build and Operate
BOAD	- West African Development Bank
BOO	- Build-Own-Operate
BOOT	- Build-Own-Operate-Transfer
BOT	- Build-Operate-Transfer
COM	- Council of Ministers
DBFO	- Design, Build, Finance, Operate
DIU	- Dam Implementation Unit
DRC	- Democratic Republic of Congo
DRIFT	- Downstream Response to Imposed Flow Transformations
DVC	- Damodar Valley Corporation
EAC	- East African Community
EAPP	- East African Power Pool
ECC	- Environmental Compliance Certificate
EIA	- Environmental Impact Assessment
EMP	- Environmental Management Plan
ENCOM	- Eastern Nile Council of Ministers
ENSAP	- Eastern Nile Subsidiary Action Program
ENSAPT	- Eastern Nile Subsidiary Action Program Team
ENTRO	- Eastern Nile Technical Regional Office
EPC	- Engineering, Procurement and Construction
EPH	- Electric Power of Henan
ESA	- Environmental Study Area
FADES	- Arab Fund for Economic and Social Development
GEF	- Global Environmental Facility
G&L	- Glomma & Laagen
GLB	- Glomma and Laagen Water Management Association
HAD	- High Aswan Dam
IADB	- Inter-American Development Bank
ICOLD	- International Commission of Large Dams
ICS	- Interconnected grid System
IDB	- Islamic Development Bank
IFR	- Instream Flow Requirements
IMF	- International Monetary Fund
IPP	- Independent Power Producer
IUCN	- International Union for Conservation of Nature
JBIC	- Japan Bank for International Cooperation
JEXIM	- Japan Export Import Bank
LHDA	- Lesotho Highlands Development Authority
LHWC	- Lesotho Highlands Water Commission
LHWP	- Lesotho Highlands Water Project
LV	- Lake Victoria
LVB	- Lake Victoria Basin
LVBC	- Lake Victoria Basin Commission
MDB	- Multilateral Development Banks
M&E	- Monitoring and Evaluation
MIGA	- Multilateral Investment Guarantee Agency
MoU	- Memorandum of Understanding
MPP	- Multi Purpose Project
MW	- Megawatt
NBI	- Nile Basin Initiative
NBICOM	- Council of Ministers of NBI
NEL	- Nile Equatorial Lakes

NEL-CU	- Nile Equatorial Lakes Coordination Unit
NELSAP	- Nile Equatorial Lakes Subsidiary Action Program
NGO	- Non-Governmental Organization
Nile-COM	- Nile Council of Ministers
Nile-SEC	- Secretariat of the Nile Basin
NOK	- Norwegian Kroner
NPC	- National Power Corporation
O&M	- Operation and Maintenance
OMVS	- Organisation for the Development of Senegal River
PPA	- Power Purchase Agreement
PPP	- Public-Private Partnership
PMU	- Project Management Unit
PRC	- Peoples Republic of China
RAP	- Resettlement Action Plan
RCU	- Regional Coordination Unit
RPTP	- Regional Power Trade Project
RSA	- Republic of South Africa
SAP	- Subsidiary Action Program
SAPP	- South African Power Pool
SDO	- Social Development Office
SINELAC	- Societe Internationale des Pays des Grand Lacs
SVP	- Shared Vision Program
SPC	- Special Purpose Company
SRMP	- San Roque Multipurpose Project
SRPC	- San Roque Power Corporation
TARDA	- Tana and Athi Rivers Development Authority
TCTA	- Trans Caledon Tunnel Authority
TOR	- Terms of Reference
TRC	- Transforming Resource Center
TSO	- Transmission Systems Operator
UNEP	- United Nations Environmental Programme
USD	- United States Dollar
WB	- World Bank
WWA	- World Water Assessment
YRCC	- Yellow River Conservancy Commission
ZESCO	- Zambia Electricity Supply Company
ZRA	- Zambezi River Authority

FOREWORD

The Review of Hydropower Multipurpose Project Coordination regimes is the result of a literature study based on documents available in NBI-RPTP's library and other literature found on the Internet and from other sources¹. All data refers to these documents. There have been no field studies carried out regarding this paper. The conclusions from the various reports are synthesized and summarized in the compendium and conclusions and recommendations are given on the basis of an analysis of the input from the reports. The Final Report comprises two documents, a "Best Practice Compendium" and an "Issues Paper". A common Executive Summary for the two papers is included in the "Best Practice Compendium". The executive summary has been written in bullet point form for easy usage in decision making.

In this report, the term Multipurpose Project (MPP) is used for project that have more than one use, for example hydropower production and irrigation, regardless if the project was planned for multipurpose or single

The Compendium has been elaborated by Tore Hagen, Leif Lillehammer and Suha Satana and supported by Gerya Güvenc, under the supervision of the RPTP office in Dar es Salaam, with considerable input from the stakeholders that participated in the NBI-RPTP Workshop on the "Review of Hydropower Multipurpose Project Coordination Regimes" held 26th – 28th May 2008 in Dar es Salaam.

¹ However, a big bulk of the data from the LHWP is derived from the consultants own participation in the Lesotho Water Sector Improvement Project.

EXECUTIVE SUMMARY

The Review of Hydropower Multipurpose Project Coordination regimes is the result of a literature study based on documents available in NBI-RPTP's library and other literature found on the Internet and from other sources. The Final Report comprises two documents, a "Best Practice Compendium" and an "Issues Paper". The Executive Summary is common for the two papers and is included in the "Best Practice Compendium". The executive summary has been written in bullet point form for easy usage in decision making, as this is a best practice compendium to be used as such. The issues are highlighted as follows:

Overall principles and issues

Main considerations

- When planning a hydro power plant, multipurpose use should always be considered
- Other use than power generation (irrigation water, general water supply) should contribute to the revenues of a MPP and be part of economic and financial calculation
- Most MPPs are still being funded by the public sector

Cost sharing

- Off-take agreements are some of the main sources of funding from MPPs
- Not all purposes attractive to private sector funding (often users are not charged for irrigation water, water supply does not give high returns)
- If the water pricing profile is not sensitive to user profile, pricing burden might be put on the poor and create conflicts
- A cost-benefit analysis is crucial for maintaining financial support

Some challenges/bottlenecks in the development of MPP Schemes

- The withdrawal of traditional public sector funding from large dam project influences the ability to find financing for MPP
- MPPs are difficult to fund privately as they share many problems with large hydropower projects
- Low creditworthy of various users causes that MPPs often lack financial viability, making it unattractive for private investors
- Multiple beneficiaries result in a complicated and potentially vulnerable contract structure
- MPPs are usually projects with large storage reservoirs that have potentially large environmental impacts and more complex resettlement issues
- Regulatory issues for MPPs are more complex than for hydropower alone
- MPPs has normally limitations in reservoir operation
- Multiple users create Potential water management conflicts

Private participation in MPPs

- Private control over any water project can influence all other downstream projects in the river basin.
- The reluctance of the private sector to get involved with projects because of the involvement of many parties.
- The regulatory controls that would be needed to achieve a sensible balance between the interests of the private investor, the consumer and the host government, are complicated

- The public sector has an even larger role to play than for private hydro in terms of providing funding for projects that may be financially only marginally viable in their entirety, but for which discrete elements may well be viable.
- Most multipurpose projects require dams, and a balanced approach is needed to firstly weigh the benefits and costs, and then to streamline the consultation and permitting process.

Decision making

Planning process

- Participatory planning is obligatory
- Policy, institutional and technical options shall be taken into consideration
- The planning process should start with assessment of needs
- The planning process should end with screening of all options to assess actions

Steps in Ranking of Development Options

- Policy review – Review of Energy policy, legal and administrative frameworks
- Energy needs assessment – Assess needs for energy as well as irrigation, water supply and flood control
- Screening of development options – eliminate those unlikely for implementation
 - Quality and availability
 - Negative social or environmental impacts
 - Cost of firm energy
 - Minimum project size
 - Degree of multipurpose use
- Comparative analysis – Multi criterion analysis incl. multipurpose capabilities and cumulative impacts
- Risk analysis – for each development option (environment, opposition, health, hydrology, climate, financial)

Identification of all options that will meet the needs

- Options may vary widely and include structural and non-structural alternatives
- Supply and demand side management and efficiency measurements should be evaluated
- Pay attention to scale of intervention and time frame
- Options must be sufficiently described (technical, economic, financial, environmental, institutional, and social)
- Provisions for multipurpose planning should be embedded in national and regional legal and regulatory framework
- Introduce strategic environmental assessment with stakeholder involvement

Power Trade

Potential benefits with power trade

- A reduction in operation costs due to economic power exchange;
- Lower investment costs in additional supply due to least-cost development of energy resources from a regional—as opposed to a national perspective;
- Spinning reserve requirements as a proportion of peak load; and coincident peak load relative to average load;
- Water conservation and land protection effects, and from a reduction in greenhouse gas and other pollutant emissions caused by a shift from thermal to hydropower-based generation.

- Hydro-hydro complementarities
 - difference in hydrology and distribution pattern of water runoff over the year for the various plants
 - difference in reservoir capacity between the systems.
- Hydro-thermal complementarities
- Mutual assistance in case of disturbances and maintenance
- Economies of scale in new generating capacity

Regulatory framework

- Liberalization of the power sector is a main objective in the NBI region
- Harmonized legal frameworks is of importance
- Non-harmonized legal framework cause problem for trans-boundary projects and a constraint in attracting investment
- Private sector will prefer to launch projects in countries which have completed the legal reform process
- This might result in a concentration of projects in countries already benefiting from them, instead of attracting investment to underutilized areas

Barriers for Power Trade

- Lack of infrastructure, such as power transmission interconnections, regional/interregional control centers
- Poor performance of state-owned utilities, unable to fully conduct normal commercial activities.
- Long distances and challenging geographical and natural environment.
- Disparity in the countries' power sector size.
- Weaknesses of the national grids, which require strengthening before trading is possible.
- Lack of energy strategies that rely on self-sufficiency.
- Difficulty in obtaining project financing for cross-border transmission interconnections and government guarantees for cross-border deals.
- Lack of a (commercial/legal/regulatory) framework for transactions to take place.
- Lack of agreement on the tariff system to remunerate the use of transmission infrastructure.
- Lack of institutions to give regional trading political legitimacy and to play the coordinating and energy trade enhancement role. Lack or non coordinated legal framework for energy trade.
- Lack of general harmonization of technical codes, specifications and standards.
- Lack of trading mechanisms in the energy sector, which is much more complex than trading of other goods or commodities.
- Lack or scarcity of qualified human resources to manage technical / commercial /regulatory aspects of cross border trading.

Financing

Balance sheet financing

(On)-Balance sheet financing is any form of direct debt or equity funding of a firm. If the funding is equity, it appears on the firm's balance sheet as owners equity. If it is debt, it appears on the balance sheet as a liability. Any asset the firm acquires with the funding also appears on the balance sheet.

- Assets owned by public utility
- Borrowing undertaken by utility/executing agency

- Funding generally a combination of internal resources, government outlays and loans (partly grants/soft terms)
- Funding may or may not be dedicated to a particular project
- Financing raised on the basis of the financial strength or credit rating of utility
- Project cash shortfalls for reimbursement of loans made up by utility

Project Financing

Project financing (or Off-balance sheet financing) , is any form of funding that avoids placing owners' equity, liabilities or assets on a firm's balance sheet. This is generally accomplished by placing those items on some other entity's balance sheet.

- Financing prospects rest mainly on financial strength of project itself
- Requires a separate entity - Special Purpose Company (SPC)
- SPC will, for example build, own, operate and transfer (i.e. BOOT) the assets to the government
- Financed by equity from sponsors and/or loans to SPC
- Loans on commercial terms with possible soft financing for infrastructure components
- Limited recourse – reimbursements of loans from SPC cash flows plus potential guarantees
- Investors in SPC may be the private sector, the public sector , or a mix

Lessons learned

Maximizing Benefits

- Larger multipurpose projects can be as a driving force to establish national and or regional power pools. Specific examples are the Kariba dam and the Glommen and Laagen cascade system. For planned NBI multipurpose projects this is relevant for the Rusumu and Kakono dams complex in western Nile and the Baro, Karadobi and Mendaya complex in Eastern Nile.
- Some of the older projects, e.g. Fincha and Koka dams were originally planned for hydropower only. Later on these have shown to benefit other users as domestic water supply and irrigation. Inclusion of multiple use in the planning process might have benefited other users even more. Thus in future planning of projects mainly for hydropower, all potential multiple uses should be investigated including secondary beneficiaries as for the Kariba dam.
- Larger multipurpose projects, as especially with the case of HAD and the Senegal River Basin Dams, can provide significant contribution to national and regional economies sparking social and economic development, providing a sampler of functions including energy provision.
- River Basin Organizations has proved to be effective institutions in the river basin development especially if there is a firm ownership for physical structures (e.g. multipurpose dams) and regulatory arrangements in place for coordinated operation. In transboundary water management this is of paramount importance, securing that benefits are properly shared between countries, e.g. as in the case of OMVS in Senegal river and in the case of the Lesotho Highlands Water Projects where regulation and management of the joint water resources is regulated by treaties, institutional structures are in place and where joint ownership by the water structures secures benefit sharing between the countries.
- Multipurpose dams have proven successful in flood protection/management and inland navigation. Examples are High Aswan Dam and the dams on Senegal River.

- Plans for development of tourism should be considered during dam planning as these often become tourist attractions and spots for recreation and boating, e.g. as for High Aswan Dam and the Lesotho Highlands dams.
- Most of the dams studied have proven important in development of fisheries and measures to strengthen this should be included in the planning of new dams.
- Along with regional and national grid development, off takes to local grid systems, as for the case of Merowe in Sudan, should be strongly considered when developing multipurpose dams to provide energy to the local areas.
- Developing multipurpose dams in cascades can provide for silt trapping, providing sedimentation benefits to downstream dams.
- Developing multipurpose dams in conjunction with transport infrastructure (bridges, roads etc.), as in the case of Owen Falls and Kariba can increase accessibility thus affecting positively local and regional economies.
- Multipurpose projects provide “clean” energy and can reduce CO2 emissions compared to the development of energy dependant of fossil fuels.
- Proper resettlement as in the case of Xiaolangdi dam can enhance the socio-economics of those people resettled.

Economic benefits from alternative multiple use functions

Water Supply

- *Health benefits due to improved sanitation:* These benefits include avoided expenditure on treatment and care, avoided loss of working days, avoided time due to treatment and avoided death.
- *Consumer benefits:* These include avoided expenditure on chemicals for water treatment, time savings related to water collection, increased property value by tap water installment, savings related to avoided expensive sources of water.
- *Agricultural and industrial benefits:* These benefits include avoided impact of sick workers, time savings, increased income-generating activities, and increased efficiency in land use.

Irrigation

- *Increase in gross national agricultural income:* Irrigated agriculture increases gross national agricultural income significantly. Though implemented irrigation projects could be costly, most of the projects have a high rate of return, resulting in a positive net income.
- *Increase in net farmer income:* Not only the returns from increased agricultural productivity but also increased employment opportunities result in a positive net farmer income.
- *Reduction in dependency on rain-fed water sources for agriculture:* Irrigation increases crop yields as negative effects of seasonality are minimized. Minimizing rain-dependency is an important requirement for the economic development of drought-prone regions.
- *Increase in crop diversity and value of output:* Irrigation enables farmers to diversify crops, especially by introducing of high-yielding cash crops. Farmers may also benefit from multiple harvests through out the year. Irrigation increases both farmer income and the raw materials available for export and industries.

Flood Control

- *Maximized efficiency of use of the catchment:* Flood control not only minimizes flood losses but also enables efficient management of the catchment.
- *Avoided crop losses:* Loss of crops, whether for local consumption or exports, is minimized since agricultural land is secured from flooding.
- *Efficient use of agricultural subsidies:* Whether on inputs such as fertilizer and irrigation water, or on output prices, subsidies help support agricultural production. When the agricultural land is flooded, the subsidies are wasted as there is no economic benefit. Flood control increases the efficient use of subsidies.
- *Improved management of agricultural land markets:* Floods sometimes result in the temporary or permanent removal of agricultural land from production. Flood control stabilizes the supply of agricultural land.

Tourism

- *Additional income for local populations:* Recreational facilities, water sports, food and accommodation areas offer an income-generation option for the local residents. Increased employment opportunities and potential for small business investment enhance the economic activities of the area.
- *Incentives for sustainable management:* When the dam site attracts tourism, it creates an incentive for maintaining environmental sustainability in the area.

Inland navigation

- *Large-load and large-dimension cargo savings:* Larger loads could be carried per barge than highway or rail. It is cost-effective since number of barges decrease as load per barge increase. Volume constraints are also minimized and large-dimension cargo could be shipped easily.
- *Fuel savings:* Railway and especially highway transportation consume more fuel than inland navigation transportation. Fuel savings minimize petroleum-dependency of transportation sector.
- *Transportation cost savings:* When inland navigation becomes safer and risks such as current, ice and changing river levels are lower, transportation costs minimize. This has a positive effect on the volume of trade.

Minimizing Impacts

- Integrated catchment management and protection will reduce environmental impacts in general and siltation problems specifically
- Public participation and increased transparency in all phases will increase the success rate and reduce conflict potential for projects
- Resettlement planning must involve the affected people. This will make resettlement smoother and reduce conflicts
- Resettlement planning should include re-creation of livelihood and long-term planning for the resettled and the host communities
- Good baseline data is necessary for monitoring environmental and social impacts
- Systematically and comprehensive mitigation planning and monitoring will reduce environmental and social impacts
- Flow release from dams to mimic the natural flow regime and mitigating flow variations (seasonally and daily), has shown to improve livelihood and aquatic and riparian ecosystem health
- Good coordination between different multipurpose uses may reduce impacts
- Clear legal and regulatory framework gives better predictability

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- Careful calculation and inter-governmental agreements are necessary to avoid future conflicts
 - Countries already suffering from resettlement issues and conflicts may hesitate to host new projects

Cost and Financing

- Equal ownership of MPPs in transboundary waters, regulated by treaties, will benefit and affect positively the member states of the treaty.
- Such ownership may give member states equal commitment and guarantees for loans, and spark donor involvement for other projects.
- Large MPPs are difficult to finance with private capital only
- Financing models where the water way and power station is financed privately, while the reservoir, dam and spillway is financed publicly, might be a viable option
- If other use of the MPP than power (for instance water for irrigation or domestic supply) is priced commercially, private financing of the whole MPP might be viable

Regional cooperation

- Water supply could emerge as a key motivation for regional integration
- Egypt could play a key role in provision of funding projects in Ethiopia
- Power trade can best be developed in steps; first bi-lateral, then in the sub-regions, and at last for the whole region.
- Analysis shows that sub-regional integration has been more successful than partnerships across the whole NBI region as a whole.
- Geographical and historical context influence power structures among the countries
- Upstream-downstream tension has set different priorities
- Planned transmission line expansion strengthen this trend
- Lack of full integration between the two sub-regions causes limitation on intra-region financing opportunities

Specific issues related to Hydro Power and MPPs

- Difficulty in structuring procurement contracts,
- Potential conflict between the interests of the system and the private developer,
- Unusually high construction risk
- Environmental sensitivity and costs
- High front-end costs
- High proportion of local costs
- Heavily capital-intensive nature
- Long payback periods
- Necessary to agree upon how to share risks for hydrology, construction, geology, capital investment, marketing, production, operation

RÉSUMÉ

Le recensement des différents régimes de coordination des centrales hydro-électriques à usages multiples est le résultat d'une étude documentaire basée sur les travaux disponibles à la bibliothèque du NBI-RPTP et sur des données recueillies par le biais d'Internet ainsi que d'autres sources. Le rapport final comprend deux documents, un recueil méthodologique et un récapitulatif des points litigieux.

Le présent résumé est inclus dans les deux documents. Il est présenté comme un résumé synthétique de points particuliers, pour un usage facile et rapide lorsque des décisions doivent être prises. Les sujets sont présentés comme suit:

Considerations et principes généraux

Considérations principales

- En planifiant une centrale hydroélectrique, l'ensemble des usages possibles de la centrale doit être pris en compte,
- Des utilisations autres que la production d'électricité (irrigation, alimentation en eau des populations, etc.) doivent contribuer aux revenus d'une centrale multi-usages (ci-après dénommées M.P.P – Multi Purpose Plant) et faire partie des considérations économique-financières lors de la conception du projet,
- La plupart des M.P.P. est toujours subventionnée par le secteur public.

Partage des coûts

- Les contrats d'achat sont l'une des sources principales de subventions des M.P.P. Tous les usages des M.P.P. ne sont pas nécessairement attractifs quant à l'obtention de subventions au travers du secteur privé (souvent les particuliers ne paient pas pour l'eau d'irrigation, et l'approvisionnement en eau ne fournit pas des retours sur investissement corrects),
- Si le système d'établissement des prix de l'eau ne tient pas compte du profil des utilisateurs, le système peut défavoriser les pauvres et donc créer des conflits,
- Une analyse des coûts et des rentrées d'argent est cruciale pour le maintien d'un soutien financier.

Quelques défis et obstacles au développement de projets de M.P.P.

- Le retrait des subventions traditionnellement accordées par le secteur public aux grands projets de barrages influe sur la possibilité de trouver des financements pour les M.P.P.,
- Il est difficile de trouver des subventions privées pour les M.P.P. car ils ont beaucoup de problématiques en commun avec les grands projets de centrale hydro-électrique,
- La faible solvabilité de nombreux utilisateurs fait que les M.P.P. ne sont pas complètement viables financièrement, ce qui les rend inattrayantes aux yeux des investisseurs privés,
- Des bénéficiaires multiples induisent un environnement contractuel compliqué et potentiellement vulnérable,
- Les M.P.P. sont généralement des projets impliquant de grands barrages qui ont potentiellement un grand impact écologique et nécessitent des déplacements de population,

- Les regulations nationales autour des M.P.P. sont plus complexes que pour des centrales hydro-electriques simples,
- Les M.P.P. ont generalement des limitations dans la gestion de l'eau des barrages,
- Des utilisateurs multiples peuvent engendrer des conflits dans la gestion de l'eau.

La participation privée dans les M.P.P.

- Un contrôle privé sur n'importe quel barrage peut influencer tous les autres projets en aval dudit barrage,
- Le secteur privé rechigne à s'engager dans des projets lorsque trop de partis sont impliqués,
- Le contrôle des regulations nationales nécessaires à l'obtention d'un équilibre raisonnable entre les intérêts privés, les intérêts du consommateur et ceux du gouvernement hôte est compliqué,
- Le secteur public a un rôle à jouer encore plus grand pour les M.P.P. que pour les installations hydro-electriques privées en ce qui concerne le financement de projets qui peuvent n'être qu'à peine viables financièrement dans leur globalité mais pleinement viables sur certains aspects,
- Les projets de M.P.P. nécessitent des barrages, et une approche saine est imperative pour premièrement peser les avantages et les coûts, et ensuite peaufiner la consultation et les demandes de permis.

La prise de décision

Processus de planification

- La planification participative est obligatoire,
- Les options politiques, institutionnelles et techniques sont prises en considération,
- Le processus de planification devrait commencer par l'évaluation des besoins,
- Le processus de planification devrait se terminer en évoquant toutes les options pour évaluer les actions à entreprendre.

Les étapes du classement des options de développement

- Recapitulatif de la stratégie énergétique ainsi que des cadres légaux et administratifs,
- Evaluation des besoins en énergie, en irrigation, en approvisionnement en eau et en termes de contrôle des crues,
- Enumeration des options de développement : éliminer celles qui ont peu de chances d'être applicables :
 - ✓ Qualité et disponibilité,
 - ✓ Impacts sociaux ou environnementaux négatifs,
 - ✓ Coût de l'énergie qui doit être livrée contractuellement,
 - ✓ Taille minimum du projet,
 - ✓ Degré d'usage multiple.
- Analyse comparative : analyse multi-critères incluant les possibilités d'usage multiple et le cumul des impacts,
- Etude de risques pour chaque option de développement (environnement, opposition, santé, hydrologie, climat, finances).

Identification de toutes les options qui répondront aux besoins

- Les options peuvent varier largement et inclure des alternatives structurelles et non structurelles,
- L'énergie disponible, la consommation électrique prévue et les mesures d'efficacité doivent être évaluées,
- Être attentif à la taille des interventions et au temps alloué,
- Les options doivent être suffisamment détaillées (techniquement, économiquement, financièrement, environnementalement, institutionnellement et socialement),
- Les cadres légaux nationaux et locaux devraient laisser la porte ouverte aux projets multi-usages,
- Introduction d'évaluations environnementales stratégiques avec l'implication des investisseurs privés.

Le commerce énergétique

Les avantages potentiels du commerce énergétique

- Une réduction des coûts opérationnels en raison d'un échange peu onéreux de l'énergie,
- Coûts réduits de l'approvisionnement supplémentaire ponctuel en raison du développement à moindre coût des ressources énergétiques à l'échelle régionale – par opposition à une perspective plus nationale.
- Évaluation de la capacité de production des installations de secours en cas de défaillance des installations principales, et ce en fonction de la demande maximale et en fonction des pics de demandes simultanées par rapport à la demande moyenne.
- Conservation des réserves en eau, protection des territoires et réduction des émissions de gaz à effet de serre et autres polluants par le passage d'une production d'électricité thermique à une production hydro-électrique.
- Complémentarité hydro-hydro :
 - ✓ différences hydrologiques relatives aux bassins versants qui induisent des alimentations variables pour chaque centrale en fonction des saisons.
 - ✓ différences dans la capacité des réservoirs entre les différents systèmes.
- Complémentarités hydro-thermales,
- Assistance mutuelle en cas de dérangements et en cas d'entretien,
- Économies d'ampleur dans les capacités de production nouvelle.

Cadre régulateur

- La libéralisation du secteur de l'énergie est un objectif principal dans la région de NBI (Nile Basin Initiative – Syndicat d'Initiative du Bassin du Nil),
- L'harmonisation des cadres légaux est importante,
- Des cadres légaux non harmonisés posent des problèmes pour les projets trans-frontaliers et tendent à diminuer les investissements,
- Le secteur privé préférera investir dans des pays qui ont finalisé le processus de réforme légale,
- Ceci pourrait avoir pour résultat une concentration des projets dans les pays en profitant déjà au lieu d'attirer des investissements vers des zones sous-utilisées.

Les barrières au commerce energetique

- Le manque d'infrastructure, comme des interconnexions de reseaux electriques ainsi que des centres de contrôle régionaux / interrégionaux,
- Le mauvais fonctionnement des equipements publics, incapables de transporter fiablement de l'electricite a des niveaux de tension classiques.
- De longues distances et un environnement géographique / naturel difficile,
- Des disparites internationales dans la taille et la capacite des reseaux electriques,
- La faiblesse des reseaux nationaux qui doivent être renforces avant que le commerce soit possible,
- L'absence de stratégies energetiques reposant sur l'auto-approvisionnement,
- La difficulté pour obtenir des fonds pour des projets d'interconnexion trans-frontaliere,
- La difficulté pour obtenir des garanties gouvernementales quant aux accords tarifaires inter-pays,
- Le manque de cadre commercial et legal pour les transactions,
- Absence d'accords sur la facon de rémunérer l'usage des reseaux de transmission d'electricite,
- Absence d'institutions qui pourraient donner une légitimité politique au commerce régional et jouer le rôle de coordonnateur et de developpeur du commerce d'énergie. Absence ou non-coordination du cadre légal pour le commerce d'énergie.
- Manque d'harmonisation des codes techniques, des spécifications et des normes.
- Manque de mécanismes commerciaux dans le secteur de l'énergie, qui est beaucoup plus complexe que le commerce d'autres articles ou denrées,
- Absence ou rareté des personnes qualifiées pour gérer les aspects techniques / commerciaux / legaux du commerce transfrontalier d'electricite.

Financement

Financement par bilan financier

Le financement par bilan financier correspond au financement d'une societe par n'importe quelle forme de dette directe ou par l'utilisation de capitaux propres. Si le financement se fait par le biais de capitaux propres, ceci apparaît sur le bilan de l'entreprise comme les capitaux propres du propriétaire. S'il se fait par contraction de dettes, ceci apparaît sur le bilan comme un passif. N'importe quel actif que l'entreprise acquiert avec le financement apparaît aussi sur le bilan :

- Les actifs possédés par la fonction publique,
- Les emprunts contractés par les agences de la fonction publique,
- Le financement est généralement une combinaison de ressources internes et de dépenses et prêts gouvernementaux,
- Le financement peut être dédié ou non a un projet en particulier,
- Le financement est basé sur l'assise financière ou le taux d'endettement des services publics,
- Les manques de liquidités pour le remboursement des emprunts contractés par les services publics.

Financement de projet

Le financement de projet correspond a toute forme de financement qui évite de placer les titres, les responsabilités ou les actifs du propriétaire sur le bilan de l'entreprise. Ceci est généralement réalisé en transférant ces éléments sur le bilan d'une autre entité.

- Les perspectives de financement reposent principalement sur la force financière du projet lui-même
- Necessite une entité séparée, une « Société à But Particulier » (SPC – Special Purpose Company),
- La SPC va par exemple construire, posséder, gérer le projet (par exemple BOOT) puis transmettre les actifs et les biens au gouvernement,
- Financement par capitaux propres des sponsors et/ou par prêts à la SPC,
- Emprunts avec un financement le plus souple possible pour les composants infrastructureux,
- Recours limité – Remboursement des emprunts de la SPC, flux d'espèces et garanties potentielles,
- Les investisseurs dans les SPC peuvent être le secteur privé, le secteur public, ou les deux en même temps.

Retour d'expérience

Maximiser les profits

- De plus grands projets multi-usages peuvent être une source de motivation pour établir des équipes de projet nationales ou régionales. Des exemples spécifiques sont le barrage de Kariba et le système de cascades du Glommen et Laagen. Dans le cadre des projets multi-usages planifiés par NBI, ceci est particulièrement pertinent pour les complexes hydrauliques Rusumu et Kakono sur la partie ouest du Nil et pour les complexes Baro, Karadobi et Mendaya sur la partie est du Nil.
- Certains des anciens projets, par exemple les barrages Fincha et Koka, étaient à l'origine prévus pour fonctionner en centrales hydro-électriques seulement. Plus tard, il s'est avéré qu'ils ont bénéficié d'autres en termes d'approvisionnement en eau et d'irrigation. L'inclusion d'usages multiples dans la conception des projets a profité encore plus à d'autres utilisateurs. C'est pourquoi, dans le cadre de la conception des centrales hydro-électriques, il faudrait examiner l'ensemble des usages possibles y compris les bénéficiaires secondaires comme ce fut le cas pour le barrage de Kariba.
- De plus grands projets multi-usages, comme par exemple le HAD et le barrage-reservoir sur le fleuve Sénégal, peuvent contribuer grandement au développement social et économique de régions voire de pays entiers tout en fournissant des modèles à suivre notamment en ce qui concerne l'approvisionnement en électricité.
- Il s'est avéré que les organismes de gestion des bassins étaient de redoutables développeurs de ces mêmes bassins, particulièrement s'il existait une propriété bien définie des installations (par exemple des barrages multi-usages) et des cadres légaux pour une gestion coordonnée du projet. Dans le cadre d'une gestion trans-frontalière de l'eau, ceci est d'une importance primordiale, car cela garantit un partage équitable des profits entre nations. C'est le cas notamment pour les projets OMVS sur le fleuve Sénégal et le projet hydraulique sur les Hauts Plateaux du Lesotho où la gestion des ressources d'eau communes est régie par des traités, les institutions ad-hoc ont été créées et où une propriété partagée des équipements et structures garantit un partage des profits entre nations.
- Les barrages-reservoirs à usages multiples ont prouvé leur efficacité dans la gestion et la lutte contre les inondations et dans la navigation lacustre / fluviale. Des exemples concrets sont le barrage du Haut Aswan ainsi que les barrages sur le fleuve Sénégal.
- Le développement du tourisme devrait toujours être pris en compte lors de la conception des projets de barrages puisque ceux-ci deviennent souvent des

attractions et des zones dédiées au divertissement et aux sports d'eau, comme c'est le cas pour la retenue du Haut Aswan et des retenues sur les Hauts Plateaux du Lesotho.

- La plupart des barrages étudiés ont montré leur grande influence sur le développement de la pêche, et des mesures pour renforcer cet aspect devraient être incluses lors de la planification de nouveaux barrages.
- Le développement des réseaux de transport électrique ne doit pas seulement se faire à l'échelle régionale et nationale mais aussi à l'échelle locale pour que les populations locales puissent bénéficier du projet. Un exemple concret en est le barrage Merowe au Soudan.
- Le développement de barrages multi-usages en cascade peut favoriser le piégeage des limons, ce qui diminue la sédimentation dans les barrages en aval.
- Le développement des barrages multi-usages en conjonction à celui des infrastructures routières (routes, ponts, etc.) peut augmenter l'accessibilité et donc affecter positivement les économies locales et régionales en question (exemple : chutes Owen et barrage Kariba).
- Les projets multi-usages fournissent une énergie « propre » et réduisent les émissions de CO₂ comparativement aux installations fonctionnant aux énergies fossiles.
- Les populations forcées de déménager pour cause de création de retenue peuvent expérimenter un développement social et économique (exemple : barrage Xiaolangdi).

Les avantages économiques des usages multiples alternatifs

Approvisionnement en eau

- *Avantages sanitaires en raison d'une meilleure potabilité de l'eau* : ces avantages incluent les dépenses évitées sur les hospitalisations et les soins, la perte évitée de jours travaillés et de temps d'hospitalisation ainsi que les morts évitées.
- *Bénéfices pour le consommateur* : ceux-ci incluent la suppression de l'achat de produits chimiques pour le traitement de l'eau, le gain de temps sur l'approvisionnement « traditionnel » en eau, la hausse de la valeur des terrains dus à la présence de réseaux d'adduction d'eau, et les économies relatives aux sources en eau potable onéreuses (puits, pompes, etc.).
- *Bénéfices agricoles et industriels* : ces bénéfices incluent la diminution de l'absentéisme des travailleurs pour cause de maladie, des gains de temps, la hausse des activités génératrices de profits ainsi qu'une efficacité accrue dans l'utilisation des terres.

Irrigation

- *Augmentation du revenu agricole national brut* : une agriculture irriguée augmente le revenu agricole national brut de manière significative. Même si les travaux de mise en place des structures d'irrigation sont onéreux, la plupart ont un très bon retour sur investissement, ce qui crée un revenu net positif.
- *Hausse des revenus des agriculteurs* : une productivité accrue induit aussi plus d'emplois, ce qui renforce les revenus des agriculteurs.
- *Réduction de la dépendance envers les sources d'eau liées à la pluviométrie* : l'irrigation augmente les récoltes par réduction de l'effet des saisons. La réduction de la dépendance envers la pluie est une condition importante pour le développement économique de régions sujettes à la sécheresse.

- *Hausse de la diversite des cultures et des possibilites de gain economique* : l'irrigation permet aux agriculteurs de diversifier les cultures, specialement par l'introduction de varietes a haute resistance et a haute productivite. Ils peuvent aussi beneficier de plusieurs recoltes par an. L'irrigation augmente en même temps les revenus de l'agriculteur et les quantites de fruits / legumes disponibles pour l'industrie voire l'export.

Controle des crues

- *Efficacité maximale des captages d'eau* : le controle des crues minimise non seulement les degats dûs aux inondations mais rend aussi possible une gestion efficace des captage.
- *Pertes de recoltes evitees* : les pertes de recoltes, qu'elles soient destinees a une consommation locale ou a l'export, sont minimisees puisque les terres cultivees sont a l'abri des crues.
- *Utilisation optimisee des aides aux agriculteurs* : que ce soit sur les charges (fertilisants, eau d'irrigation, etc.) ou sur les prix finaux, les aides soutiennent la production agricole. Quand les terres cultivables sont inondees, les aides sont gachees puisqu'il n'y a plus de benefice economique. Le controle des crues augmente donc l'utilisation efficace des aides.
- *Gestion amelioree du volume de terres cultivables* : les inondations induisent parfois un abandon temporaire ou definitif de terres cultivables. Le contrôle des crues stabilise donc le volume de terres destinees a l'agriculture.

Tourisme

- *Un revenu supplémentaire pour les populations locales* : Les installations touristiques, les infrastructures pour sports nautiques, les restaurants et les hotels offrent des options pour la creation de revenus supplementaires pour les locaux. Des emplois supplementaires et un besoin de petits commerces améliore l'économie de la region.
- *Un encouragement au developpement durable* : quand le barrage attire le tourisme, il encourage au developpement durable environnemental.

Navigation intérieure

- *Economies avec l'emploi de bateaux* : les cargaisons embarquees sur bateau sont plus grandes que celles acheminees par camion ou par train. Ceci est rentable puisque le nombre de bateaux diminue inversement proportionnellement a leur taille. Les contraintes de volume sont aussi minimisees et des cargaisons de grandes dimensions peuvent être facilement transportees.
- *Economies de carburant* : le train et particulierement l'autoroute consomment plus de gazole que la navigation en interieur sur fleuves / rivières / retenues. Les economies en carburant ainsi realisees diminuent la dependance au petrole du secteur des transports.
- *Economies sur les coûts de transport* : quand la navigation intérieure devient plus sûre et que des risques comme les courants, la glace et les variations intempestives de niveau des rivières disparaissent, les coûts de transport diminuent. Ceci a un effet positif sur l'activite commerciale dans la region.

Minimisation des Impacts

- La gestion intégrée des captages et leur protection réduisent les impacts environnementaux en général et les problèmes de sedimentation en particulier.

- La participation des organismes publics et une transparence accrue dans toutes les phases augmentera le taux de réussite et réduira le potentiel de conflit autour des projets.
- La planification des déplacements de populations doit impliquer les personnes affectées. Cela rendra les opérations plus simples et réduira les conflits.
- La planification des déplacements de populations doit inclure l'étude à long terme des moyens de subsistance offerts aux personnes déplacées ainsi que leur intégration aux communautés hôtes.
- Un niveau de référence est nécessaire pour évaluer les impacts écologiques et sociaux,
- Une prévision et un suivi systématiques et détaillés réduiront les impacts écologiques et sociaux.
- Des lâchers d'eau pour simuler les variations saisonnières et journalières d'écoulement des fleuves permettent de préserver voire de consolider les divers écosystèmes.
- Une bonne coordination entre les différentes utilisations des M.P.P. peut réduire les impacts.
- Un cadre légal clair donne une meilleure prévisibilité.
- Des calculs soignés ainsi que des accords inter-gouvernementaux sont nécessaires pour éviter des conflits futurs.
- Les pays ayant déjà rencontré les problèmes et conflits engendrés par les déplacements de populations peuvent hésiter à accueillir de nouveaux projets.

Coûts et financement

- La possession à parts égales de M.P.P. dans les eaux communes, réglementée par des traités, profitera et affectera positivement les états signataires du traité.
- Une telle possession peut provoquer chez les états signataires un réel engagement et donner des garanties pour les emprunts, et provoquer l'implication d'investisseurs pour d'autres projets.
- Les grandes M.P.P. sont difficiles à financer avec des capitaux privés seulement.
- Des modèles de financement où la centrale hydro-électrique est financée par des fonds privés et le réservoir, le barrage et le déversoir sont financés par les organes publics, pourraient être des options viables.
- Si des utilisations alternatives à la production d'électricité ont été tarifées pour une M.P.P. (par exemple l'irrigation ou l'approvisionnement en eau), le financement privé d'une M.P.P. entière peut être viable.

Coopération régionale

- L'approvisionnement en eau peut apparaître comme une motivation clé pour l'intégration régionale.
- L'Égypte pourrait jouer un rôle clé dans la subvention de projets en Éthiopie.
- Le commerce d'énergie ne se développe bien que par étapes successives : d'abord bi-lateral, puis dans les sous-régions, et enfin pour la région entière.
- Une analyse montre que l'intégration sous-régionale réussit mieux que les partenariats à travers la région du NBI dans son ensemble.
- Les contextes géographiques et historiques influencent les structures énergétiques entre pays.
- Les tensions amont-aval induisent différentes priorités.
- Le renforcement du réseau de transmission électrique fortifie cette tendance.

- Le manque d'intégration totale entre les deux sous-regions freine le financement intra-régional.

Les problèmes spécifiques a l'énergie hydro-electrique et aux M.P.P.

- La difficulté pour structurer les contrats d'acquisition
- Conflit d'intérêts potentiel entre les interets du système et ceux de l'entrepreneur privé
- Risque inhabituellement haut concernant la construction
- Sensibilité environnementale et coûts
- Grands coûts frontaux
- Haute proportion de coûts locaux
- Grande dependance vis a vis des capitaux
- Retour sur investissement effectif apres de tres longues periodes
- Necessite de s'accorder sur le partage des risques lies a l'hydrologie, la construction, la géologie, l'investissement des capitaux, le marketing, la production et la gestion / supervision des installations

1. INTRODUCTION AND BACKGROUND

1.1 The Nile Basin Initiative

The Nile Basin Initiative (NBI) is a partnership of the riparian states of the Nile² (see also figure 1.1). The NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security. The NBI started with a participatory process of dialogue among the riparian states that resulted in the agreement on a shared vision; to “achieve substantial socioeconomic development through equitable utilization of, and benefit from, the common Nile basin water resources”, and a Strategic Action Program to translate this vision into specific activities and projects³.



Figure 1.1. The River Nile with some of its major structures (Source: NBI/WB)

² The Nile riparian countries include Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. Eritrea is currently in the NBI as an observer.

³ Nile Council of Ministers, Policy Guidelines for the Nile Basin Strategic Action Program, February 1999

1.2 Strategic Action Program

The NBI's Strategic Action Program is made up of two complementary programs. The basin-wide *Shared Vision Program* (SVP); to build confidence and capacity across the basin, and the Subsidiary Action Program (SAP); to initiate concrete investments and action on the ground at sub-basin levels. The programs are reinforcing in nature. The SVP, which focuses on building regional institutions, capacity and trust, lays the foundation for unlocking the development potential of the Nile, which can be realized through the SAP. These investment-oriented programs are currently under preparation and implementation in the Eastern Nile and the Nile Equatorial Lakes Regions (ENSAP and NELSAP). The SVP includes seven thematic projects related to environment, power trade, agriculture, water resources planning and management, applied training, communication and stakeholder involvement, and macro-economics. An eighth project, the SVP Coordination Project, aims at building capacity at the NBI secretariat for program execution and coordination. The SVP is being executed by the Secretariat of the Nile Basin (Nile-SEC) on behalf of the Nile Council of Ministers⁴ (Nile-COM). In executing the program, the NBI is supported by a Technical Advisory Committee drawn from participating member countries.

1.3 The Eastern Nile Subsidiary Action Program (ENSAP)

The Eastern Nile Subsidiary Action Program (ENSAP) is an investment program by the Governments of Egypt, Ethiopia and the Sudan under the umbrella of the Nile Basin Initiative (NBI). It is led by the Eastern Nile Council of Ministers (ENCOM), comprised of the Water Ministers in the three Eastern Nile countries, and an ENSAP Team (ENSAPT) formed of three technical country teams. The objective of ENSAP is to achieve joint action on the ground to promote poverty alleviation, economic growth and reversal of environmental degradation. Management and coordination for the preparation of ENSAP projects is undertaken by The Eastern Nile Technical Regional Office (ENTRO) in Addis Ababa, Ethiopia. ENTRO also capacitate and strengthen institutions and provides secretariat support to ENCOM/ENSAPT. ENTRO has a Social development Office (SDO) that supports all ENSAP projects through: capacity building in social development, input to project design, formulation of guidelines, initiation of pilot and background studies and analysis.

1.4 Nile Equatorial Lakes Subsidiary Action program (NELSAP)

The Nile Equatorial Lakes Subsidiary Action program's (NELSAP) mission it to contribute to the eradication of poverty, to promote economic growth, and to reverse environmental degradation in the NEL region. NELSAP oversees implementation of the jointly identified SAPs and promotes cooperative inter-country and in country investment projects related to the common use of the Nile Basin water resources.

The Nile Equatorial Lakes region includes the six countries in the southern portion of the Nile Basin—Burundi, Democratic Republic of Congo, Kenya, Rwanda, Tanzania and Uganda—as well as the downstream riparians Egypt and Sudan. NELSAP is expected to be a long-term program, with multiplier effects in broader economic integration as the program shows results on the ground. Facilitation of project preparation and implementation is undertaken by the NELSAP Coordination Unit, NEL-CU.

1.5 The Nile Basin Regional Power Trade Project

The Nile Basin Regional Trade Project (RPTP) is one of eight projects implemented under the SVP of the NBI. The project aims to facilitate the development of the

⁴ Ministers in charge of water affairs in the Nile Basin member states.

regional power markets among the nine Nile Basin Initiative countries and build analytical capacity to manage the Nile Basin Resources in keeping the Vision articulated by the Nile riparian's.

Cheap and reliable supply of electricity is a critical input for economic growth, employment generation and poverty alleviation. As such, the long term objective of the Nile Basin RPTP is to contribute to poverty reduction in the region by assisting the NBI countries in developing the tools for improving access to reliable, low cost, sustainably generated power. An important element in achieving this goal is to create a conducive environment for the facilitation of power markets and trade opportunities among the countries participating in the Nile Basin Initiative. The creation of a regional electricity market can play a key role in furthering cooperation among the Nile Basin states and in ensuring that the hydropower resources of the Nile Basin are developed and managed in an integrated and sustainable manner. The preceding and necessary condition for the power trade and power markets development is the creation of bilateral or multilateral tie lines among some or all of the NBI countries.

The Regional Power Trade Project is expected to deliver against the following two results:

- (i) ***Deliver Technical Assistance;*** focused on providing the countries with tangible results for achieving compatibility in the policy and regulatory environment, establishing common technical operating standards and access rules, and fostering the appropriate framework within which trade can occur. This will include providing training, commissioning key studies, as well as promoting dialogue between the key players in the region.
- (ii) ***Facilitate infrastructure development for power trade;*** by promoting key regional investments, particularly backbone interconnections, in coordination with the SAP and organizing investment seminars, among others.

2. OBJECTIVES, METHODOLOGY AND OUTPUT

2.1 Objectives of the study

The main objectives of the Review of Hydropower Multipurpose Project Coordination Regimes, under the RPTP, are:

- (i) Conduct a Review of NBI documents, including documents of multipurpose projects being undertaken under the two sub-regions of NELSAP and ENSAP.
- (ii) Global survey of power and non-power multipurpose regional projects that have integrated hydropower with water resources management and planning at regional level,

2.2 General approach

The consultant has assisted the PMU and PTC in the review of case studies relevant to hydropower development and water resources management, which is the basis in preparation of this compendium for *best practices in multi-purpose coordination regimes*. In this process we have chosen to approach the work as follows:

During the Inception Phase, the consultants worked at the PMU's office in Dar es Salaam in order to obtain the best possible understanding of the Client's expectation to the form of the compendium and the review, and to collect all available information about projects and coordination regimes available. Projects to be studied further and additional information needed were identified.

This together with the following stakeholder consultations through e-mail and phone provided the template for preparing the compendium on best practice multipurpose regimes as well as the issues paper outlining the potential for developing such regimes in the Eastern Nile and Nile Equatorial Lakes Sub-Basin. The draft compendium and issues paper thus will be discussed at a workshop at the Client's premises. Beforehand the workshop the documents will be circulated to the workshop participants and stakeholders.

After comments from the stakeholders in general and the workshop participants in particular, the final report will be prepared.

For the whole project process, the Consultants appreciate the necessity of a close cooperation and contact with the Client.

Specifically the work was/is divided into the tasks as seen below:

- (i) Inception studies and primary data collection.
- (ii) Review of Nile Basin Initiative documents in general and multipurpose project coordination regimes currently practiced in regional projects in the Nile basin.
- (iii) Conduct a global review of power and non-power coordination regimes of regional organizations that have efficiently integrated hydropower and non-hydropower operations with water resources management in the efficient operations of an interconnected regional power grid.
- (iv) Preparation and presentation of a compendium of best practices in multipurpose coordination regimes for projects integrating hydropower and non-hydropower development with water resources management, to a workshop of power and non power experts. Preparation of a detailed issues paper outlining

- the potential for developing multipurpose coordination regimes in the Eastern Nile and the Equatorial Lakes sub-basin.
- (v) To address all comments and clarifications sought by the power and non-power experts during a regional workshop.
 - (vi) To provide inputs to other studies running in parallel within the NBI.
 - (vii) Final Report

2.3 Literature Review and Information Collection

The Inception Report was based on reviewed information available from RPTP Secretariat. Secondary data largely came from the Consultants own experience and from various relevant sources on the Internet.

2.3.1 Objective

The objective of this task was to make all necessary and relevant data available, ready for review and analyses. Specific data included NBI overview reports, project appraisal documents, project implementation plans, SVP project documents and any other documents related to ongoing projects in the Nile Basin. Also, information from other sources, which outline similar roles, was collected.

2.3.2 Methodology

The Consultant collected all information available in the Client's office. In cooperation with the Client, the power and non-power coordination regimes within the NBI countries which should be reviewed further were identified.

Internet and other relevant sources was used to scan relevant international coordination regimes to be reviewed further and a select set of projects for closer review was decided upon together with the client. The methodology for selection of the most relevant projects will be revisited and updated in cooperation with the Client.

Focus was on examples from Africa (Senegal river, Lesotho Highlands, Kariba) together with other examples that specifically could shed light on lessons learned (e.g. public private partnership from Philippines etc.).

2.4 Review and analysis of all NBI and other selected multipurpose project coordination regimes

2.4.1 Objective

The objective of this task was to review all collected case studies and sort out the best ones to be analyzed and utilized as best practices examples for the Best Practice Compendium.

2.4.2 Methodology

Documents will be reviewed and analyzed related to degree of relevance for a Good Practice compendium. Ongoing projects under the SAP and SVP will also be thoroughly reviewed and analyzed. Project owners will be contacted by e-mail and telephone if additional information is required.

In consultation with the PMU and PTC, the consultant reviewed thoroughly all NBI documents, particularly the project appraisals, project implementation plan, general NBI overview reports, shared vision program documents and all information on related ongoing regional projects in the Nile basin.

The consultant also reviewed the select set of relevant global multipurpose coordination regimes decided upon together with the Client during the inception phase.

Focus was put on analyzing the costs, benefits and impacts, mitigation, participation and compliance with today's standards, and the differences between expected and actual values of these parameters. Where possible, trends was traced and compared to other projects and other areas.

A synthesis of best practice and lessons learned from the selected existing projects from the NBI counties and global projects, followed by recommendation how experiences from these projects can be used for the selected planned projects and other areas was then undertaken.

Selected parameters and criteria were:

Dam functions

- Energy production
- Irrigation
- Water Supply
- Flood control
- Environmental benefits
- Recreation
- Inland navigation
- Fisheries
- Transport links (e.g in the case of the road/bridge at Owen Falls)

Dam impacts and mitigation:

- Environmental impacts (ecosystems, flora, fauna, biodiversity etc.)
- Sediment and catchment management
- Downstream affected people
- Relocation and resettlement
- Participatory process

Unexpected costs, benefits and impacts that were not predicted during the planning but are detected after was also evaluated.

2.5 Finalization of the Compendium of Best Practices and Organization of a Workshop

2.5.1 Objective

The objective of this task was to finalize the best practice compendium and the issues paper outlining the potential for developing such regimes in the Eastern Nile and Nile Equatorial Lakes sub-basin.

2.5.2 Methodology

Beforehand the workshop the best practice compendium and the issues paper was discussed with the Client. This was followed by finalization of draft documents that was circulated to the stakeholders that participated in the workshop⁵ of 26-28th of

⁵ Nile Basin Initiative – RPTP, Workshop on the “Review of Hydropower Multipurpose Project Coordination Regimes” 26-28th May 2008.

May 2008. The documents were presented in the workshop and underwent stakeholder discussion and recommendation. Questions and suggestions from the workshop participants was addressed and worked into the final document.

2.6 Major outputs of the study

- (i) Inception Report
- (ii) A compendium of best practices in multipurpose coordination regimes for projects integrating hydropower development with water resources management, and preparation of an issues paper outlining in details how such regimes can be implemented in the ENSAP and NELSAP sub-regions,
- (iii) A final report of the assignment to the Power Technical Committee at a workshop organized by the PMU.

3. CONCEPT OF MULTIPURPOSE PROJECTS

3.1 Overview⁶

Approximately 30% of large dams (using the ICOLD definition) are for multipurpose use. The different functions are listed below (percentages given below should be read as % among other uses):

- Irrigation 48%
- Electricity generation 36%
- Water supply 36%
- Flood control 39%
- Recreation 24%
- Inland navigation 5%
- Fishing 5%

A multipurpose dam is a dam that provides more than one of these functions, whether planned or if additional functions have been attributed it after planning and construction. The figures (percentages) given in functions above is a general world wide picture and would of course differ for the functions of dams in Africa, let alone the Nile Basin states and the Nile Basin as a whole where irrigation, electricity and water supply would be of great importance followed by flood control and inland navigation on the Nile and its tributaries. Recreation is normally not a highly utilized function of dams in Africa, although many have great potentials for it, for example boating and associated tourism at the Lesotho highlands structures (Lesotho IWRM Strategy 2007).



Figure 3.1. The reservoirs of the Lesotho Highlands system is a tourist attraction, including at for potential recreation.

(Source: *Khaketla 2005*).

⁶ Derived extensively from Head (1999), but adjusted for relevance in the Nile basin.

In practice some of these functions, such as inland navigation and fishing, tend to be a secondary utilisation of a reservoir that already exists for another primary purpose such as irrigation, electricity generation or water supply. It is this primary purpose that dictates the financing arrangements of multipurpose dams.

With the exception of electricity generation, water supply and (sometimes) irrigation, the above functions tend to fall within the "non-commercial" category as far as the provision of storage is concerned. That is to say that it is relatively unusual for a dam to be promoted primarily for flood control, fishing and navigation although these may be useful spin-offs.

In most countries irrigation water is seldom priced at its full supply cost, and although there are many commercially viable private irrigation schemes around the world, there are equally many publicly owned irrigation projects which do not fully bear their direct cost in financial terms but are nevertheless economically justified. Irrigation projects in the private sector tend to be centrally managed estates growing high value cash crops. In the public sector the situation is more mixed, with many schemes being managed on a smallholder basis, often growing relatively low-value crops. The public and private sectors tend to be quite separate and there is not the same fundamental shift to financing occurring in the irrigation sector as in the power industry, at least at present.

On the other hand the water supply industry is being privatised and therefore, to a degree, the issues that arise are similar to those for hydropower. This is an issue that should be highlighted in the further identification of promising multipurpose regimes in the Nile Basin states. The quantities required for water supply are relatively small, and the market value of the commodity high, so the problem of financing is less critical. Furthermore the asset represented by the dam is typically only a small proportion of the total value of any water supply scheme.

Experience has shown that flood control is usually difficult to justify as the sole reason for building a large dam, and typically it tends to be treated as an (often unquantified) additional economic benefit to be added to the overall benefits of a dam whose primary function is hydropower or irrigation. In the operation of such a dam there is often a trade-off to be achieved between the interests of flood attenuation which requires the reservoir level to be held down at certain times of the year so that buffer storage is available, and the irrigation/hydropower interest which will generally be seeking to maintain a full reservoir for security of supply. Thus, for existing and planned dams in the Nile basin, there can be a conflict of interest related to the contractual obligations at stake in view of power trade as well as the dispatching rules for the operation of the dams. Further, it is not unusual to find that the provision of flood attenuation storage in the reservoir can only be achieved by sacrificing some of the hydropower benefits, which may well represent a larger overall economic loss but a socially justified position. Thus it is of importance for multipurpose dams to identify the net head that can be utilized during flood and non-flood periods, which are feasible within the trade off regimes.

Reservoirs are increasingly being used for recreational purposes, although not so much in Africa and the Nile basin, and it would only be in extremely rare cases that this is the primary purpose of the dam and the basis upon which it is funded. The same would be true for fish breeding, the most common application being in small farm dams (basically intended for irrigation) in the Far East.

A small number of reservoirs are used to maintain the water supply to canals for inland navigation. In practice very few of these are likely to be built in the future, and anyway the issue of financing is unlikely to be a central issue because of the relatively small cost as a proportion of the total asset value of the navigation. In summary therefore the financing of multipurpose dams tends to hinge around the primary functions of hydropower, irrigation and water supply.

Anyhow, for many multipurpose dams, especially the large ones, at any given time, there may be a huge number of possible options for use of the resource. The need to consider multiple, and often conflicting, objectives for a large number of stakeholders, and across a broad spectrum of scales, means that a huge sampler of decision variables and constraints may need to be considered along with anticipated impacts and benefits. An example of the complexity is given in the illustration below.

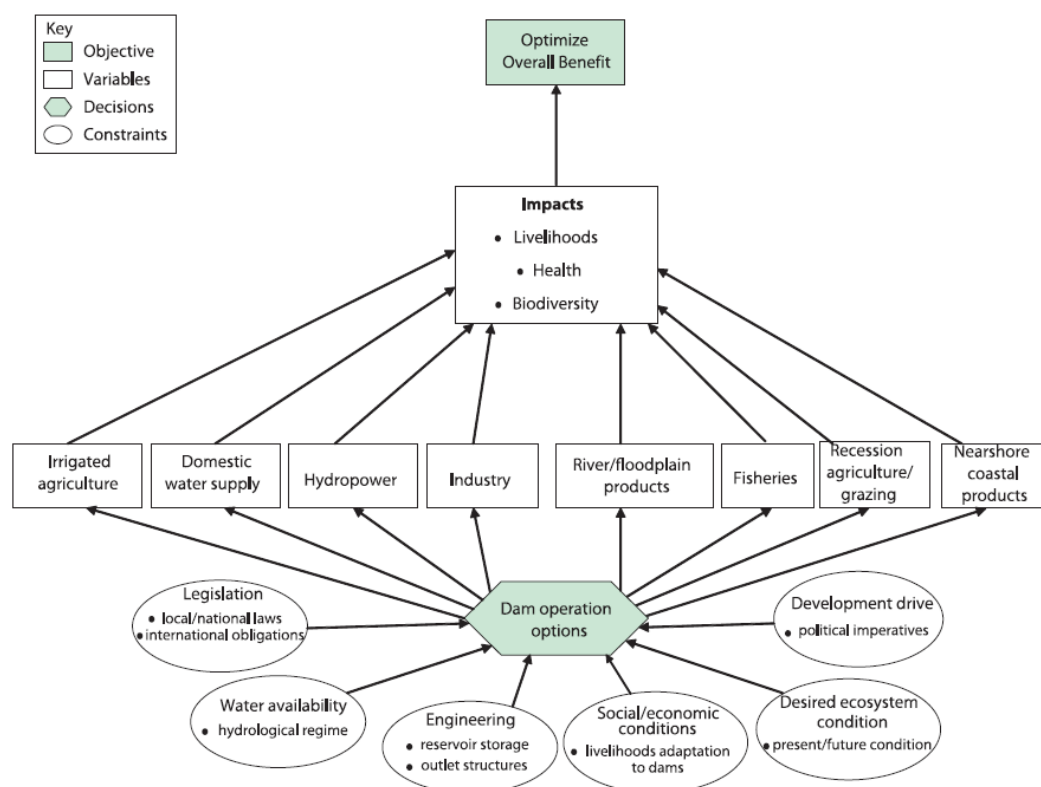


Figure 3.2. An example of the possible complex use of large multipurpose dams with associated interlinked issues, impacts and benefits

(Source: McCartney 2007).

3.2 Main Considerations

In terms of financing, most multipurpose dams still lie firmly in the public sector funded, at least in the developing world, through the ILAs on a long-term concessional basis. Although such schemes will not be immune from the wider pressures towards privatisation of infrastructure development, multipurpose projects are difficult to fund privately because they share many of the problems of hydropower (section 3.1) and, in addition, have the following factors to take into account:

- i) Potential water management conflicts.

- ii) They are usually reservoir projects.
- iii) Multiple beneficiaries result in a complicated and potentially vulnerable contract structure.
- iv) Lack of financial viability.

From the host government's viewpoint the regulatory issues are more severe than for hydro alone, because a multipurpose project can exercise control over a large area of the river basin in terms of determining downstream flow patterns and water availability. The situation is complicated because of the necessity to protect not only the position of existing projects but also the rights of future projects yet to be developed.

Thus water rights issues are almost always sensitive and loom particularly large because no government can afford to commit itself for a long period to methods of reservoir operation which it may subsequently wish to change. Yet to the private owner the limits with which he is free to operate the reservoir and use water will be crucial to the income of the project and the profitability of his investment.

Against this background it is not surprising that there have been very few privately financed multipurpose schemes. One of the few exceptions is the Cascecan Transfer Project in the Philippines which is described later.

3.3 Trends in the Development of Multipurpose Schemes

In the past most multipurpose projects were implemented by the public power utility or, to a lesser extent, the water utility or a public agency responsible for irrigation development. In many cases the power benefits effectively underwrote the financial viability of the project, while the multipurpose benefits allowed access to more concessional financing that might otherwise have been available for a power-only project. A further factor was that in many countries the power utility had more experience and capability in implementing large capital works projects.

However this approach of a single-purpose agency, like the power utility, developing a multipurpose project gives rise to problems. There are inevitable rivalries and conflicts of interest between the different water users, and projects were often plagued by the lack of a cohesive approach. There is a growing recognition that planning considerations extend far beyond the interests of a single project, and needs to be viewed at the river basin or even the national level.

It is now widely accepted that the river basin is the natural planning unit for water resources developments. In consequence many river basin development authorities have been established over the last two decades, particularly in the parts of the world where the development processes still has far to run. The Tana and Athi Rivers Development Authority (TARDA) in Kenya is an example: founded in the mid-1970s it has responsibility for planning and coordinating all water-related developments in a catchment that provides most of the country's power and irrigation potential and water supply to the local communities through Masinga Dam. However TARDA only implements multipurpose projects and technically supports the ancillary activities such as irrigation, catchment protection, etc while leaving the single purpose project components such as power generation to the government agencies concerned. Comparable arrangement, although slightly different with amongst others transboundary issues, can also be found elsewhere in Africa, for example the

Lesotho Highlands Water Project (LHWP) and the Organization for the Development of Senegal River (OMVS) described in detail in Chapter 6.4 and 6.6 respectively.

The basin wide approach is being repeated elsewhere for the large multipurpose projects, although in practice there has been, as for hydro, a significant downturn in new starts, due to:

- The withdrawal of traditional sources of public sector funding, particularly for large dam projects. However a shift in this is now slowly evolving, and large dams are being seen more and more as a solution to the problems related to climate change (floods, droughts), amongst others. This has for example been highlighted in the Lesotho IWRM Strategy.
- The complexity of launching multipurpose projects in the private sector (regulatory issues).
- The relative unattractiveness of most multipurpose projects to private investors because they often depend upon accruing "benefits" from a number of water-users, most of whom will not be creditworthy.
- The fact that under privatisation, the power and water utilities are no longer able or interested in promoting projects which are not immediately beneficial to their core activities.
- Most significant multipurpose projects involve large storage reservoirs which are facing opposition due to its environmental impacts.
- There are often legal and regulatory difficulties of implementing and operating multipurpose dams whose benefits spread beyond the borders, given the fact that the national legal and regulatory system can diverge affecting the management differently.

3.4 Emerging Financing Models

There are very few privately financed multipurpose projects. However, some few examples have proved that under favorable conditions multipurpose projects are financeable in the private sector, but most will still rely heavily on public sector funding, either partially or completely. In the long term the solution to the problem of attracting private finance to multipurpose projects probably lies in some form of public-private partnership.

Thus, the key financing issues arising from the trends in multipurpose project financing are (Head 2000):

- The willingness (or otherwise) of host governments to allow private control over any strategically important water project which can influence all other downstream projects in the river basin. This issue will be different from project to project and must be addressed in negotiations regarding concession agreement between the developer and the host government.
- The reluctance of the private sector to get involved with projects that it views as being complicated because of the involvement of many parties.
- The regulatory controls that would be needed to achieve a sensible balance between the interests of the private investor, the consumer and the host government is complicated and not easily replicable from project to project.
- The public sector has an even larger role to play than for private hydro in terms of providing funding for projects that may be financially only marginally viable in their entirety, but for which discrete elements may well be viable.
- Most multipurpose projects require dams, and a balanced approach is needed to firstly weigh the benefits and disbenefits, and then to streamline the consultation

and permitting process. Without such clearance already in place, the private investor will not be attracted.

3.5 Economic Benefits of Multipurpose dams

The economic benefits of multipurpose dams spans a variety of functions, **besides the obvious benefits of hydropower**, often in a diversity of ways. Below are assessments of the economic benefit for some major functions with some examples to highlight the various issues at stake.

3.5.1 Water supply

Water supply benefits various sectors from health to agriculture:

- **Health benefits due to improved sanitation:** These benefits include avoided expenditure on treatment and care, avoided loss of working days, avoided time due to treatment and avoided death. A study conducted by WHO in 2004 on water supply and sanitation (WSS) states that, every USD 1 spent on WSS to meet MDG goals in the field generates USD 3 to 34 in economic benefits, depending on the region⁷. We can surmise that the average return would hence be in the order about US\$ 15 for every dollar spent, corresponding to a C/B ratio of 15. It is possible to infer that this type of very high return on investment would generate an internal rate of return which would often exceed 1000 percent.
- **Consumer benefits:** These include avoided expenditure on chemicals for water treatment, time savings related to water collection, increased property value by tap water instalment, savings related to avoided expensive sources of water.
- **Agricultural and industrial benefits:** These benefits include avoided impact of sick workers, time savings, increased income-generating activities, and increased efficiency in land use.

Table 3.1 summarizes the economic benefits of improvement in water supply and sanitation, from a health-focused perspective.

Table 3.1. Economic benefits of improving water supply & sanitation

BENEFICIARY	Direct economic benefit of avoiding diarrhea disease	Indirect economic benefits related to health improvement	Non-health benefits related to water-sanitation improvement
Health sector	Less expenditure on treatment	Value of less health workers falling sick	More carefully managed environment and effect on vectors
Patients	<ul style="list-style-type: none"> • Less expenditure on treatment & related cost • Less expenditure on transport seeking treatment • Less time loss due to treatment seeking 	<ul style="list-style-type: none"> • Value of avoided loss of days at work or school • Value of avoided time loss of care for sick babies • Value of loss of death avoided 	More carefully managed environment and effect on vector
Consumers		Value of less use of chemicals and filters to	<ul style="list-style-type: none"> • Time savings related to water collection or

⁷ Making Water a Part of Economic Development, a report commission by the governments of Norway and Sweden, Commission on Sustainable Development, 2004

		clean water	accessing sanitary facilities <ul style="list-style-type: none"> • Labor-saving devices in the household • Switch away from more expensive water sources • Property value rise • Leisure activities and non-use value
Agricultural and industrial sectors	Less expenditure on treatment of employees with the disease	Less productivity impact of workers being sick	<ul style="list-style-type: none"> • Time-saving and income generating technologies • Land use changes

Source: *Making Water a Part of Economic Development*, a report commission by the governments of Norway and Sweden, Commission on Sustainable Development, 2004

3.5.2 Irrigation

Irrigated agriculture, in the drive for food security, accounts for 70 percent of water withdrawals in water stressed regions. Secure access to irrigation is an important component of food security and agricultural products as primary source of export revenue for developing countries. Benefits of irrigation could be listed as:

- **Increase in gross national agricultural income:** Irrigated agriculture increases gross national agricultural income significantly. Though implemented irrigation projects could be costly, most of the projects have a high rate of return, resulting in a positive net income.
- **Increase in net farmer income:** Not only the returns from increased agricultural productivity but also increased employment opportunities result in a positive net farmer income.
- **Reduction in dependency on rain-fed water sources for agriculture:** Irrigation increases crop yields as negative effects of seasonality are minimized. Minimizing rain-dependency is an important requirement for the economic development of drought-prone regions.
- **Increase in crop diversity and value of output:** Irrigation enables farmers to diversify crops, especially by introducing of high-yielding cash crops. Farmers may also benefit from multiple harvests through out the year. Irrigation increases both farmer income and the raw materials available for export and industries.

The Turkish case

In Turkey, it is estimated that, by expanding irrigated agriculture, gross national agricultural income increases by 5 fold. This was based on observations that on average agricultural income of 60 YTL/decare (dry crops) increased to 310 YTL/decare after switching to irrigation. This five fold increase in gross income would correspond to at least doubling of net farmer income, which in turn would correspond to a very high rate of return on the investment, often exceeding 50%.

Choosing the right project: In Turkey, criteria for setting priorities among competing irrigation projects are as follows:

Table 3.2. Criteria for setting priorities among competing irrigation projects

Criteria	Why?
Confirmed demand for irrigation from the farmers	<ul style="list-style-type: none"> • Farmers should agree to pay back 100% of the cost of the investment in small installments spread over a long period. • It is important to ensure that water use and management will be handled in a participatory manner, where farmers pay 100% the O&M costs
Ensuring the availability of a secure water source	<ul style="list-style-type: none"> • Dams are secure sources of water all through out the year and finance of the irrigation infrastructure requirement could be handled by PPP. • This also applies to multi-purpose dams in the NBI which are low cost sources of water supply for irrigation.
Technical possibility of supplying water by gravity irrigation	<ul style="list-style-type: none"> • Gravity irrigation is both less expensive and easier to manage than pump irrigation. This should be encouraged and all technical means exhausted prior to considering pump irrigation.
Completion of land consolidation on the irrigation command area	<ul style="list-style-type: none"> • The efficiency of irrigation cannot be guaranteed if land is fragmented. • Public investment for the construction of distribution network, and O&M costs would decrease where land consolidation has been completed. • Modern techniques and irrigation and transportation networks between plots are utilized
Soil productivity and quality	<ul style="list-style-type: none"> • The arable land to be irrigated should have high productivity potential.

These same criteria would also apply in NBI service area as it provides the basic requirements of an efficient irrigation scheme. Application of selection criteria, such as the above, would greatly enhance the productivity of irrigation and boost the rates of return.

Case of Ceyhan River Basin Project, Turkey:

Multipurpose Aslantas Dam in Ceyhan River, Turkey was built in early 1960s to provide water supply, hydropower, irrigation and flood control. Some 30% of the actual project cost was for irrigation. During a post review in 1999 irrigation benefits of the project were reported as⁸:

- Net irrigation realised was 84,000 ha, 95% of the planned area. Additional canals were being planned to increase the irrigated land to 147,000 ha.
- The overall water use efficiency of the project was estimated to be 43%.
- Cropping intensity was realised at 34% -- more than what was predicted.
- Value of output increased by 196%.
- Maize and watermelon yields increased 200% and 50%, respectively.
- Increase in the net farm income after the project completion varied between 103% and 178%.

⁸ Aslantas Dam and related aspects of Ceyhan River Basin, Turkey, prepared by Agrin Co.Ltd. for World Commission on Dams Case Studies, 24 Dec 1999.

3.5.3 Flood control

Flood control is an important purpose for many of the existing dams. It is the main purpose for some of the major dams of the world currently under construction. Effective flood control is accomplished by a number of multipurpose dams strategically located in a river basin. The dams are operated by a specific water control plan for routing floods through the basin without damage. The number of dams and their water control management plans are established by comprehensive planning for economic development and with public involvement. Flood control provides benefits such as⁹:

- **Maximized efficiency of use of the catchment:** Flood control not only minimizes flood losses but also enables efficient management of the catchment.
- **Avoided crop losses:** Loss of crops, whether for local consumption or exports, is minimized since agricultural land is secured from flooding.
- **Efficient use of agricultural subsidies:** Whether on inputs such as fertilizer and irrigation water, or on output prices, subsidies help support agricultural production where warranted. When the agricultural land is flooded, the subsidies are wasted as there is no economic benefit. Flood control increases the efficient use of subsidies.
- **Management of agricultural land markets:** Where agricultural land would be removed from production as the result of flooding, agricultural land prices boom. Flood control increases the stability of land markets.

Case of Ceyhan Basin Project, Turkey:

The WCD Case study ¹⁰ calculated flood benefits based on 1980 and 1984 floods. The resulting IRR on the separable and allocated costs of the dam was shown to be 13.6 %.

3.5.4 Tourism

The attractiveness of reservoirs for tourism is often a significant benefit, in addition to other purposes of a dam. This potential is especially noteworthy in areas where natural surface water is scarce or non-existent. Recreational benefits are taken into account early at the planning stage; along with other objectives achieve a balanced project. The operation of the dam and reservoir can enhance tourism. Benefits of tourism could be listed as:

- **Additional income for local populations:** Recreational facilities, water sports, food and accommodation areas offer an income-generating off-farm activity option for the local residents by the dam area. Increased employment opportunities and potential for small business investment enhance the economic activities of the area.

⁹ Green, Best Practice Methods for Valuing Flood Control Benefits, Prepared for *Thematic Review III.1:Economic, financial and distributional analysis* for World Commission on Dams, 2000

¹⁰ Aslantas Dam and Related Aspects of Ceyhan River Basin, Turkey, prepared by Agrin Co.Ltd. for World Commission on Dams Case Studies, 24 Dec 1999.

- **Incentives for sustainable management:** When the dam site attracts tourism, it creates an incentive for maintaining environmental sustainability in the area.

Table 3.3. Examples of touristic facilities in the dam sites

Dam site	Main Purpose	Touristic Purposes	Available facility
Gondand Dam in Indonesia ¹¹ .	Irrigation	recreation, fishing	camping ground, water bicycle, mini zoo
Bhakra Nangal Dam, India ¹²	Irrigation, flood-control, hydropower	dam's architecture and design, environment	picnic spot, rest houses
Vaal Dam ¹³ , South Africa:	water supply, hydropower	inland yacht race, islands	recreation area

Another example is Damodar Valley Corporation (DVC), in Kolkata, India. The corporation is planning to start a tourism development project. UK-based Mott MacDonald, which had been appointed by the corporation some time back, have submitted a report suggesting a public private partnership (PPP) model for the purpose¹⁴.

3.5.5 Inland navigation

Natural river conditions, such as current, changes in river level, ice, and changing river channels all create major problems and obstacles for inland navigation. The advantages of inland navigation management by dams over highway and rail are:

- **Large-load and large-dimension cargo savings:** Larger loads could be carried per barge than highway or rail. It is cost-effective since number of barges decrease as load per barge increase. Volume constraints are also minimized and large-dimension cargo could be shipped easily.
- **Fuel savings:** Railway and especially highway transportation consume more fuel than inland navigation transportation. Fuel savings minimize petroleum-dependency of transportation sector.
- **Transportation cost savings:** When inland navigation becomes safer and risks such as current, ice and changing river levels are lower, transportation costs minimize. This has a positive effect on volume of trade.

Enhanced inland navigation is a result of comprehensive basin planning and development utilizing dams, locks and reservoirs that are regulated to provide a vital role in realizing regional and national economic benefits.

Case of Three Gorges Project, China:

Three Gorges is located on the middle reaches of the Yangtze River, China's longest and one of the country's most important inland waterways. The permanent ship lock

¹¹ <http://www.eastjava.com/tourism/lamongan/gondang-dam.html>

¹² <http://www.surfindia.com/travel/himachal-pradesh/bhakra-nangal-dam.html>

¹³ <http://www.fallingwatersestate.co.za/dam.htm>

¹⁴ http://www.business-standard.com/common/news_article.php?leftnm=1&autono=322434

demands the most sophisticated technology in the entire Project. Tests have shown that¹⁵.

- The installation of ship locks is intended to increase river shipping from 10 million to 50 million tones annually.
- Transportation costs cut by 30 to 37%. Shipping will become safer, since the gorges are notoriously dangerous to navigate.
- The low cost of shipping goods compared to transporting them by road has also contributed to the economy.

¹⁵ <http://www.chinaeconomicreview.com/logistics/category/three-gorges-dam/>

4. CASE STUDIES

4.1 Major existing multipurpose and hydroelectric dams in the NBI area

From literature provided by NBI-RPTP, a comprehensive list of all existing multipurpose and hydroelectric projects in the Nile Basin was created. From this list, the most relevant are listed in Appendix 1. Out of these the following projects were selected to be included in this compendium's case studies (in alphabetical order):

- Aswan (Egypt)
- Finchaa (Ethiopia)
- Koka (Ethiopia)
- Merowe (Sudan)
- Owen Falls (Uganda)
- Roseries (Sudan)

4.2 Global projects to be included for lessons learned examples

The criteria used for selecting proposed global multipurpose projects for further studies were:

- (i) African projects should be prioritized
- (ii) Transboundary projects
- (iii) Other global projects with important lessons to be learned
- (iv) The selected projects should not be too old

The following projects were selected (in alphabetical order):

- (i) Casecan Multipurpose Project (The Philippines)
- (ii) Glomma and Laagen River Basin Development (Norway)
- (iii) Kariba Falls Multipurpose Project (Zambia and Zimbabwe)
- (iv) Lesotho Highlands Water Project (Lesotho and South Africa)
- (v) San Roque Multipurpose Project (The Philippines)
- (vi) Senegal River Basin Development (Senegal, Mali, Mauretania, Guinea)
- (vii) Xiaolangdi Multipurpose Project (China)

4.3 Selected planned multipurpose projects in the NBI area

Appendix 3 lists the most relevant planned multipurpose projects in the Nile Basin. A limited number of these projects were selected for further studies. Two criteria have been used for this selection of further evaluation, i.e. degree of transboundary nature and multipurpose use. The following five projects/regimes were then selected.

- Karadobi (Ethiopia)
- Mendaya (Ethiopia)
- Rusumu Falls (Rwanda, Tanzania, Burundi)
- Kakono (Tanzania)

These are further discussed in the Issues Paper in detail, as the compendium focuses on best practices of existing regimes.

5. MAJOR EXISTING MULTIPURPOSE PROJECTS IN THE NBI AREA

5.1 High Aswan Dam, Egypt

5.1.1 General

Development of the High Aswan Dam, situated some 7 km up the Nile from the city of Aswan, was decided for in the late 1940's, since the Old Aswan Dam no longer satisfied the countries needs and the desire for comprehensive control of the Nile flow to safeguard Egypt from high floods and severe droughts as well as water needed for irrigated agriculture. Thus construction started in 1960. The dam was completed in 1967, whereas the 12 turbines for hydropower generation were operational in 1970. Inauguration of the project was in March 1971 (Abu-Zeid et al. 1997).



Figure 5.1. Panorama view of High Aswan Dam

(Picture: Benjamin Frank 2005, from Wikipedia).

5.1.2 Project description

The High Aswan Dam constitutes the following salient features:

Technical data

- A rock fill dam with grout curtain and clay core
- Total crest length of 360 m and height 111 m above river bed
- A reservoir capacity of 162 km³ with a 500 km long reservoir extending into Sudan
- 12 installed hydropower turbines, each of 175 MW, totaling 2100 MW, with a generating capacity of some 10⁹ kWh per year
- Connections both to the national and local electricity grid

Usage

- Downstream flow control for matching actual water needs for different requirements
- Protection from high floods and drought hazards due to variations in the Nile flow
- Irrigation expansion: (i) Change from basin irrigation (one crop per year), to perennial irrigation (two or more crops per year) including expansion in rice and sugarcane cultivation, and (ii) land expansion by reclaiming new land for irrigation.
- Generation of hydropower to the national and local grid
- Improvement of navigation throughout the Nile
- Fisheries on Lake Nasser

Cost of Project and Financing Arrangements

- Total cost of dam is estimated at over USD 1 billion
- USSR provided funding for construction of the dam, along with funding from other sources.
- The history of the financing arrangements is thoroughly described in Biswas (2002).

5.1.3 Benefits and Impacts

Benefits

It has been estimated that the cost of the dam was recovered within only few years amounting to annual returns to the national income mainly from increase in agricultural production and hydropower generation, but also from flood protection and improved navigation (Biswas 2002). Moreover it has improved management of water supply throughout the Egyptian water system (Ahmed 1999). Thus the main benefits from the dam are strongly related to the various planned multipurpose usage of the dam. These are shortly described below.

Irrigated agriculture

The dam releases on average 55 billion m³ of water every year by which some 46 m³ billion are diverted into the irrigation canals. In the Nile Valley and delta almost 8 million feddan (a feddan is 0.42 ha) benefit from these waters producing on average 1.8 crops per year. This availability of water has secured flexibility of agricultural planning, crop patterns and crop rotation. Thus both cropping area and especially yield did increase considerably due to the dam, specifically for rice and sugar-cane.

Hydropower Generation

Installed capacity is 2100 MW, with all twelve turbines operational from 1971. By 1976 two transmission lines to Cairo, with west and east off-shoots to Alexandria and Port Said, had been completed. In 1974 the high dam generated some 53% of Egypt's entire energy output, whereas this number in 1998 was 16% due to construction of more capacity elsewhere (White 1988, Osman 1999). The power generation from the dam has also been successfully used in the electrification of Egypt's countryside, the running of old and new factories as well as for pumping stations for irrigation and drainage (Abu-Zeid et al. 1997).

Flood Management and Water Security

The construction of the dam and the 1959 agreement between Egypt and Sudan managed to satisfy both countries irrigation requirements for land under cultivation and expansion plans as well as safeguarding Egypt against the periodic drought conditions¹⁶. Moreover, the dam safeguarded the Egyptian Nile Valley and the Delta against the perils of inundation due to high floods in 1964, 1975 and 1988 (Abu-Zeid et al. 1997).

Navigation and Tourism

The dam has improved navigation along the river, both upstream and downstream down to the Mediterranean. This has resulted in an increase in the efficiency of transport economics. Improved navigation has also affected tourism positively (e.g sailing along the Nile from Cairo to Aswan). Moreover the High Aswan Dam has itself become a tourist attraction

¹⁶ From 1978 and 10 years onwards consecutive drought conditions persisted in Egypt and 90 000 MCM of water were released from the reservoir to compensate the deficit in the Nile flow.

Fisheries

Fisheries has developed along Lake Nasser, reportedly with an annual production of about 35 000 tons (Abu-Zeid et al. 1997). Availability to market and landing/processing infrastructure has however been a bottleneck for the fisheries, although factories are now in operation in the vicinity of the lake.

Impacts

Although the HAD's manifold benefits, it also brought along various environmental and social impacts (Ahmed 1999), constituting:

- A change in water quality due to less discharge, and a practically silt-free river flow. This has changed bed and bank erosion. The siltation in Lake Nasser has also caused correspondent erosion and land loss in the Mediterranean coastal areas due to the trapping of sediments that normally was transported down to the delta areas during flood periods especially.
- Less silt downstream the impoundment has also led to degradation of soil fertility, sparking the use of chemical fertilisers. These fertilizers have affected the agricultural drainage water, which in many cases are routed back to the agricultural and domestic water systems.
- Salinity and water logging problems due to over irrigation of lands, increase in cropping intensity and expansion of rice and sugarcane cultivation¹⁷.
- Propagation of scistosomiasis and the northward migration of malaria mosquito vectors from Sudan. It is however now clear that this propagation occurred not during irrigation, but during human contact with canal water due to the absence of water-supply and sanitation facilities (Biswas 2002).
- Negative effects on fisheries in the Nile system and coastal lakes, due to the fact that migration of certain species were dependent on the arrival of turbid floodwater now absent. Furthermore, the mineral rich silt in the turbid floodwaters nourished species such as sardines which breed in the estuaries of the Nile. The sardine almost disappeared after post impoundment but during the last years it has resurged back¹⁸. Scientists do not have a clear answer to the resurging, however it is a possibility that the sardines could have adapted to new ecosystem regimes in the Mediterranean sea and the Nile delta areas as well as the dynamics between these.

¹⁷ This issue is more attributable to the water management practises than the dam itself. However the dam and the water diversion provides the water to the irrigation systems and is therefore commented upon.

¹⁸ <http://www-ocean.tamu.edu/Quarterdeck/QD3.1/Elsayed/elsayed.html>

- The rise of groundwater levels, requiring new approaches to land drainage.
- Widespread growth of weeds in waterway channels as a result of inflow of silt-free water, use of fertilizers and intensification of agriculture. This has endangered the safety and effectiveness of irrigation and drainage networks and disturbed environmental conditions.
- Resettlement of between 100 – 120 000 Nubians and inundation and relocation of historical sites and monuments.



Figure 5.2. Lake Nasser and the High Aswan Dam stretching from Aswan and into Sudan

(Source: Wikipedia).

5.1.4 Mitigation Measures, Public Participation and compliance with today's standards

The High Aswan Dam was developed at a period of time when full EIA's (including mitigation measures) and public participation normally was not part of the planning of big infrastructure development projects. Actually, not until the late 70's Environmental Impact Statements were added onto the end of previously designed projects and only as late as the 90's real public participation started to be part of the processes (Lillehammer et al. 2001). This is also reflected in the "ad hoc" inclusion of mitigation measures and in public participation related to the development of the High Aswan Dam. Although some minor mitigation measures have been undertaken related to environment most of it is focused on resettlement of the affected Nubian population. Implementation of the resettlement suffered because of inadequate capacity, however the planning was well undertaken according to today's standards including design of new housing and choice of resettlement locations. Related to participation the Nubians were not directly involved in the policy making and planning, by which was exclusively a national and provincial government responsibility. Regardless these shortcomings the government wanted the Nubians to be better of following removal as well

as more integrated within the Egyptian Society. Plans included both compensation and development, and development would include both arable land and non-farm employment opportunities (Scudder 2003). After about 30 years, the social impact on the resettled people has been viewed remarkably positive by the population concerned (Abu-Zeid 1997), except for the Arab pastoralists that were not “in handy” of land titles, thus not compensated for loss of livelihood.

5.1.5 *Lessons Learned*

A review of the impacts of the High Aswan Dam based on more than 25 years of operation indicates that it has had an overall positive impact despite having contributed to various environmental problems and some discrepancy in public participation¹⁹. Some of these problems have however proved to be significantly less than was generally expected (e.g. the scistomasis and the sardine recovery amongst others). Thus HAD generally deserves more credit for its significant beneficial contributions to Egypt’s overall social and economic contribution. However, if the dam had been developed today more transparency in the impact assessment and public participation process would have been required as well as more focus on mitigation and monitoring of the environmental and social impacts, including those of loss of livelihood. Through its various colonial and post-colonial treaties Egypt also has rights and priorities to secure water flow at HAD (e.g. reservoir projects in Ethiopia and operation of Owen Falls amongst others), which is an important aspect of power politics in the region.

5.2 **Fincha Dam, Ethiopia**

5.2.1 *General*

In Ethiopia there are only five existing main dams²⁰ with significant reservoir storage capacities, and which were originally all intended for hydropower production. Fincha dam on the Fincha River, in the north-east, constitutes one of these five dams (Figure 5.3).

5.2.2 *Project description*

The Fincha dam, commissioned in 1973, dam’s constitute the following salient features:

Technical data

- The Fincha dam height is 22,2 meters with a crest length of 340 meters.
- Reservoir capacity at 2,219 masl is 625 million m³ for the Fincha dam.
- Capacity of Fincha hydropower plant is 134 MW.

Usage

- The original purpose of the dam was for hydroelectric power production. Fincha hydropower station is connected to the inter connected grid system (ICS) at 230 kV.
- Although not originally planned for, the dam have also become useful to regulate the high flood season and supply water for the downstream irrigated land as well as supplying water for downstream towns and villages after it generates electricity (UNESCO/MOWR/GIRDC 2004).

¹⁹ E.g. not to include compensation for the Arab pastoralists.

²⁰ Including Chara Chara weir which commands lake Tana.

Cost of Project and Financing Arrangements

The construction cost of the Fincha dam has been estimated to 80 Million Pound Sterling²¹. Financial arrangements are unknown, however Fincha was a loan.



Figure 5.3. The Ethiopian part of the Nile with Fincha Dam marked on the map

(Source: TecSult 2008).

5.2.3 Benefits and Impacts

Benefits

Hydropower

The Ethiopian power stations currently connected to the ICS have a total installed capacity of

²¹ Guariso et al. Implications of Ethiopian water development for Egypt and Sudan (Water Resources and Development Vol. 3 Number 2).

731 MW; of which hydropower has more than 98% of the total energy production, thus the production from Fincha benefits this interconnected system as well as the local system (UNESCO/MOWR/GIRDC 204).

Irrigated agriculture, flood management and water supply

As reported earlier the Fincha dam, although originally planned for hydropower solely, have become useful to regulate the high flood season, irrigate downstream land²² as well as provision of water supply for downstream towns and villages. Actually Fincha provides water for some 15 000 ha of irrigable land²³.

In Ethiopia (as elsewhere) there is a growing recognition that planning considerations extend far beyond the interest of single purpose projects (as the dam were originally planned for), and needs to be viewed at the river basin scale or with respect to multipurpose development aspects, which results in a number of benefits associated with human well-being such as secure water supply, irrigation for food production, hydroelectric generation, flood control, watershed management, improved navigation etc. that makes the projects economically viable and environmentally acceptable.

Impacts

Hydropower dams in Ethiopia have mostly been situated in the highlands area (as for Koka (see 5.3) and Fincha) which has favored exploitation of the potential at a relatively low unit energy cost, with less resettlement and loss of productive agricultural land as compared with the lower lying areas. However any development of dams inevitably involves a certain degree of environmental impacts, and so also for Fincha (as for Koka) when it was constructed and during operation. Some of these are inundation of habitats in the reservoir areas and upstream as well as change in runoff and geomorphology downstream with its effect on both humans and ecosystems. Specifically for the Fincha dam the following impacts have been reported (Olana 2006).

- Resettlement
- Losses of swamp and forest land
- Decrease in permanent grazing land, thus impacting livestock production
- Increase in cropland, mainly on the higher and sloping areas, thus increasing soil erosion and sedimentation

In general, due to poor land use management and lack of appropriate cultivation in the catchment of Fincha it is quite seriously affected by sedimentation due to erosion. The lack of proper cultivation often leads to gully erosion, which is often aggravated by development of infrastructure (such as roads e.g). Sustainable catchment management might have decreased erosion and sedimentation rates affecting the longevity of the dam.

The general accumulation of sediments has a sampler of consequences besides storage loss, the following being the most prominent:

- It reduces the reservoirs capacity to regulate flows and therefore will reduce the reliable yield. Affecting both annual energy generation and benefits obtained from irrigated agriculture negatively.
- It will also reduce the reservoir capacity to attenuate flood peaks.

²² Specifically water for Fincha provides irrigated water for Fincha sugar factory.

²³ Guariso et al. Water Resources Development. Vol. 3. No. 2.

5.2.4 *Mitigation Measures, Public Participation and compliance with today's standards*

Fincha dams was developed several decades ago, therefore an EIA was not conducted²⁴, thus no pre-planned mitigation measures has been undertaken, let alone a public participation program related to the impacts of the dam and its resettlement. Anyway, relocation of farmers to alternative farmlands has been reported for the dam²⁵. It is thus far away to comply with today's standards for water infrastructure development. This is partly due to the period it was developed.

5.2.5 *Lessons Learned*

Information is scanty about the Fincha dam that can bring about issues that can be highlighted for lessons learned. However an important issue, as for the development of the Koka dam and the Roseries dam in Sudan, is the inclusion of integrated catchment management measures to be undertaken in the upstream catchments of the reservoirs to decrease erosion and siltation of rivers and thus increase the lifespan of the reservoirs. Furthermore, in order to maximize the benefits of the dam, secondary use assessment during planning would probably have increased the benefits.

5.3 Koka Dam, Ethiopia

5.3.1 *General*

Koka dam is situated on the Awash River, in the south-central part of Ethiopia and constitutes the second of the five existing dams as reported in 5.2.

5.3.2 *Project description*

The Koka was commissioned in 1960 and constitute the following salient features:

Technical data

- The Koka dam has a height of 23,8 meters and with a crest length of 458 meters.
- Reservoir capacity for Koka is 1 850 million m³ at 1,590 masl.
- Capacity of Koka is 43,2 MW.

Usage

- The original purpose of the Koka dam was for hydroelectric power production²⁶. Koka is further connected to the inter connected system at 132 kV.
- As for Fincha, the dam have also become useful to regulate the high flood season and supply water for the downstream irrigated land as well as supplying water for downstream towns and villages after they generate electricity, although not originally planned for (UNESCO/MOWR/GIRDC 2004).
- Further, the Koka reservoir supports a fishing industry with some 625 ton's of fish landed each year (FAO 2003).

²⁴ Full EIA's became common in infrastructure development projects in late 80's, early 90's.

²⁵ Z. Gebrehiwot pers. com.

²⁶ Koka also generate power for operation of the power cascade that includes Awash I and II.

Cost of Project and Financing Arrangements

The construction cost of Koka was 346 million Ethiopian birr (at today's exchange rate about 38 million USD). Financial arrangements are unknown, however Koka a grant.

5.3.3 *Benefits and Impacts*

Benefits

Hydropower

The Ethiopian power stations currently connected to the ICS have a total installed capacity of 731 MW; of which hydropower has more than 98% of the total energy production, thus the production from Koka (as for Fincha) benefits this interconnected system as well as the local system (UNESCO/MOWR/GIRDC 204). Furthermore the Koka dam (43,2 MW) serves as a regulation dam for power production at Awash II (32 MW) and III (32 MW), by which all three in total have an installed capacity of 107.2 MW.

Irrigated agriculture, flood management and water supply

As reported earlier the Koka (as for the case of Fincha), although originally planned for hydropower solely, have become useful to regulate the high flood season, irrigate downstream land²⁷ as well as provision of water supply for downstream towns and villages. Koka supports a total irrigated area in the Awash basin of some 69 000 ha.

Other secondary uses

The Koka reservoir has been reported to be popular with tourists and city-dwellers for recreation. The scale and importance of this is however not known. There is also a variety of wildlife and birds that utilize the lake and its surroundings. Furthermore, according to the Ethiopian Department of Fisheries and Aquaculture 625 tones of fish are landed each year, a yield that is well within the sustainable threshold of the lake.

Impacts

As for Fincha the development of the dam inevitably involves a certain degree of environmental impacts, during construction and operation. Some of these are inundation of habitats in the reservoir areas and upstream as well as change in runoff and geomorphology downstream with its effect on both humans and ecosystems.

Specifically for Koka dam it has been reported that it has increased abundance of disease vectors and subsequent malaria case-rates (IWMI 2007), as well as some relocation of peasant farmers.

The Koka dam and reservoir has the same problem as Fincha due to poor land use management and lack of appropriate cultivation in the catchments. Thus it is seriously affected by sedimentation due to erosion²⁸. The lack of proper cultivation often leads to gully erosion, which is often aggravated by development of infrastructure (such as roads e.g), and is especially common in the Koka catchment. It is estimated that Koka has lost more than 30% of its initial total storage and almost all of its dead volume. Although storage loss due to sedimentation has been foreseen in the feasibility study and captured in the design of the dam, sustainable catchment management might have decreased erosion and sedimentation

²⁷ Specifically water from Koka supports Wonji sugar factory and downstream requirements.

²⁸ The erosion rates in the Koka catchment exceeds 6 000 t/km²/yr (UNESCO et al. 2004)

rates affecting the longevity of the dam.

AS for Fincha, the general accumulation of sediments has a sampler of consequences besides storage loss, the following being the most prominent:

- It reduces the reservoirs capacity to regulate flows and therefore will reduce the reliable yield. Affecting both annual energy generation and benefits obtained from irrigated agriculture negatively.
- It will also reduce the reservoirs capacity to attenuate flood peaks.



Figure 5.4. Koka dam area

(Source: www.MediaEthiopia.com).

5.3.4 Mitigation Measures, Public Participation and compliance with today's standards

Koka dam was developed 5-6 decades ago, and an EIA was not conducted, thus no pre-planned mitigation measures has been undertaken, let alone a public participation program related to the impacts of the dam and its resettlement. Anyway, relocation of farmers to alternative farmlands has been reported for the dam²⁹. It is thus far away to comply with today's standards for water infrastructure development. This is partly due to the period it was developed.

²⁹ Z. Gebrehiwot pers. com.

5.3.5 Lessons Learned

Information is scanty about the Koka dam that can bring about issues to be highlighted for lessons learned. However an important issue, as for the development of the Fincha dam and the Roseries dam in Sudan, is the inclusion of integrated catchment management measures to be undertaken in the upstream catchments of the reservoirs to decrease erosion and siltation of rivers and thus increase the lifespan of the reservoirs. Furthermore, in order to maximize the benefits of the dam, secondary use assessment during planning would probably have increased the benefits.

5.4 Merowe Dam, Sudan

5.4.1 General

The Merowe Dam, or Merowe Multi-Purpose Hydro Project, is a large construction project in northern Sudan, situated on the Nile about 450 km downstream of Khartoum, close to the 4th Cataract where the river divides into multiple smaller branches with large islands in between. The main purpose of the dam will be the generation of electricity when it is finished in 2008/2009. Its dimensions make it the largest contemporary hydropower project in Africa.



Figure 5.5. Construction of Merwoe dam

(Source: Sudaninside.com)

5.4.2 Project description

The Merowe Dam constitutes the following salient features:

Technical data

- Two concrete-faced rockfill dams on each river bank, an earth-rock dam with a clay core in the left river channel and a live water section in the right river channel (sluices, spillway and power intake dam with turbine housings).
- Total length of the dam will be 9,2 km and the height will be 67 meters.
- A reservoir capacity of 12,5 km³ with a 176 km long reservoir.
- 10 installed hydropower turbines, each of 125 MW, totaling 1250 MW.
- To utilize the extra generation capacity the Sudanese power grid will be upgraded and extended.

Usage

- Prime usage is to produce hydroelectric power for the national and provincial power grid
- Supply of water for irrigation as well as flood control
- It is expected that the dam will improve navigation and fisheries.

Cost of Project and Financing Arrangements

- Total project cost is estimated to 1900 Million USD where 33% is construction of the dam, 25% is technical equipment and 30% is upgrading of the power grid and 800 Million USD for resettlement projects.
- The project receives funding from China Import Export Bank, various Arab funds and from the Sudanese government.

5.4.3 Benefits and Impacts

Benefits

The main purpose of the Merowe project is electric power generation (about 5600 GWh/year), supply of water for irrigation and flood control.

Hydropower

At present, some 1315 MW of power is installed in Sudan and the 1250 MW Merowe will thus boost the availability of energy to the growing demand in the country. As part of the Merowe project, on 23rd December 2003, a contract to build transmission lines was signed. This included both national and regional grid connections (500 kv, 220 kv, 110kv and 33 kv) to Khartoum, Atbara, Port of Sudan, Merowe, Debba and Dongola.

Irrigated agriculture

It is planned to provide water for irrigation for the potentially very fertile Dongola reach of the Nile Valley, and the design of the dam allows for this type of water abstraction. As per March 2006 no planning details were available (EAWAG 2006). However, two irrigation intakes have been incorporated in the dam structure design, and the reservoir is capable to irrigate 400,000 hectares of farmland, potentially benefiting more than 3 million people.

Flood protection

One of the highlighted benefits of the dam is flood protection. However given that the main purpose of the dam is hydropower generation with a planned daily peaking that will make the downstream water levels to fluctuate with a magnitude between 2.6 and 4.9 meters some 20 km downstream and then dampen, the overall flood protection benefit needs to be investigated in more detail for this section.

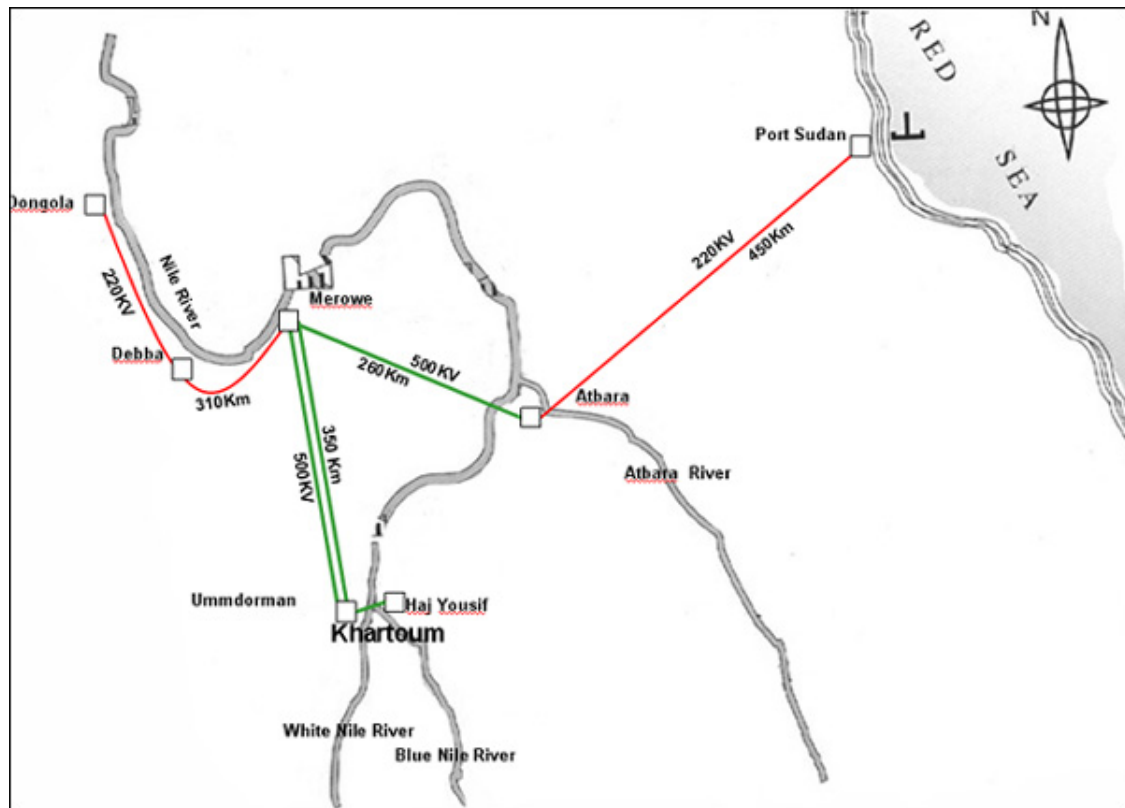


Figure 5.6. The Merowe dam transmission line grid extension

(Source: Sudaninside.com)

Silt trapping

The Merowe dam will trap silt and its estimated lifetime spans from 50 (EAWAG) to 150 years (Lahmeyer). This function will however decrease the amount of silt entering Lake Nasser and thus benefiting the High Aswan Dam and Lake Nasser.

Impacts

The amount of impacts reported from the Merowe Dam has been assessed by Lahmeyer and EAWAG. Below is a short summary of the findings.

- The construction of Merowe dam will have some impacts on wildlife population. The dam and its lake will not block any migration route. Nile crocodiles, monitor lizards and aquatic birds will be impacted to various degrees, e.g. loose their nesting grounds amongst others.
- There will be changes in aquatic ecology. It is expected that the alteration of fish population will resemble that observed after the construction of the High Aswan Dam. Fishes that can not adapt to the new environment will disappear while easily adaptable species may have a benefit. The Merowe reservoir can be used for commercial fishing a

few years after impounding. The composition of fish population is expected to be similar to Lake Nubia. Most traditional fishing methods will probably need to transform into commercial fishing. The dam will act as a barrier especially to migratory Cyprinid species found also in Lake Nasser.

- Impounding the river to form the lake reservoir will increase the surface area of the Nile subjected to solar radiation and therefore increasing evaporation losses.
- The peak operation of the dam will result in fluctuation of water level affecting people working on the river banks or on small boats downstream. Changing water levels will also have an impact on small-scale irrigation pumps and ferry landing sites in this area.
- In general the Merowe Dam together with the HAD will allow a higher salt water intrusion from the Mediterranean into the Nile Delta and will accelerate salinization of the fertile farmlands present in this area.
- As the Merowe reservoir is filled with sediments, new reproduction areas for hosts of plasmodium causing Malaria will probably become available. During low water levels, submerged islands will become wetlands or pounds, providing new breeding grounds for insects and mosquitoes. During construction of the dam new breeding possibilities are available in ditches, puddles or excavations, increasing the risk of infections for local workers and the population.
- The Merowe dam will affect archaeological heritage since the area upstream the 4th cataract has been densely populated through nearly all periods of (pre)history. Recent surveys have confirmed the richness and diversity of traceable remains, including amongst others the noted towns and cemeteries from the Pharaonic period and the Napato-Meroitic era, which stretched from 900 B.C. to A.D. 350. At Gebel Barkal, the post-Meroitic tumuli, or grave mounds of Zuma and the Christian monastery of Ghazali give an insight on the cultural heritage.
- Approximately 50 000 people and three communities will be affected by the Merowe dam: The Hamdab, by 8%, the Amri by 28%, and the Manasir tribe by 64% of the population. Each of these communities underwent different circumstances in the evacuations, compensation and resettlement process.

5.4.4 Mitigation Measures, Public Participation and compliance with today's standards

All issues regarding resettlement of local tribes and compensation was managed by the Dam Implementation Unit (DIU) installed by the Ministry of Irrigation. At a later stage Lahmeyer prepared detailed Environmental management plan (EMD) and resettlement action plan (RAP) to provide solutions and mitigation measures for the created negative impacts as well as to enhance the positive ones³⁰.

However, public participation and mitigation measures have been reported to not being comprehensive enough, as well as the rescuing of cultural heritage and excavating of archaeological sites.

As reported, the dam is also built for irrigation purposes, it is however unknown to which scale and detail this plan is to be realized with in the near future.

³⁰ Three projects for resettlement of people are reported to be in place for the Merowe project (Source: RPTP Workshop, 26-28 May)

5.4.5 *Lessons Learned*

Mitigation planning and implementation as well as public participation could have been undertaken more comprehensively, the last mentioned especially in the planning stage.

Moreover the Lahmeyer EIA was not an independent study, and the quality of it has become under heavy scrutiny, partly because of this. A general international principle is that EIA's should be undertaken by an independent consultant.

Furthermore, the resettlement and cultural heritage planning and implementation rests as a case to be better planned.

On the benefit side the Merowe project will however boost the availability of energy in the country, and also have an important transboundary function in being a silt trapping facility that will benefit lake Nasser and the High Aswan Dam.

5.5 Owen Falls Dam, Uganda

5.5.1 *General*

The Owen Falls Dam with its hydropower station started operating in 1954 and is located on the Victoria Nile River, at the outlet of Lake Victoria, in the southeast Uganda near Jinja. The Owen Falls system constitutes now after its extension the Nalubaale³¹ power station (the original Owen Falls) and the Kiira power station that started operating in 2000.

5.5.2 *Project description*

The Owen Falls complex constitutes the following main features:

Technical data

- The Owen falls dam; a 30 m high gravity dam that submerged the waterfall and controls the discharge of water from Lake Victoria into the White Nile.
- Lake Victoria, the second largest freshwater lake in the world (68 000 km²), functions thus as a natural reservoir for the Own Falls dam.
- The Nalubaale power station capacity is 180 MW at present. Originally it was designed for 150 MW with 10 turbines at 15 MW each. The station was however refurbished in the 1980s with increase in the output power of the generators to 18 MW each.
- In 1993 work started on the Owen falls extension project, with a second powerhouse, Kiira, located approximately 1 km downstream of Nalubaale. A new, additional, power canal to bring water from Lake Victoria to Kiira power station was excavated and constructed. The Kiira extension has space for five generators of 41 MW each at a head of 20.8 m, with 3 installed as per 2003.
- The two power stations are connected to the Ugandan national grid and also provide power to parts of Kenya.

³¹ *Nalubaale* is the Luganda name for Lake Victoria.



Figure 5.7. Kiira hydropower station at Owen Falls, Uganda

(Source: Lahmeyer International).

Usage

- Prime usage is to produce hydroelectric power for the Ugandan power grid as well as to deliver power to parts of Kenya (30 MW), Tanzania (9 MW) and Rwanda (5 MW).
- The road over the dam provided a new means of transportation connection, especially towards Kenya.

Cost of Project and Financing Arrangements

The total cost of the Owen falls extension was 84 million USD. This was funded by IDA (WB), NORAD, NDF and Government of Uganda, and thus a pure public sector investment. The proposed downstream Bujagali project on the other hand, estimated to a cost of USD 582 million, is planned to be a private sector investment with governmental support. The total cost of the original 1954 scheme was 22 million Pound Sterling, or about 45 million USD using today's exchange rates (MoE 2008).

5.5.3 *Benefits and Impacts*

Benefits

Hydropower

Through its sequential upgrading from the start in 1954 and onwards the Owen Falls system has provided more and more electricity to the Ugandan grid by which also has been extended concurrently. Major sequences has thus been the First (Owen Falls), Second and Third Power Project, with the Second and Third Power Project constituting upgrading of Nalubaale and construction of Kiira power stations respectively, to meet the growing demands³². Kenya – Uganda electricity agreements was signed in 1955 with the purpose of providing Kenya with 45 MW of electricity continuously for 50 years. Later this was reduced to 30 MW to accommodate load growth in Uganda. The power production also benefits Tanzania (9 MW) and Rwanda (5 MW).

Flow regulation and lake water levels

Prior to the Owen Falls construction between 1950 and 1954, water levels in Lake Victoria were moderated by a natural rock on the north side of the lake. The rising water would spill over this natural “dam” and into the White Nile. Thus when water level dropped to levels lower than the “natural” dam, flow from Lake Victoria ceased (MoE 2008). The construction of the dam enabled abolishment of this “risk”. Furthermore, the formula known as the “agreed curve”, sets the levels of lake outflow to be between 300 and 1700 m³/s at Owen Falls depending on the water level.

Furthermore, natural and “artificial” lake level variations in Lake Victoria impact all the multiple uses of the lake which constitutes a huge sampler of issues from irrigation, water supply, transport, fisheries etc. Thus “artificial” lake level variations is discussed under impacts and is related to power production and operation (and demand) of the Owen falls System.

Other benefits

As mentioned under usage, the road over the dam provided a new means of transportation connection, especially towards Kenya. The main land transport of goods from Kenya (Mombasa and Nairobi) to Kampala is through this northern route.

Impacts

As the original Owen Falls (Nalubaale) construction took part during 1950-54, at a time when environmental impact assessment was virtually absent from hydro planning scanty information about the impact of this system is available, although some exist from the Kiira extension. However for the planned Bujagali, HPP, this is available, and clearly an integral part of the planning.

A issue that has surfaced concurrently with the lake levels decline, the last one especially prominent between 2002 and 2005, is the operation of the “new” Owen Falls system and its it's potential additional impact on the lake level³³.

At the early stages of the receding lake levels in 2002, the World Bank Investigation Panel

³² This has been followed by Power IV, which constitutes installing of the last two 40 MW turbines at Kiira amongst others.

³³ The root cause of the increase in outflow has been linked to the increased demand in Uganda for power and thus more intensive operation of the Owen Falls Complex.

concluded that the Owen Falls complex /Nalubaale and Kiira extension) was over designed and incapable of full capacity (World Bank 2002). This resulted to over release of water, contributing additionally to the low water levels of the lake. How much the Owen Falls operation has contributed to lake level decline is however a matter of dispute and vary widely, and is especially exaggerated in mainstream literature³⁴. A thorough analysis of the decline has however been undertaken by the Lake Victoria Basin Commission (2006) which reported the following on the comparison of the lake level and the outflows:

“The summary of flow characteristics for River Nile outflow in Table 2 indicate an increase in average flow out of the lake by 15% to 1057.6 Cumecs in the period 2001-2004 as compared with the long term average of 1046 Cumecs in the period 1950-2000 including the per cent of all losses with the remaining loss being evaporation. But this increase in outflow occurred during a period of falling water levels, which is a departure from the long-term relation between level and outflow. Although the recent record is for a shorter period than the long-term period, it nevertheless gives a general pointer to the new hydrologic trend that may emerge. The lake cannot maintain its water level if outflows of the past five years are maintained; unless substantial increases in rainfall and river discharge are realized”

The key issue is thus that the lake cannot maintain it's “present” outflow³⁵, e.g. present operation of the Owen Falls complex, under the current climatic conditions. The implications of the declining water levels is multiple and can shortly be summarized as follows (elaborated freely from LVBC 2006):

- Alternation of shoreline, littoral and pelagic habitats affecting ecosystem structure, biodiversity and local fish populations/production
- Increase in conflicting uses of water in shoreline areas ranging from water supply, livestock watering, washing etc. all compounding the water quality situation in shoreline areas.
- Falling water levels have also affected the hydropower production affecting its hydro-potential, creating a “catch 22” situation.
- Various other socio-economic activities related to water supply, water transport and fishing, amongst others.

5.5.4 Mitigation Measures, Public Participation and compliance with today's standards

Comprehensive mitigation measures and public participation is not known to have been undertaken for the Owen Falls complex, however this has been an integral part of the planned Bujagali HPP. Thus in general the planning does not comply with today's standards, partly because the first stages of the development was undertaken several decades ago.

³⁴ An example is Daniel Kull (2006) which links 55% contribution to the operation of the dams whereas a more “sober” description comes from the reported LVBC report (2006).

³⁵ E.g those between 2002-2005.



Figure 5.8. The shoreline and the near shore areas of Lake Victoria, with its multiple users, is prone to the fluctuations of the lake levels.

(Source: Statkraft Grøner et al. 2003. Picture is taken close to Mwanza Tanzania by Mark Bain).

5.5.5 Lessons Learned

Lessons learned from the Owen Falls system is more focused on operation than the planning of the complex given the fact that more info from the operation that the actual planning is available and the potential impact the operation can have on the lake level. To reverse the lake levels decline LVBC has thus proposed the following, amongst others (LVBC 2006).

- Investment in alternative sources of energy
- Construct a new power station downstream the existing power facilities, utilizing the return water
- The Republic of Uganda should start reducing release of water at Jinja and move towards the agreed curve release policy
- Initiate a process to formulate and implement a new adaptive lake regulation policy, based on modification of the agreed curve, benefiting also the riparian states around Lake Victoria.

Furthermore, the EIA for the Kiira extension should have addressed the possibilities of its effect on lake level decline during dry periods.

5.6 Roseires Dam, Sudan

5.6.1 General

The Roseires Dam, finished in 1961, is situated close to the town of Damazin on the Blue Nile about 500 km southeast of the capital of Khartoum, close to the border of Ethiopia (some 150 km downstream). The Roseires constituted for a long time, nearly half of the power output of Sudan (280 MW), although at present some 1315 MW are installed and another

1250 MW will be added by the construction of Merowe. There are also ongoing studies/plans to heighten the Roseires dam.



Figure 5.9. The Sudan part of the Nile, with Roseires dam on the map
(Source: UNEP 2006).

5.6.2 Project description

The Roseires Dam constitutes the following salient features:

Technical data

- The dam consists of a 1000 meter-long central concrete buttress section with earth embankment sections on each flank, 8.5 kilometers and four kilometers in length
- The dam height of the central section is 60 meters.
- A reservoir capacity of 4 billion m³ with a 290 km² reservoir surface area.
- As the Roseires still is the main generating facility in Sudan, it's the main supplier of power to the main interconnected electrical grid – The Blue Nile grid and the Western

grid, which cover a small part of the country. There is however plans for extension and interconnection with Ethiopia (SMEC 2005).

Usage

- The prime usage of the dam was to provide water for the irrigation of the Rahad and Gezira schemes; however it has become prominent of producing hydroelectric power for the main interconnected electrical grid mentioned above.

Cost of Project and Financing Arrangements

- The International Bank for Reconstruction and Development together with the International Development Association and Kreditanstalt für Wiederaufbau made available loans to the Republic of Sudan equivalent of USD 32.5 million for helping financing the construction of the Roseires dam and its associated irrigation scheme. The loan agreement was signed in June 1961³⁶.
- A planned increase in dam height is estimated to cost some 500 million USD.



Figure 5.10. The Roseires dam, Sudan

(Source: Sudantribune).

5.6.3 *Benefits and Impacts*

Benefits

Hydropower

Up to date Roseires has been Sudan's main hydroelectric generation facility with its 280 MW

³⁶ International Organization. Vol. 15, No. 4, pp 705-710 and the United Nations – Treaty Series 1961.

serving the interconnected electrical grid. At present a 10 m increase of the Dam height is under planning which will affect the power output amongst others. Almost 27% of the dams storage has been lost due to sedimentation of the reservoir and together with periodic low water levels this has often caused the capacity to fall to 100 MW. The dam height increase will however increase the generation output from 950 to 1740 GWh. Gross storage will increase from around 4 to 7,3 billion m³.

Irrigated agriculture

The Rahad and the Geizra scheme receive water for irrigation purposes from the Roseires dam. The planed heightening of the dam is proposed to irrigate some additional 0.6 billion m³ hectares for the Kenana scheme and to extend the Rahad scheme. Irrigation was considered the main purpose of Roseires when it was planned for and constructed.

Impacts

The planning and construction of the Roseires dam took place at a time where environmental studies, let alone Environmental Impact Assessments were not an integral part of hydro and development planning, thus knowledge about impacts from the study is somewhat scanty and mostly rely on observed impacts during the operation period³⁷. However the following has been reported.

- The construction of Roseires dam led to resettlement of 10 000 people. It is currently unknown what kind of resettlement measures were taken or what kind of compensation measures these received, if any.
- Due to poor land management practices in the upstream catchment of the dam (both in Sudan and Ethiopia) the dam is highly prone to sedimentation, and almost 27 % of its storage potential is already lost, affecting both hydropower production and irrigation potential.
- Irrigation of the Geizra scheme has lead to soil salination.
- The fish mortality in the reservoir has been reported to be high due to an anoxic hypolimnion³⁸.
- Impacts on aquatic ecosystem, fish migration, water quality and quantity as well as cultural heritage has probably been of some importance as for all large dams projects, however these are not at present known.

5.6.4 Mitigation Measures, Public Participation and compliance with today's standards

The Roseries do not have an EIA, thus no planned mitigation measures has probably been undertaken, let alone a public participation program for the impacts of the dam and its resettlement. It is thus far away to comply with today's standards for water infrastructure development. This is partly due to the period it was developed. The heightening of the dam to be studied and probably undertaken will however include an EIA that should comply with

³⁷ Actually the Merowe dam is the first hydropower development project in Sudan with an EIA as part of the project development.

³⁸ Anoxic hypolimnion is the result of decomposition of organic material, that consumes the oxygen in the deep layers of the reservoir, resulting in death of fish amongst others.

today's standards for impact assessment.

5.6.5 Lessons Learned

The high sedimentation rates in the reservoir as reported for the Roseires calls for integrated catchment management measures in the upstream catchments, when heightening of the dam is to be undertaken. This will decrease erosion and siltation of rivers and thus increase the lifespan of the reservoir.

Furthermore, if the dam and power station had allowed for passing of silts by use of deep sluices it could also have increased the lifespan of the reservoir.

Fish migration and production would have benefited if a fish ladder had been installed with the dam. Combined with other measures to preserve the livelihood, this would have benefited the local population that utilizes the resources in the reservoir.

The cost of heightening the dam in Phase II is manifold the cost if the now anticipated dam height would have been included in Phase I.

6. GLOBAL PROJECTS

6.1 Casecnan Multipurpose Project, Philippines

6.1.1 General

The Casecnan Study is based on information gathered from different sources found on the internet.

The Casecnan Project is a combined irrigation and hydroelectric power project in the northern part of Luzon, the Philippines' main island. It began operation Dec. 11, 2001, and collects water from the Casecnan and Taan Rivers and transports it through a 26-kilometer tunnel to the existing Pantabangan Reservoir. Its power component provides approximately 150 megawatts of hydroelectric capacity to the Luzon grid. The project also irrigates 35,000 hectares of agricultural lands and stabilizes the water supply to 102,000 hectares of existing irrigated areas. The Casecnan Project is the first multipurpose Build-Operate-and Transfer project in the Philippines.

The owner and operator is CE Casecnan Water and Energy Company, Inc., an affiliate of CalEnergy International. An agreement provides for CE Casecnan Water and Energy Co. Inc., an affiliate of CalEnergy International, to own and operate the project for a period of 20 years, after which ownership will be transferred to the Philippine government at no cost. Thus the contract type is a Build-Operate-Transfer/Power Purchase Agreement (PPA)/Unsolicited Project, with a cooperation period of 20 years (April 5, 2002 - April 5, 2022).



Figure 6.1. The Casecnan dam and multipurpose project

(Source: www.calenergy.com/html/projects5b.asp).

6.1.2 *Project description*

The Casecnan Multipurpose Project constitutes the following salient features:

Technical data

The project is an inter-basin transfer collects water from the Casecnan and Taan Rivers and transports it through a 26-kilometer tunnel to the existing Pantabangan Reservoir. Two small diversion weirs are built in Casecnan and Taan/Denip Rivers.

Installed capacity in the power plant is 150 MW and the power production is approximate 400 GWh/year. The power station consists of an underground powerhouse with two generating sets each 75 MW, 90 MVA, operating on a net head of 250 meters. The powerhouse is connected with a 150 meter high vertical bus bar shaft to a switchyard with an area of approximately 6300m² consisting of, among other things, the 2x150 MVA transformers.

A new 4-km access road was built from the Pantabangan Reservoir area to the location of the in-stream diversion structures near the intersection of the Casecnan and Taan/Denip Rivers.

Usage

- Prime usage is to produce hydroelectric power for the Luzon power grid
- The project also irrigates 35,000 hectares of agricultural lands and stabilizes the water supply to 102,000 hectares of existing irrigated areas.

Cost of Project and Financing Arrangements

Casecnan is one example of a genuinely privately funded scheme. The cost of the project is approximately USD 500 million. The project is being developed by a locally incorporated special purpose company with 70% holding by two large American investors. The project is being financed using \$350 million of debt (72% debt - 28% equity ratio) raised on the USA bond markets in one of the first examples of bond financing for a hydro project. The government counterpart agency is the National Irrigation Authority which buys both the water and power, and then on-sells the power to the National Power Corporation.

This project is viable in the private sector because of the high value attributed to them irrigation water (US 2.9 c/m³) which accounts for 45% of the revenue, and because it also has a strong revenue stream from the sale of power. The private company is only dealing with one offtaker (NIA) and, perhaps most important of all, it is a run-of-river project with no large reservoir involved. It is arguable that had this not been the case, it would not have been possible to raise the finance in the private market.

Casecnan's cost (levelized, PhP/KWh) is the highest among IPP contracts. Reasons can be:

- 1) Short payback period
- 2) Subsidizing added revenues to two other power plants, Pantabangan and Masiway.

6.1.3 *Benefits and Impacts*

Benefits

Hydropower

The project is a 150 megawatt (MW) run-of-the-river hydroelectric power plant, expected to generate 425 GWh of energy per year for the Luzon power grid.

Irrigated agriculture

The project also irrigates 35,000 hectares of agricultural lands and stabilizes the water supply to 102,000 hectares of existing irrigated areas. The project helps the Philippines self-sufficiency in rice production.

Impacts

The developer states that energy from Casecnan is produced by non-polluting, renewable indigenous hydroelectric sources. Water from the Casecnan and Taan Rivers is collected and diverted by two small diversion weirs.

6.1.4 *Mitigation Measures, Public Participation and compliance with today's standards*

The project has been attacked by NGOs for the following reasons:

- Violation of the BOT Law - though unsolicited, involves direct subsidies. By this is meant that the government did not earmark this project as a priority, and therefore did not issue a call for interested parties to submit a bid.
- The contract was given to a company managed by an old friend of President Ramos. The Technical Committee of the Investment Coordinating Committee could not approve the project because it had many questions about the project that National Irrigation Administration could not sufficiently and satisfactorily answer. There were basic disagreements about the financial viability of the project. The technical working group's estimate was a negative internal rate of return. There were basic disagreements between NEDA and the NPC on the one hand, and NIA and the Department of Agriculture on the other.
- It is claimed that the fees for water and power are overpriced
- It is claimed that the Government of the Philippines has absorbed an unfair portion of the project risks.
- CE Casecnan, an American company with a maximum of 15% Filipino ownership, controls the flow of water at those weirs. This might be a violation of the Philippine Constitution.
- ICC merely required CE Casecnan's compliance with an environmental compliance certificate (ECC) rather than undertake its own environmental impact assessment of the project.
- The ICC did not undertake its own social impact analysis of the project.

The contract places the minimum water off-take of Casecnan at 801.9 million cubic meters of water per year. During ICC review the Secretariat had reservations about the ability Of Casecnan to deliver 801.9 million cubic meters of water. DPWH and NEDA in consultation with technical hydrology experts must to conduct further studies to ascertain a just guaranteed Capacity for water delivery. Because of this provision, NIA has to pay

Casecanan the equivalent of 801.9 million cubic meters of water whether or not the Casecanan and Denip Rivers can provide such amount

6.1.5 Lessons Learned

The Casecanan project shows that it is possible to implement a privately funded multipurpose project. It must be noted that. The private company is only dealing with one offtaker (NIA) and, perhaps most important of all, it is a run-of-river project with no large reservoir involved. It is arguable that had this not been the case, it would not have been possible to raise the finance in the private market. The private company is only dealing with one offtaker (NIA) and, perhaps most important of all, it is a run-of-river project with no large reservoir involved. It is arguable that had this not been the case, it would not have been possible to raise the finance in the private market.

The conclusions in the reports from NGOs is that participation of all stakeholders from the start of planning and a transparent planning process are essential to a smooth implementation of the project and that the developer follow all rules and regulations from the planning stage through implementation. Failure to do so might cause delays and unnecessary law suits after the project is implemented.

6.2 Glomma and Laagen Basin Development, Norway

6.2.1 General

The Glomma and Laagen (G&L) Study is based on a case study undertaken as part of the WCD process, where a common approach and methodology was used to assess the development effectiveness of large dams.

This study considers the development experience with an integrated system of 40 dams and reservoirs, watercourse diversions and 51 hydropower stations (total installed capacity of 2,165 MW) in the Glomma and Laagen river basin (G&L basin) in Southeast Norway. It considers the development of the basin over one hundred years and illustrates how decision-making on new dams and operations have evolved over time, shaped by both national and local interests.

6.2.2 Project description

The hydropower development in the G&L basin reflects a history of more than 100 years. The main construction period in the basin was from 1945 to 1970. Most regulation dams and power stations in the G&L basin were built more than 30 years ago in a context quite different from the present situation in the G&L basin.

Today the G&L basin encompasses 40 regulation reservoirs with a total capacity of approximately 3500 million m³ of storage, equivalent to 16% of the basin runoff. Generally the hydropower reservoirs are natural lakes with water level fluctuation of 2-12 meters after regulation. Lake regulation capacities result from a combination of heightening and lowering natural water levels. The increase in total basin lake area is

approximately 46.6 km². The highest dam in the basin is 40.8 meters and many of the lower dams qualify for the ICOLD definition of large dams due to the size of the reservoir they regulate. The largest power station in the basin has an installed capacity of 300 MW. The total installed capacity in the basin is 2 165 MW, with an average capacity of 42 MW for the 51 power stations.

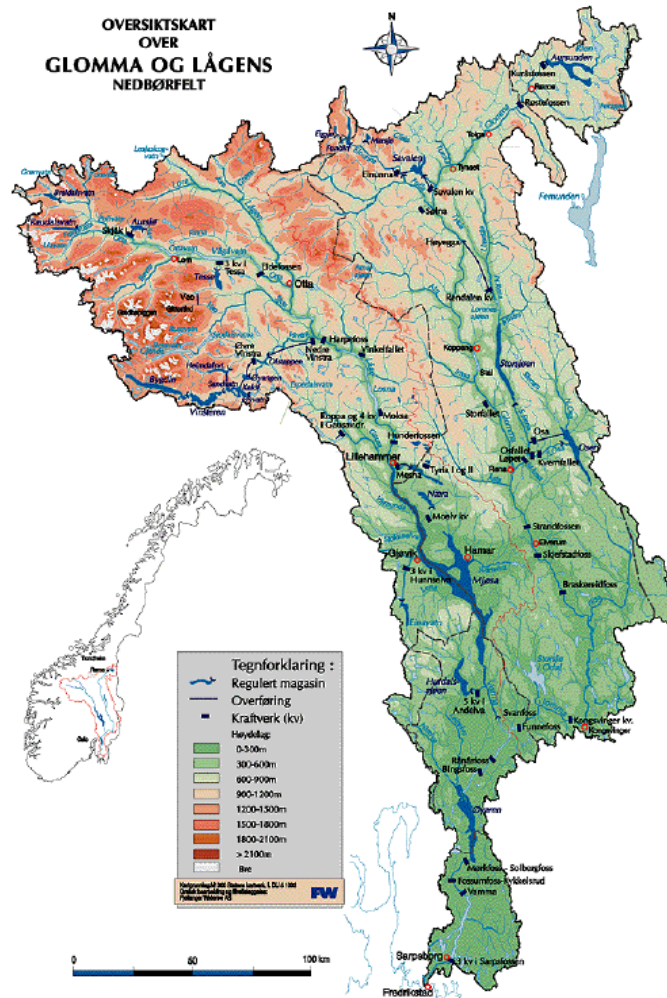


Figure 6. 2. The Glommen and Laagen basin in Norway

(Source: WCD 2000)



Figure 6.3. One of the many regulation reservoirs, Kykkelsrud Dam and Power Plant

(Source: Glomma & Laagen web page).

Usage

- Prime usage is to produce hydroelectric power for the national and provincial power grid
- The reservoirs reduces the flooding peaks at extreme floods
- The river also provide water for irrigation as well as municipal and industrial water supply

Cost of Project

The assessment of predicted versus actual costs of dams for reservoir development is affected by the following conditions:

- Time consuming (up to 25 years) licensing procedures
- Changes of plans (mostly reductions) during licensing procedures
- Changes of technology during construction period
- Changes of interest rates or financing environment (taxes, VAT etc.) before completion
- Changes in legal framework such as Labor Act, Planning and Construction Act etc. during construction period
- War-time and post war obstacles (WW I and WW II)
- Variation in employment situation and competition for manpower

Cost estimates from the time of license approval and actual costs of the projects have been available from the 4 non-focal dams in the G&L basin. A common feature of all of the projects analyzed is that the actual costs of the projects have been higher than the estimated cost at the time of license approval. The main reasons for the deviation was the delay of 3-5 years till the start of construction for each of the projects and that the compensation part of the total costs (mainly for land acquisition) were higher than originally estimated.

6.2.3 *Benefits and Impacts*

Benefits

Hydropower

Mean annual production is approximately 10 000 GWh from an installed capacity of 2165 MW. The power production has far exceeded the original predicted. However, several hydropower plants initially established prior to the licensing system have been rebuilt and upgraded step by step and are influenced by new reservoir developments. It is therefore difficult to analyse how the actual power production compare with the predicted production.



Figure 6.4. Rånåfoss Power Station

(Source: Akershus Energiverk web- page).

Flood protection

Although flood mitigation was cited as a major reason for constructing the regulation dams, there were no specific targets set for flood control in terms of predictions to reduce flood levels, flooded area or damage. There has been a general trend towards reduced flood levels in the G&L basin during the last 150 years concurrently due to the establishment of reservoirs that permit coordinated flood management decision. Calculations of flood peak attenuation of the major floods in the main rivers from 1900 to 1999 show that today's reservoir capacity yields considerable extra flood attenuation. The dams will reduce the incidence of damaging floods in the lower part of the G&L Basin. Flood peaks have been reduced by about 20 percent. The most severe flood the last century occurred in 1995. The culmination level during this flood in Lake Øyern in the lower part of the G&L Basin was reduced by 1.9 meters by reservoir storage.

Irrigated agriculture

The G&L basin contains some of Norway's main agricultural areas, which comprise 2 400 km² or 5.8% of the total basin area. The climate and the distribution of rainfall in Norway do not call for a high interest in dam building in relation to irrigation. The agricultural land is widely distributed and there is a high variability of production. Most irrigation plants depend on existing lakes and rivers and to a small extent to smaller irrigation ponds, which supply water for a short period.

None of the reservoirs in the basin are built for irrigation purposes and there was no expected water withdrawal for irrigation from the reservoirs when they were licensed. In total, 3 265 properties in the basin had installations for irrigation in 1989 and the irrigated area was 385 km² or 16% of the agricultural area. Few of the irrigation installations withdraw water from the hydropower reservoirs, and water withdrawal for irrigation is negligible compared to the discharge of the main rivers of the basin.

Municipal and Industrial Water Supply

The municipalities in the basin have 227 water supply plants serving 682 000 inhabitants with water from main rivers, tributary rivers, lakes, and ground water resources within the basin. Lake Mjøsa is the only reservoir in the G&L basin with considerable municipal water supply interests. Of the 150 000 people living in the immediate surrounding of the lake, about 35000 persons use Lake Mjøsa as their source of drinking water. According to records the annual water abstraction from Lake Mjøsa is 4.75 million m³. Most of the water returns to the lake as runoff from sewage treatment plants and has minor effect on hydropower production.

Economic Benefits

The developments have had a positive effect on employment and the local economy. 2350 persons are employed in the G&L power sector. Public revenues from the hydro power production in G&L system amounted to NOK 534 million in 1998, of which 80 % went to the G&L region.

Impacts

- There has been no resettlement due to the construction of the dams and inundation of reservoir area.
- No impacts on socio-economic activities upstream and downstream apart from downstream flood protection are registered.
- No significant unexpected social impacts are registered.
- The dams act as migration barriers for fish migration.
- Changed water flow downstream the dams and diversion/intake tunnels.
- Negative effect on fish harvesting was the only predicted impact at the time of dam construction (The construction of most of the dams took place before EIAs were required). After construction negative impacts on fish, fisheries and aquatic biology has been registered.

6.2.4 Mitigation Measures, Public Participation and compliance with today's standards

The step-by-step hydropower development took place during a period of more than 100 years. All but one reservoir are modified natural lakes. The water level fluctuations are small. Reservoirs with great water level amplitudes are located in remote mountainous areas. The conflicts during the licensing process and the construction phase have been very moderate. Projects with strong opposition have not been developed. There are divergent views on this issue among stakeholders, but there is general agreement that the current impacts do not cause major conflicts.

A large number of hydropower projects were forwarded for licensing to the Parliament in post-war Norway, resulting in a growing frustration amongst the politicians having to deal with these applications one by one. A binary planning system was thus developed, with one set of plans for protection (The Protection Plans for Watercourses), and one set of plans for development (The Master Plan for Hydropower Development Projects). The Master Plan defines an order of priority for the consideration of individual hydropower projects on the basis of economic considerations, and the degree of conflict with environmental and other user interests. The Master Plan was, from the outset, a contested tool in hydropower policy, and it remains uncertain question weather or not the plan has had a conflict reducing function in the public debate on power policy. The various stakeholders have divergent views on the planning system and this is particularly related to the Master Plan.

The "Glommen Water Management Association (GB)" was founded in 1903 and the "Glommen's and Laagen's Water Management Association (GLB)" in 1918. Together they operate the reservoirs as a sector organisation for the hydropower producers in the G&L basin. GLB members include 21 hydropower and industry companies. GB and GLB hold licenses for a complex of 26 regulated reservoirs of small and medium size, which together provide some 3 500 million m³ of storage, equivalent to 16% of the runoff in the G&L basin. Optimizing the water resources for hydropower production is the main objective of GLB. However as a consequence of the increasing number of issues within water resource development the association also does other types of management work in the joint reservoir system, for example in relation to environmental issues.

The negative impact on fish and fisheries have been compensated and mitigated. Prediction of mitigation measures effectiveness for maintaining fish stocks were too optimistic.

6.2.5 Lessons Learned

- The step-by-step development history/process in the G&L basin, with alpine natural lake reservoirs and downstream power stations, has reduced the conflicts to other user interests and sectors.
- Periodic, planned re-evaluations of project operations provide a mechanism for incorporating changes in science, technology, social values, and user interests into project operations.
- The Protection Plan for watercourses and the Master Plan for Water Resources have been important tools for hydropower development planning.

- Regional distribution of income from hydropower development in the Norway is ensured and dependent upon by a formalised system involving compensation, taxes, license fees, the sale of licensed energy, and owner incomes.
- In the G&L basin, the combination of a moderate regulation and special flood operation procedures has high flood prevention effect.
- Flexibility in the authorisation of mitigation and co-operation in the G&L basin has yielded more effective measures to compensate for the negative impact of hydropower development.
- The Glomma and Laagen Water Management Association (GLB) is an important institution in the integrated operation of the G&L basin with respect to hydropower production, flood dampening and environmental mitigating procedures.
- In the G&L basin, systems for the monitoring and sharing of data are needed in hydropower production and flood prevention, to illustrate compliance with current regulations and to measure social and ecological impact.

6.3 Kariba Dam, Zambia and Zimbabwe

6.3.1 General

The Kariba Study is, as for the GLB, based information from a case study undertaken for the WCD process, where a common approach and methodology was used to assess the development effectiveness of large dams.

Kariba Dam, constructed in 1955–59, with a storage capacity of 180km³, extending over a length of about 300km, and having a surface area of some 5500km² at full supply level, is one of the largest dams in the world. The dam was constructed on the Zambezi river, along the border between the countries of Zimbabwe and Zambia and is jointly owned by the two countries. Kariba was designed as a single purpose hydropower project, but as it turned out both fishery and tourism became important benefits. Two power stations with a combined generation capacity of 1320 MW have been installed at the dam.

6.3.2 Project description

The Kariba Dam constitutes the following salient features:

Technical data

Type of Dam	Double Curvature Concrete Arch dam
Height	128m
Crest length	617m
Spillway Gates Discharge	6 gates, 8.8m wide and 9m high
Capacity of Spillway	9500m ³ /s
Length of Reservoir	280km
Minimum Retention Level	488.50m

Minimum Operating Level	475.50m
Total Storage	180.6km ³
Live Storage Maximum	64.8km ³
Surface Area	5577m ²
Depth of Stilling Pool	78m
Volume of Stilling Pool	410 x 106 m ³
Kariba South Bank Power Station	6 x 117.5MW = 705MW max capacity
Kariba North Bank Power Station	4 x 153.5MW = 615MW max capacity
Total Generation Capacity	1320MW



Figure 6.5. The Kariba dam

(Source: Encarta/Robert Harding)

Usage

- Kariba Dam was planned as a single purpose projects with the prime usage to produce hydroelectric power for the national and provincial power grid.
- Besides hydropower, Kariba yielded many other benefits that were not taken into account in the project justification. These include fisheries, tourism, irrigation development and wildlife conservation.

Cost of Project and Financing Arrangements

Stage 1 was originally assumed to cost £72.2 million (\$1230 million: all costs converted to constant 1998 US dollars). This was revised upward to £79.38 million (\$1350 million) during the tender stage. The cost increase was largely because of raising the dam by 6m, and the addition of one 100MW turbine unit. The final expenditure was £77.61 million (\$1320 million), or 97% of projected cost, in spite of the addition of two more spillway gates and extra work on the south abutment. Stage 1 was completed in 1960, on schedule, in spite of two record floods during the construction period.

In the 1955 planning document Stage 2 of the project would immediately follow Stage 1 and was then estimated to cost \$57.1 million. However Zambia decided to implement the Kafue project first, which delayed Stage 2 by several years. In 1970 a World Bank loan for Stage 2 was negotiated. The World Bank appraisal report mentions that with Kafue in operation, most of the power of Kariba Stage 2 was to be exported to Zimbabwe. The new target date for commissioning was 1974, with costs estimated at \$195 million.

6.3.3 Benefits and Impacts

Benefits

Hydropower

In the original planning document of 1955, the full station output was expected to be 6720GWh per year. The average output for the period 1977–1996 was about 6400GWh per annum, in spite of a slightly higher than planned maximum capacity of the turbines (1320 instead of 1200MW) and a 10% higher than expected flow. This indicates that the scheme is generally operated at lower heads than expected, and therefore also with lower efficiency.

If Kariba had not been built, then – in an all-thermal scenario – coal-fired steam plant would have been built in Harare (then called Salisbury), Bulawayo, Umtali and at several copper mines. The 1955 Kariba project report gives details.

CO₂ - reduction

The WCD case study of Kariba is also commenting that offsetting coal-fired generation, hydropower plants help to combat global warming. In this analysis, it is normal to assume that during the first 3 full years of operation the savings of CO₂ of the thermal plant are used to offset the CO₂ production associated with the construction of the project (cement, steel, diesel oil, etc.) and the decay of biomass in the reservoir. If after these first 3 years, the savings in thermal plant CO₂ are fully credited to Kariba at a rate of \$7 per avoided ton of CO₂ emission then the economic analysis for the project would yield an increase in the economic rate of return to 18.7%. Since the reduction of greenhouse gas (GHG) emissions does not reach the targets set by the Kyoto protocol, it could also be assumed that the marginal value is actually equivalent to the damage (rather than mitigation or avoidance) cost. The damage value is several hundred dollars per ton of CO₂ emission. The message is that the Kariba project has been an important factor in the combat of global warming.

Dynamic Power Benefits

Hydropower plants not only offset thermal generation, they also are well suited for a range of ancillary services (dynamic benefits): voltage and frequency control, load

following, system black start, etc. The magnitude of these dynamic benefits cannot be predicted accurately, but range from about \$20/kW/year to \$50/kW/year. If the lower value is taken, and credited to Kariba, then the economic rate of return increases to 15.9%.

Tourism

A thriving tourism industry has developed around lake Kariba since the dam was built, based on water sport, wildlife resources of the area and infrastructure (eg, airport and paved roads) provided by the Kariba project. 17 hotels have been constructed, 9 of them in Zimbabwe. They have a total of 933 beds, 706 of them in Zimbabwe.

Irrigation

The potential use of Kariba water for irrigation was not investigated as part of the project. A number of irrigation schemes have been established around the lake, and are drawing water from it. The amount of water being extracted by these irrigation schemes is too low to have any impact on power generation. In addition more irrigation development than has been established to date could have been carried out for the benefit of the people of both countries without significantly affecting the power generation capacity of the dam.



Figure 6.6. Satellite Imagery of the Kariba reservoir.

Source: NASA

Fishing

One major impact of Kariba Dam that was not mentioned in the project document is the fisheries industry that has developed on the lake. A large kapenta (Lake Tanganyika sardine) fishing industry developed, mainly in Zimbabwe, following the introduction of the fish from Lake Tanganyika in the 1960s. Unfortunately, the capital intensive nature of the kapenta fishing business makes it difficult for most of the local displaced people to easily

participate, and the industry has therefore not significantly benefited the local people who were displaced by the dam.

Fish yield in Kariba reservoir rose from 5.6 kg/ha per annum to about 33kg/ha per annum in 1986. Fishery and fish farming have become one of the most important secondary benefits of the Kariba project.

Impacts

There was no Environmental Impact Assessment (EIA) done for Kariba and therefore baseline studies on any of the environmental parameters are not available. A few impacts are however listed below:

- The water storage volume of Kariba reservoir of 180km³ translates into a mass of 180 billion metric tons. The reservoir is located in a tectonically active area, at the southern end of the African Rift Valley. Since its construction and filling in the early 1960s, Kariba has caused numerous earthquakes in the area, This is of significance for dam safety.
- Of the 5500 km³ inundated area, only about 1000 km² was cleared. The eutrophication of the reservoir led to a boom in fish in the first years of its existence. Also various waterweeds, including the water hyacinth, were prolific. The situation normalised after a few years.
- The Kariba lake environment has been beneficial to some species such as crocodiles and aquatic birds. The number of crocodiles on the southern shore was around 10 000 in 1985. In the early stages of the lake the number of hippos and buffaloes may have declined, but it has since risen considerably as a result of the development of *Panicum* grassland on the shore.
- Pre-impoundment studies on the mid-Zambezi identified 28 species in the area upstream of Kariba. The number of species now is 42, including those in the reservoir. In the reservoir, cyprinids, which need flowing water, have almost completely disappeared, whereas Cichlids have become the main fish in the littoral zones of the lake. Pelagic zone fish were absent before impoundment, but *Limnotrissa miodon* was introduced in 1976/77.
- As Kariba regulates most of the incoming floods, the number of times that the downstream Mana Pools are inundated is less than in the pre-dam period. This reduces the deposit of fresh alluvial material, which has led to a decline in grazer density. At the same time the occurrence of the dominant canopy tree *Faidherbia albida* declined and the occurrence of termites *Macrotermes* increased. The downstream impacts of Kariba Dam extend all the way to the Indian Ocean. The seasonal high and low floods do not occur as much as they did before Kariba. As a result, the Zambezi River does not break its banks as it used to, and the delta floodplain ecology has been negatively affected. Shrimp catches have decreased, floodplains have been invaded by upland vegetation because of the absence of annual flooding, mangrove are dying off because of poor flooding of coastal areas, productivity of artisanal fisheries in the delta area has decreased. And wildlife populations in the delta areas have been negatively impacted upon.
- Health issues were not included in the original Kariba Project Report. However the Kariba Lake Coordinating Committee, formed after the decision to build Kariba,

surveyed the incidence of diseases prior to impoundment and instituted programmes for disease control after the establishment of the dam. The reservoir does not in any way worsen the malaria situation, as the vector mosquito does not breed in large water bodies. During the construction period, a high number of sexually transmitted infections were observed. Of late, there is a steep increase in the number of HIV/AIDS cases in Kariba, as a result of tourism and the fishery industry (transport).

Resettlement

The pre-project planning document (1951) estimated the number of people to be resettled at 29 000. In the Kariba 1955 project document, there is little detail on the resettlement program, except for a budget allocation of £4 million that was to be spent on this program. A decision was made that each of the governments in Zambia and Zimbabwe would have responsibility for managing resettlement in their country. This decision meant that the resettlement program was removed from the main project. The actual number of people to be resettled increased from 29 000 to 57 000. The budget for resettlement remained unchanged.

Actual resettlement took place in 1957 and 1958. It was reported that the people to be resettled “were treated like animals or things rounded up and packed in lorries” to be moved to their new destination. Most of the new land was of poor quality and easily erodible. Also, as no recession agriculture was possible due to the far distance to the river, only one crop per year could be produced. Resettling too many people to areas too small aggravated the problem. It is therefore not surprising that food production decreased and famine occurred in the first years after resettlement. In later years many more problems occurred, caused by lack of water, breakdown of wells and other basic infrastructure provided as part of the resettlement program, as well as influx of commercial fishermen.

6.3.4 Mitigation Measures, Public Participation and compliance with today’s standards

When the WCD cas study was written (1999 – 2000) several programmes were underway to make up for the mistakes of the past and to uplift the living conditions and employment opportunities of the population affected. The Zambezi River Authority (ZRA), the Zambia Electricity Supply Company (ZESCO), the Southern Africa Development Bank (SADB) and the World Bank play an active role in this effort.

“Operation Noah” began in response to concerns about the fate of animals that would get drowned when the reservoir would start to fill. A wide variety of 4 000–6 000 large animals and numerous small ones were rescued. Mammals were initially released to the nearest shore, but after 1961 most animals were translocated to other parts of the country. Of particular note was the translocation of 40 black rhinoceros to Hwange National Park. This project led to the creation of wildlife sanctuaries along the southern lake embankment, which was one of the factors that stimulated tourism.

6.3.5 Compliance

In the 1950s there were not many laws and regulations in place for the construction of a major dam project in North and South Rhodesia. When rockfalls occurred during the

excavation of the Karibac North Bank Cavern, Zambia was seeking to invoke its Mines and Minerals Act, which contained a number of safety measures. According to the World Bank this “made it virtually impossible for the contractor to implement its work program”. Zambia eventually agreed to lift the act for the rest of the construction work.

There were no internationally binding design conventions, but by hiring reputed consultants it was assumed that all works would be state-of-the-art. In terms of environment there were no regulations whatsoever. Voluntarily Northern and Southern Rhodesia approached the government of Portuguese East Africa (now called Mozambique), to negotiate a minimum release from the dam. It was agreed that this mandatory release would be 10000 cusec or 283 m³/s. This value is still being adhered to.

6.3.6 *Lessons Learned*

- Hydroelectric schemes may have far more positive implications than just the production of electricity. The Kariba project provided access roads to hitherto isolated area; led to the development of a thriving fishery industry; triggered the formation of important wildlife sanctuaries; became a major tourist attraction; and was the basis for an interconnected electricity network of two countries. These developments cannot all be predicted accurately, but in future studies the development potential of non-electricity benefits should to be accorded more attention.
- Major hydropower projects can lead to continuously low tariffs, with major benefits for the residential, commercial and industrial consumers.
- Large man-made reservoirs can cause earthquakes, especially when they are constructed in a tectonically active area, as is the case of Kariba. The induced seismicity may affect dam safety and lead to other damages such as flooding of downstream areas and should therefore be investigated in the planning stages of the dam to ensure dam safety.
- With the numerous unexpected impacts that arose since its completion, the Kariba Dam illustrates the importance of systematic impact assessment in the planning of large dam projects. Many of the negative impacts of Kariba could certainly have been avoided if some impact assessment had been applied in a systematic way at the time. The impact assessment should as a minimum, address environmental impact, social impact and health impact.
- A dam project is governed and guided by the prevailing laws of the country. In situations where the laws are unjust, it is difficult for the project to deliver benefits equitably, and to minimise social and economic costs. As a minimum, it is important for a dam to ensure that the land rights of the people (especially the tribal land rights) are not lost as a result of the project.
- In dam projects, cases of involuntary resettlement require detailed planning and the full participation of the affected people in the planning process. In addition, the planning process must be carried out well ahead of resettlement process and must ensure adequate infrastructure in the new areas of settlement to minimise the trauma of resettlement for those displaced by the dam. As far as possible, the displaced people must be equally or more comfortable in their new settlement areas than their areas of settlement in the dam basin.

- Where resettlement process leads to community fragmentation, one of its potential consequences can be a loss of cultural identity.
- The effectiveness of a dam project must be evaluated on the basis of the extent to which it provides meaningful development opportunities for the people who are affected by the dam.
- In resettling people who are displaced by large dam projects, efforts must be made to ensure that the relocated people are familiar with the agro-ecology of the new areas of settlement, and that they have the necessary agricultural skills for their new settlement areas.
- Resettlement is not completed when the people affected are relocated. In addition to compensation aimed at enhancing livelihood conditions in a sustainable way, continuous support is necessary over many years to help them to get adapted to a new style of life.
- Projects of the nature of Kariba not only require regional co-operation, but are also opportunities for fostering it. As a large international and inter-country hydroelectric project, Kariba facilitated the creation of regional power pools and ensured reliability of power supply to the participating countries. In turn, regional power pools can reduce the unit cost of power through the optimisation of use and economies of scale.

6.4 Lesotho Highlands Water Project and Orange River

6.4.1 General

The Orange River Basin has a drainage area of about 1 000 000 km², with its origin in the Lesotho Highlands and Drakensberg Mountain-range. The mean annual runoff of the basin is 11 200 million m³, and 46 % of this is generated in Lesotho whilst only covering 3% of the basin area. Thus Lesotho with its catchments is the “water tower” of the Orange-Senqu³⁹ River Basin. This together with the growth and the “thirst” of the Gauteng Province (Johannesburg, Pretoria etc.) just north of Lesotho makes the highlands strategically important for Lesotho, but especially for RSA⁴⁰ in coping with its ever growing water demands (MNR 2007). These are the major reasons that sparked the development of the Lesotho Highlands Development Project.

Thus the Treaty of the Lesotho Highlands Water Project was signed in 1986, and has had the single-most greatest impact, together with the development of the associated highlands infrastructure, on the usage of Lesotho’s water resources. The LHWP is a massive bi-national multi dam construction project, and one of the biggest transfer schemes in the world. It was designed, based on the treaty arrangements, to divert about 40%, or 70 m³/s of the water of the Senqu River (Lesotho) into the Vaal River Basin⁴¹ in RSA. Under the terms of the LHWP Treaty the Lesotho Highlands Water Commission (LHWC) (formerly known as the Lesotho Permanent Technical Commission) for joint overview of the LHWP by RSA and Lesotho. Lesotho Highlands Development Authority (LHDA) and Trans-Mohakare (Caledon) Tunnel Authority (TCTA) was established in Lesotho and RSA respectively to manage the implementation, operation and maintenance of the project on either side of the border. LHDA

³⁹ Orange-Senqu is the Sesoto name of the Orange.

⁴⁰ Republic of South Africa.

⁴¹ Both sub-basins of the Orange

and TCTA are required to consult with LHWC on a wide range of designated implementation and financial matters.

The project and the associated dam and infrastructure development has been divided into six phases, whereupon phase 1A and 1B has been undertaken, phase 2 has started and phases 3, 4 and 5 are considered for the future. Major dams constructed during phase 1A and B constitute, Katse, Mohale and Muela dams.



Figure 6.7. The Katse dam in the Lesotho Highlands Water Project

(Photo by Astrid Janssen, Source: Lesotho IWRM Strategy 2007).

6.4.2 Project description

System Description and usage

The massive dams in the Lesotho Highlands principal role is to serve industrial and domestic water demand and needs in the Gauteng province of RSA, whilst at the same time produce hydropower for Lesotho. Besides this the Government of Lesotho receives royalties of the transferred water as defined in the Treaty of the LHWP.

The main structures of the highlands system are the dams, reservoirs and the transfer tunnels. The Mohale reservoir is connected to the Katse dam via a 32 km transfer tunnel, whereas the Katse reservoir is connected to the Muela reservoir that generates hydropower via a 45 km transfer tunnel. After the passage through the Muela hydropower plant the water is transferred, through a delivery tunnel, to the upper reaches of As river (in RSA), which is part of the Vaal basin. This water then flows northwards to the Vaal dam, where it is collected

for domestic and industrial use in the Vaal region of RSA.

Layout and technical data of main existing and planned LHWP structures is given below (see also figure 6.9 for a schematic overview):

Existing

Phase 1 (completed 1998)

- Katse dam: Concrete double arch dam with height of 185 m, crest length of 710 m and reservoir storage of 1950 million m³.
- Transfer tunnel from Katse reservoir to the Muela reservoir (45 km and 4 meters in diameter)
- Muela dam (ROR with a storage of 6 million m³) and hydropower station (72 MW)
- Delivery tunnel from the Muela reservoir to the Vaal river (37 km)

Phase 1A (completed 2002)

- Mohale dam: A rock fill dam with height of 145 meter and crest length of 620 meters and reservoir storage of 958 million m³.
- Transfer tunnel from the Mohale reservoir to Katse dam (32 km).
- Matsuko diversion weir (5-6 km)
- Transfer tunnel from the Matsuko weir to Katse dam



Figure 6.8. Mohale Dam, Lesotho Highlands Water Project

(Source: Terje Farestveit, Sweco).

Planned

Phase 2

- Mashai dam: 182 meters height with a 3306 million m³ storage reservoir. Includes a planned hydro facility of 166 MW.
- Transfer tunnel from the Mashai Reservoir to upstream of Katse dam (19 km)
- A Second transfer tunnel from Katse reservoir to the Muela reservoir (45 km)
- Upgrading of the Muela HPP to 110 MW
- Second delivery tunnel from the Muela reservoir to the Vaal river basin (37 km)

Phase 3

- Tsoelike dam with height of 155 m and a storage of 2224 million m³.
- Transfer tunnel from the Tsoelike reservoir to upstream of the Mashai reservoir (4.3 km)

Phase 4

- Ntoahae dam
- Transfer tunnel from the Ntoahae reservoir to upstream Tsoelike dam (4 km)

Phase 5

- Malatsi dam (not shown in Fig. 6.5. schematization)
- Transfer tunnel from the Malatsi reservoir to upstream of the Ntoahae dam

Cost of Project and Financing Arrangements

The total cost of phase 1 amounted to EUR 1.5 billion and attracted external funding from European export credit agencies (USD 380 million), the World Bank (USD 69 million), the EU Commission (EUR 50 million) and European Investment Bank (EUR 23.5 million), while the rest (approx. 1 billion USD) was endorsed by RSA. Phase 1B estimated at 1.1 EUR billion had a similar funding pattern but with EIB having a bigger share and RSA endorsing 450 million USD.

6.4.3 Benefits and Impacts

Benefits

Lesotho remains one of the least developed countries in the world with few major natural resources except for its water of which it consumes less than 6% domestically⁴². Government's strategy was therefore to maximize the benefit from the sale of the excess water. Savings in realizing the LHWP have been split between the two countries with 54% being allocated to Lesotho, in the form of royalties from South Africa. There are two types of royalties. The first one corresponds to the cost difference between the LHWP and the Orange Vall Transfer Scheme. This benefit is fixed and is shared between South Africa and Lesotho in a ratio of 0.46:0.54. The second type is related to the selling of water and is expressed as a rate per cubic meter of water delivered. These royalties were totally reinvested in a revenue fund allowed for creation of job opportunities and other development for local communities (roads, footbridges, small dams, forestry and soil conservation works). In 2006, a total of USD 35 million was granted for that kind of projects. The royalties has however been assessed not representing the real value of

⁴² This is however also due to its shortage of proper infrastructure in the lowlands, where most of the Basoto live, and where they witness periodic drought conditions during the dry season (Sweco Grøner and WL Delft Hydraulics 2007)

the water, although RSA took the cost of developing the highlands structures. Thus to partly compensate for this options to divert some smaller amount water from the highlands scheme to the lowlands, to meet the future demand of Lesotho has been proposed as part of the Lesotho IWRM Strategy. Model simulations of the highland system with RIBASIM have shown that this is feasible without curtailing future demand and needs in RSA (MNR 2007).

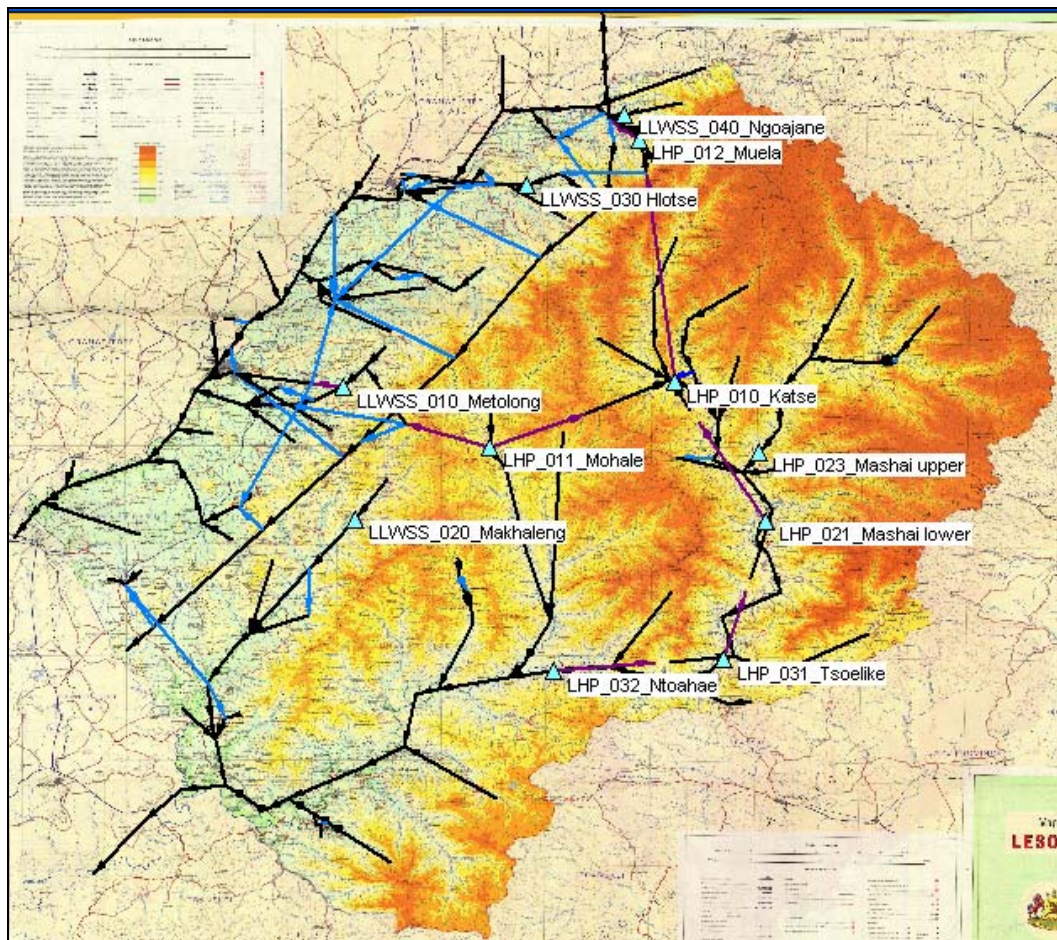


Figure 6.9. The Lesotho Highlands reservoirs shown as part of a water balance RIBASIM schematization undertaken as part of the Water Sector Improvement Project in Lesotho

(Sweco Grøner and WL Delft Hydraulics 2007)⁴³.

The water transfer to South Africa not only generates royalties but also gives some energy independence to Lesotho. Former to the implementation of the LHWP, Lesotho was a net importer of hydropower from South Africa. The LHWP also generates direct

⁴³ The water balance model was set up by Ron Paschier and Astrid Janssen from WL Delft Hydraulics

and indirect employment opportunities for local communities, but also in Maseru, the capital. Therefore the LHWP is a critical project that in many ways favors poverty relief and development for Lesotho (Duc and Carrasco 2007). LHWP has also brought along development in other infrastructure like roads, transmission lines and telecommunications. In total it has been calculated that Phase 1A constituted about 14% of GDP in 1994, whilst Phase 1B constituted 6.5 and 3.9% of the GDP in 1998 and 2002 respectively.



Figure 6.10. Mohale reservoir, Lesotho Highlands Water Project

(Source: Terje Farestveit, Sweco).

South Africa is an arid country with periodic droughts and a very unevenly distributed rainfall. Moreover, the availability of water is very unequal with a considerable part of the population still without access to safe water and adequate sanitation. Prior to the LHWP the chronic shortage of water was particularly acute in the Gauteng area with its large industrial activity and its numerous townships. While this region with a population of more than 10 million generates almost 60% of the national GDP, it is one of the very few metropolitan areas in the world not established along any natural body of water. An active and urgent search for additional water resources had therefore become of prime importance and inter-basin water transfers had been identified as the least cost solution leading to the comprehensive LHWP. Compared to a situation "without project" or with another project, Phase 1A and 1B of the LHWP results in savings to South African water users estimated at USD 30 million per year.

Impacts

The construction of the dams prejudiced about 27'000 people in Lesotho through the loss of arable land due to inundation and construction work, the depletion of vegetation cover and the impoverishment of local population. The losses are relatively small compared to similar large projects in other countries. However, in relation to the total arable land available in Lesotho, the loss is significant and has had profound effects on the local communities. Loss of land represents 1% of total arable land that stand for 13% of Lesotho area. The effects were even more serious because of inadequacies related to resettlement, replacement of land and compensation during Phase 1A. The LHDA indemnity policy was inadequate mainly because all farmers could not be compensated with new fields due to intense land pressure.

Critical long-term impacts of the LHWP on the environment are especially related to the aquatic environment. In order to assess the long-term impact, the LHDA requested Metsi Consultants to perform an Instream Flow Requirements (IFR) to predict the long term impacts of reduced river flows caused by the LHWP. This study, using the DRIFT methodology, has been claimed to be one of the most comprehensive IFR studies ever undertaken in the world, and the approached elaborated has been adopted elsewhere.

Metsi calculated the flow alternation due to the dams operation would lead "critically severe" biophysical impacts that will cost between US\$ 2.8 to 4.2 millions per year. Almost all aspects of geomorphology and water quality are predicted to show severe and/or critically severe changes close to the structures. For instance riverbeds will silt up and riffles will disappear in many places. Therefore habitat diversity will decline, this will have a negative impact on the food chain with a substantial decline in animal food available for fishes and birds. Decrease in different fish species (e.g. Maluti Minnow already highly threatened) will have negative influences in the nutritional levels of people, especially children having already low nutrition values.

Furthermore, soil erosion, in the highly erodible Lesotho, was exacerbated by the resettlement of people moving to more marginal areas in the highland. Erosion has been ranked as the main IWRM challenge in the country, by the stakeholders, in the Lesotho IWRM strategy (MNR 2007).

6.4.4 Mitigation Measures, Public Participation and compliance with today's standards

The LHWP began (in the eighties) before the implementation of environmental legislation, and therefore without an EIA. Problems encountered during the construction of Phase 1A, such as the lack of interaction between engineers, environmental scientists and the population, as well as compliance with the World Bank requirements lead to the elaboration of an EIA before the construction of Phase 1B.

Related to resettlement the compensation scheme involved building homes for people whose property was destroyed and by providing seedlings for lost trees. For each hectare of land lost, people were to receive 1'000 kg of maize every year during 15 years. However, the Transforming Resource Center (TRC) in Maseru relates that indemnification was not taken seriously or that the money was mismanaged. In fact corruption led to delayed, incorrect or insufficient compensation. For example, in 2005,

six years after construction began, many resettled people still lacked the electricity, sanitation and schools they were promised. Moreover the poverty of communities affected has worsened and local death rates increased.

Another problem occurring during the Phase IA, was the weak relationship between the government, the LHDA and the local population, e.g lack of public participation. Mitigation measures have not been discussed with the population before the beginning of constructions. This led to improper planning and implementation of these measures. This was ameliorating for the Phase IB by the application of an EIA in order to assess environmental and social impact of the project. The LHDA also started to work directly with communities and nongovernmental organizations (NGOs) for Phase 1B.

Furthermore, the WATSAN program under the Environmental Action Plan (EAP) aimed at mitigating adverse impacts resulting from the implementation of the LHWP. The program provides water supply to affected communities. It also provides ventilated pit latrines, clean potable water, solid waste, and sullage management systems.

The Metsi Consultant IFR study led to formulation of an IFR Policy that included criteria for quantifying river health status of project rivers. This should be expanded to a national system. Detailed studies for this will be needed. However based on information available, an additional coarse screening has been undertaken for a sampler of sites besides those reported in the IFR Policy Paper (2003). The IFR policy is also focused on status as a result of impoundment of water resources structures and should be adjusted especially related to pollution if applied to lowland areas.

In the classification system of the policy, conditions are divided in two; (i) present river condition class, which represents the pre-impoundment conditions of the rivers. This relates to both existing and planned impoundments; and (ii) target river class which represents the present condition class of river reaches after impoundment for existing structures and feasible condition class for planned structures.

6.4.5 Lessons Learned

So far the LHWP has been a very successful project in reaching it overarching goals, although there are some shortcomings in social and environmental issues. There are five major Lessons Learned from this project.

- Where there was detailed, competent, transparent, collaborative planning and preparation of projects is highly likely to result in sound outcomes.
- Where there was less planning and less participation, the results were more disappointing and damaging for the status of the project (e.g. the case of mitigation measures for phase 1A).
- Proper resettlement measures leads to less conflict and less impact on the environment (e.g moving people to more marginal areas sparking soil erosion). Thus this needs to be undertaken also including the catchment management perspective.

- Avoiding stakeholder participation in the design, planning, and implementation of projects will inevitably mean that important issues are overlooked and support for the project is undermined.

6.5 San Roque Multipurpose Project, Philippines

6.5.1 General

The San Roque Study is based on information gathered from different sources found on the internet.

The San Roque Multipurpose Project is one of the largest dam projects in Asia. The dam was constructed on the Agno River in the northern Philippines for four main objectives: electricity generation (345 megawatt capacity), irrigation of 87,000 hectares of land, flood control, and water quality improvements. Despite failure to comply with several Philippine laws and Japan Bank for International Cooperation (JBIC) policies, and despite strong opposition from local communities, dam construction was completed, and the commercial operation of the power component began in May 2003.

The project has been implemented with the partnership of San Roque Power Corporation (SRPC) and the Philippine government's National Power Corporation (NPC). The SRPC is comprised of Marubeni (owned 42.45 percent of the stocks of the company), Kansai Electric (7.5 percent) and Sithe Energies (50.05 percent)¹. In the Power Purchase Agreement (PPA) between the SRPC and the NPC, the SRPC generates power for 25 years and the NPC pays a fixed amount monthly to SRPC.

This combined hydropower and irrigation project involves a large reservoir, and it is notable that at the time of writing construction is being constantly interrupted by banning orders initiated by local groups who are objecting over issues relating to compensation and resettlement. The project is largely financed in the public sector by JEXIM (Japan Export Import Bank) and it is geographically split, with a number of government agencies taking responsibility for the "non-power" elements including the dam where much of the construction risk lies. The private sector element is the powerhouse, which is again largely financed by JEXIM backed by commercial lending.

6.5.2 Project description

The San Roque Multipurpose Project (SRMP) constitutes the following salient features:

The primary features of the San Roque Multipurpose Project are its massive gated spillway and 200-meter-high, 1.2-kilometer-long embankment dam on the Agno River spanning the municipalities of San Manuel and San Nicolas, Pangasinan, nearly 200 km north of Metro Manila.

The dam impounds a reservoir with a surface area of about 12.8 square kilometers extending North into the municipality of Itogon, Benguet. The gated spillway protects the dam from overtopping. Each wet season, the run-off is stored for later release via water turbines to generate power and irrigate crops.

The Agno River is the third largest river in the Philippines with a total length of 221 km and a drainage basin at the Project site of 1,225 square kilometers. The river originates in the Cordillera Mountains, initially flows from north to south, and divides into several channels in the flat central plain of Luzon and meanders westerly through the provinces of Pangasinan and Tarlac before emptying into the Lingayen Gulf.

Ownership of the dam and spillway was transferred to NPC upon construction completion, as it contributed funds for the non-power components on behalf of several agencies. SRPC will own and operate the power generating facilities for 25 years, after which their ownership transfers to NPC.

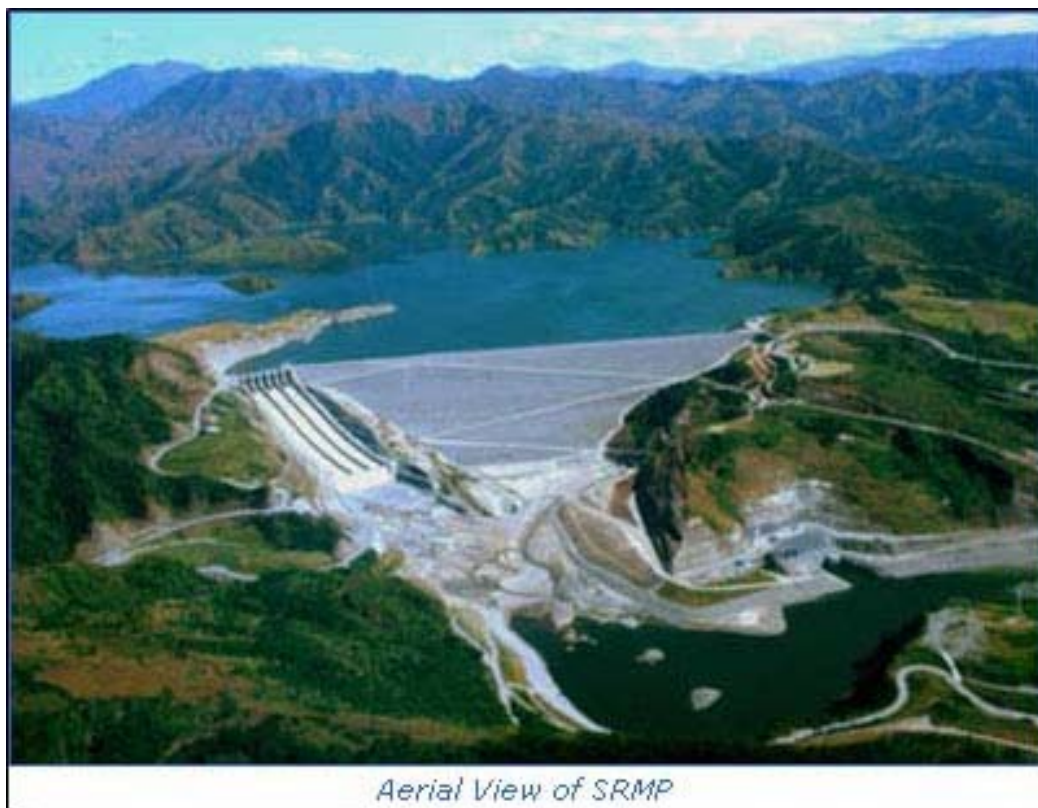


Figure 6.11. Aerial view of San Roque MPP

(Source: SRMP web-site)

Usage

- Prime usage is to produce hydroelectric power for the Luzon power grid
- Irrigation of 87,000 hectares of land,
- Flood control
- Water quality improvements.

Cost of Project and Financing Arrangements

The total cost of the project was \$1.19 billion. JBIC and private banks provided \$500 million in loans to the SRPC, and JBIC alone provided \$400 million in loans to the NPC. The financing for the dam construction and the power component has been disbursed entirely (as of January 2005), even though many outstanding environmental and social problems have not been resolved. The Philippines government is also requesting a JBIC loan for the irrigation component currently known as the Agno River Integrated Irrigation Project (some \$140 million), which has not yet been implemented.

San Roque Power Corporation (SRPC) financed and constructed the SRMP under a power purchase agreement (PPA) with the National Power Corporation (NPC) on a Build-Operate-Transfer (BOT) basis. SRPC substantially completed the SRMP February 14, 2003, at which time its peaking power, irrigation, flood control and enhanced water quality benefits became available to the surrounding regions, which include the Northwest Luzon Economic Growth Quadrangle. In reality, all but its power benefits have been available since mid 2002 when the dam and spillway were completed.

6.5.3 Benefits and Impacts

Benefits

Hydropower

The SRMP has an installed rated capacity of 345 megawatts (MW). It operates primarily as a peaking plant during periods each day when the electrical output of base and intermediate load power plants cannot fulfill consumer demand. The basis for the capacity payments under the PPA is a firm capacity of 85 MW. The balance is surplus power that reduces dependence on imported fuel oil and also lowers the variable operating expenses of other power plants.

The SRMP offers substantial power benefits in addition to the peaking capacity and energy considered in the economic analyses conducted by NPC and the National Economic Development Authority. Most of these benefits are unique to large hydroelectric facilities.

Irrigated agriculture

The SRMP can provide year-round irrigation benefits for 708 square kilometers of farmland downstream of the dam with a partially diversified crop during the dry season, mostly in Pangasinan, but including parts of Nueva Ecija and Tarlac.

Flood protection

The SRMP produces a marked attenuation (reduction) in the perennial flooding of the Agno River affecting at least 16 Pangasinan and Tarlac towns. For floods up to a 50-year event, or such floods so large as to recur only once in 50 years, peak outflows from the dam are at least one-third (1/3) less than peak inflows to the reservoir.

It is complemented by the 3-phase, PHP 9.7 billion Agno Flood Control Project managed by DPWH. Phase I is completed; Phase II is in progress; Phase III will begin in 2004 and be completed in 2009.

Water Quality and Sediment Trapping

The SRMP improves the quality of the water in the Lower Agno River via a proactive integrated watershed management plan (IWMP) and by trapping sediments caused by erosion and by such other sources as small-scale mining.

Impacts

Little literature is found on the impacts on physical and natural environment. Impacts on social environment is mainly taken from information on different NGO's internet pages. Some of the reported impacts are listed below.

- Sedimentation behind the reservoir will raise the level of the river bed and flood adjacent low-lying lands. Reservoir inundation may affect up to 20000 villagers of the Ibaloi, and indigenous people who depend on the Agno River upstream the dam.
- The Communities of Ibaloy, indigenous people living upstream of the dam, are strongly opposing the project, insisting that they will lose their access to land as a consequence of the project. The dam will prevent people from farming and subsistence gold mining by removing them to areas where those activities are impossible. It will also decrease the quality of the water by creating a large amount of sedimentation.
- NGOs have reported that more than 4,000 hectares of land were expropriated by the SRMP, 2,500 families were also forced to give up their agricultural land to make way for the project, including some 750 families' resettlement, and more than 3,000 gold panners lost their livelihoods.

NGOs also claim that the Power Purchase Agreement between the SRPC and the NPC heavily favours the SRPC. The cost of the power is greatly inflated, and the NPC has agreed to pay some \$10 million a month to the SRPC regardless of whether there is sufficient water available to generate power or not.

6.5.4 Mitigation Measures, Public Participation and compliance with today's standards

The project involves a large reservoir, and during construction the work was constantly interrupted by banning orders initiated by local groups who are objecting over issues relating to compensation and resettlement.

The Cordillera Peoples' Alliance estimates that if the dam is built, more than 35,000 indigenous people living upstream could be adversely affected by the project. International Rivers network is working with the CPA and the Ibaloi community organization, the Shalupirip Santahnay Indigenous People's Movement, to discourage JBIC investment in the project.

Thus, after the substantial criticism, the developer, San Roque Power Company (SRPC) has introduced a comprehensive social uplift program for the affected people, including:

- A Livelihood and rehabilitation Plan offers adequate economic activities for the affected families of San Miguel and San Nicolas, Pangasinan.
- An Indigenous Peoples Development Plan provides livelihood opportunities and assistance in capacity building activities to indigenous people affected by the project from Itogon, Benguet.

- The project company has facilitated construction and rehabilitation of school buildings and made provision for financial support and capacity building of programs for teachers.
- Health services such as medical and dental missions are provided.
- Infrastructure projects such as construction/rehabilitation of roads, bridges and foot trails, solid waste management programs, and provision/enhancement of water supply facilities are provided.
- Disaster Preparedness Program and Emergency Action Plan in partnership with governmental agencies.
- It is given provision of financial assistance to community affairs and activities such as fiestas, foundation days, and other significant community and organizational affairs within the host Local Government Units.
- SPRC is committed to the environmental compliance obligations set forth in the Environmental Compliance Certificate and the original, updated Environmental Impact Studies, implemented via an Environmental Monitoring and Management Plan and the Environmental Standards, Procedures and Practices and as further set forth in applicable permits, regulatory approvals, laws, rules and regulations.

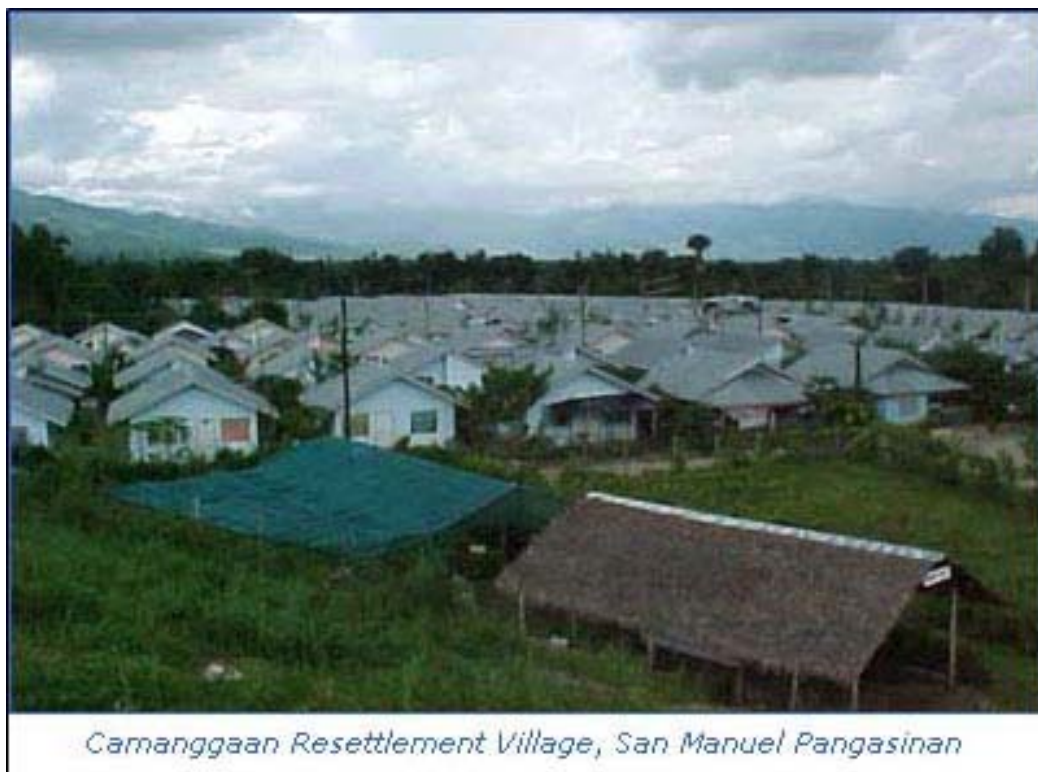


Figure 6.12. Camangaan Resettlement Village

(Source: SRMP web-site).

6.5.5 *Lessons Learned*

The SRMP is one of the very few multipurpose projects with a large reservoir financed as public private partnership, and the most interesting lessons to be learned from this project is how the project financing and ownership was arranged. As indicated above, the San Roque Power Company was responsible for construction of the reservoir dam with spillway and the powerhouse. Then, upon construction completion, ownership of the dam and spillway was transferred to NPC, as it contributed funds for the non-power components on behalf of several agencies. SRPC will own and operate the power generating facilities for 25 years, after which their ownership transfers to NPC.

The SRMP has been a very controversial project. NGOs are of the opinion that many of the problems could have been avoided had JBIC played a more active role in project selection and preparation, and had there been clear monitoring throughout project implementation. Further, the following preconditions should be secured before the financing was approved:

- To confirm the number of relocated in the reservoir area and secure the consent from them;
- To conduct consultations with any other project affected peoples than relocates (including the Indigenous Peoples) and surveys to confirm the number of the affected people;
- To secure remedies for all affected people (including the proper consideration for the Indigenous Peoples);
- To establish monitoring system for the environmental and social issues.

NGOs argue that participation of all stakeholders from the start of planning together with a transparent planning process are essential to a smooth implementation of the project.

6.6 Senegal River Basin

6.6.1 *General*

The case of the Senegal River basin constitutes integrated transboundary management of the area, especially between the riparian states. Two main structures are central in this regard, the upstream Manantali Dam (Mali) and the downstream Diama dam (Senegal). The Organisation for the Development of the Senegal River (OMVS) is responsible for integrated management of the river basin, including operation of the two dams, with its mandate to ensure food security and harmony among riparian users. Combined the two main dams provide energy, irrigated agriculture and year round navigation. The management approach of the OMVS is based on a concept of "optimal distribution among users" rather than volumetric water withdrawals. The basin, which covers 300 000 km² and is the largest in West-Africa, has three distinct parts: The upper basin, which is mountainous, the valley (divided to high, middle and lower) and the delta, the latter a source of biological diversity and wetlands. It is shared by Guinea (11%), Mali (63%), Mauritania (26%) and Senegal (19%). The basin has a total population of about 3,5 million inhabitants, 85% of whom live in the vicinity of the river (WWA 2006). The river basin is core to the economic activity and social development in the riparian states.



Figure 6.13. Senegal River Basin with Manantali and Diama dams

(Source: WWA 2006).

6.6.2 Project description

Management Challenges

The OMVS river basin organisation was established about three decades ago by three of the four riparian states⁴⁴. The OMWS functions with the following management permanent bodies: (i) Conference of Heads of State and Government; (ii) Council of Ministers; (iii) High Commission, executive body; (iv) Permanent Water Commission (defines the principles and procedures for the allotment of the Senegal river water between member states and water users). Additionally various non-permanent bodies are set up/exists. The organisational framework is statutory strong but flexible on the operational level, which enables for effective participation.

Mali's principal interest are the maintenance of river levels so as to obtain navigable access to the sea and energy production, Mauritanian and Senegalese interest converge in power production and irrigation, whereas Senegal also seeks improved livelihood for local populations.

⁴⁴ Senegal, Mali and Mauritania

Technical data - Dams

- The *Manantali dam* (Mali) was commissioned in 1988, some 1200 km upstream the river.
- Height of the dam is 70 m, whereas crest length is 1 600 m. Total capacity is 11,5 bm^3 whereas the active storage is 8 bm^3 . Area of the reservoir is 345 000 m^2 .
- The dam is a buttress dam with adjoining rockfill dams on both sides with a clay core
- The *Manantali dam* has an installed capacity at 200 MW (5 kaplan turbines à 40 MW). It is connected to a 1300 km transboundary transmission line system, and the power station came online in 2002, and worked at full capacity from May 2003.
- The *Diana dam* in the delta, originally designed as a salt wedge dam, is located some 23 km from St. Louis near the mouth in the river delta in Senegal. It has an embankment 80 km long and controls the entry of floodwater to some 250 km^2 . The dam permits floodwaters to pass through its sluice gates while preventing the encroachment of salt water; it has improved considerably the supply of fresh water in the delta region.

Usage

Manantali

Initial objectives were to;

- Produce 200 MW, to furnish an average 800 GWh/year for the transnational (Mali, Mauretania and Senegal) grid. The predicted energy production is now however at 547 GWh/year.
- Help regional food sufficiency in cereal production, and particularly rice, to be attained through irrigated agriculture. Irrigated agriculture rapidly expanded after the new dams were filled, with the irrigated area increasing from 20 000 ha in 1980 to the present 100 – 120 000 ha (WWA 2006).
- Through flow alternation, support navigation up to Kayes in Mali, also constituting an internal port of trade with associated inland development (IUCN).



Figure 6.14. The Manantali dam

(Source: OMVS)

Diama dam

The dams threefold purpose is to (WWA 2006);

- Block seawater intrusion and thereby protect existing or future water and irrigation wells
- Raise the level of the upstream waterbody, creating reserves to enable irrigation and double cropping of around 42 000 ha at an altitude of 1,5 masl and 100 000 ha at an altitude of 2,5 masl; and
- Facilitate the filling of the Guiers Lake in Senegal and Lake Rkiz and the Aftout-es-Saheli depression in Mauritania.

Cost of Project and Financing Arrangements

The loans to construct the Diama and Manantali dams were guaranteed equally by Mali, Mauritania and Senegal. Furthermore there is a huge sampler of other infrastructure and development activities that has been developed in conjunction or concurrently with the dams under the Senegal River Basin initiatives, including transmission lines for power service delivery to the three countries. Financing spans some 2-3 decades from construction of the dams to the more recent Regional Hydropower Development Project which is a multi-donor initiative of USD 445 million equivalent to bring value to past investment in the Diama and Manantali Dam. Besides WB other donors involved include KfW of Germany, AFD of France, CIDA, EU/EIB, Islamic Development Bank (IDB), AfDB, Arab Fund for Economic and Social Development (FADES) and West African Development Bank (BOAD). Financing of the operating cost of the various OMVS bodies, comes directly from the member states divided in equal 1/3 shares.

6.6.3 Benefits and Impacts

Benefits

Hydropower

Since the Mantali HPP has been in operation from September 2001 it has provided electricity to the three OMVS countries in a much more reliable and extensive manner through the interconnected grid, than beforehand construction of the power station and the grid. A benefit from this is that the increased available electricity, although not sufficient, is slowly transforming the economies of the OMVS countries. Another secondary benefit of reliable energy (and water) supplies is that this is encouraging income generating activities, and making investment less risky in the OMVS economies (Anon. 2004). Construction of the Manantali power plant has also resulted in cheaper electricity in the three member states, and to electrification of villages near the dam (WWA 2006).

Irrigated agriculture, domestic and industrial use

Before the two dams were filled in the late 80's, locals were directly dependent on rainfall (rain-crops) or on floods (flood recession crops), thus prone to variable drought and flood conditions. The dams enabled the development of large areas of land for irrigated agriculture to contribute to food security⁴⁵. Although at present water for irrigated agriculture is some 100 – 120 000 ha, the increase from 20 000 ha mainly due to the dams (WWA 2006), the plans through the OMVS program is that 375 000 ha should be made available for irrigation (IUCN 2004). Furthermore, the Diama dam has improved considerably the supply of fresh water in

⁴⁵ Including double cropping.

the delta region⁴⁶, and supports irrigated rice fields with water at minimal pumping cost (Duvail et al. 2003).



Figure 6.15. Rice Fields in the Senegal river basin

(Source: UNESCO)

The year round availability of freshwater has also provided water in sufficient quantities for domestic uses, agro industry and to groundwater recharge. Together with increase in agricultural land a secondary effect of this has been economic growth and better job opportunities thus a reverse immigration of people who had left to find employment in the cities (WWA 2006).

Navigation

The dams help support navigation up for 900 km up to Kayes in Mali. Although Kayes constitutes an internal port of trade with associated inland development (IUCN), navigation on the river is however far below its potential. OMWS is aware of the strategic importance of navigation development and a navigation project is under study. The ability to increase the transportation of heavy goods at a lower cost could give a new impetus of the regions economy (WWA 2006).

Other and secondary benefits

The dams and especially the Manantali both mitigate the potential damage related to flood and drought conditions, as was the case of the 2003 flood.

Furthermore the countries have benefited from using their common physical and institutional infrastructure, which includes shared hydrological data collection, to jointly manage extreme events, such as floods and droughts⁴⁷.

Although flow alternation due to construction of the dam has affected aquatic and estuarine ecosystems especially, the sluices at Manantali dam enabled for artificial flood releases to partly mimic the “natural” flow regime⁴⁸. This took first place in 1995 and has together with

⁴⁶ Through prevention of intrusion of saltwater in the delta region

⁴⁷ As for the case of the above mentioned 2003 flood.

⁴⁸ E.g. the annual flooding, also designed to optimize flooding for cultivation of 50 000 ha of floodplain.

habitat improvement positively affected fauna, flora and livelihood activities (including recession agriculture) especially in the valley and delta regions (IUCN 2004)⁴⁹.

In connecting Manantali to the three national grids, dual purpose fiber optic technology was used for the transmission lines, which the telecommunication sector can also use, thus lowering communication cost.

The dam constrictions has partially opened and stimulated exchanges between areas they have been built and the rest of the sub-region due to road construction, and improved healthcare for nearby villages through construction of dispensaries and health clinics as well as supported development of fishing activities for populations living near the Manantali dam.

Impacts

A major impact of the OMVS development program and the two dams is that the flood plain ecosystem has changed from a salty and brackish aquatic environment with marked seasonal changes to a low-flow perennial freshwater ecosystem (WWA 2006), with thus associated faunal and floral changes in species composition and biodiversity as well as affecting ecosystem dynamics. More specifically the dam constructions has had the following negative effects (IUCN, WWA 2006):

- Proliferation of water borne diseases (bilharzia, malaria, diarrhea) due to changes in ecological conditions as a result of the blocking of seawater intrusion with the Diama dam. This is exacerbated by the favorable environmental conditions for the growth, spread and increase of snails, an intermediate host of several diseases.
- Proliferation of water weeds in the valley and delta. Clogging water courses and contributing substantially to making the ecosystem and their dynamics more uniform.
- Modification of the hydrodynamic characteristics of the estuary with the reduction of the flushing phenomenon of seasonal floods.
- Water pollution caused by the development of irrigated agriculture and the agro-industry (CSS and SAED in Senegal, SONADER in Mauritania).
- Disappearance of wetland areas
- Increase in soil salinity in low-lying parts of the flood plain
- River basin erosion, especially in the upper part where the topography is more rugged
- Decline of the flood-dependent woodland plant species, *Acacia nilotica*, a major source of fuel and construction wood
- Reduction of fish yields due to loss of floodplain habitat for fish feeding and reproduction
- Potential loss of habitat for migratory birds in the delta

Related to the socio-economic issues besides the obvious impact on the displaced people for both dams⁵⁰, the following impacts has been reported:

- Loss of land available for recession agriculture and an increase in conflict through greater competition for a reduced and homogenized resource base
- Reduction of pasture land and loss of floodplain habitat for livestock grazing
- Emigration of adult males seeking alternative means of financing the capital cost of rice production thus also increasing number of woman and children doing formerly male tasks

⁴⁹ The Diawling Experience.

⁵⁰ Population resettled for the Manantali dam was some 10 000.

6.6.4 Mitigation Measures, Public Participation and compliance with today's standards

Work has been undertaken to restore the livelihoods (especially recession agriculture) lost by the drought and flow alternation. The yearly artificial flood release is contributing to this. Furthermore, to restore the valley's ecological diversity and rural livelihoods, Mauritania and Senegal both established the Djoudi and Diawling Parks in 1971 and 1991, respectively.

Community level measures have been especially effective. For example, market gardening has proved successful in providing an alternative income source for local populations, especially women.

The addition of the two sluice gates at Manantali and the release of the yearly artificial flood have positively affected floodplain and delta ecosystems.

Public participation is quite high on the agenda for OMVS and they are reaching out to stakeholders by inviting their representation in its central advisory bodies such as the Permanent Water Commission. Furthermore, conflicts among different water users were avoided in the case of Diawling National Park by working directly with local communities. Some have however voiced that also top-down planning without relationship to the local needs of the beneficiaries have occurred also for the Senegal river development (WWA 2006)

The Senegal River Basin Monitoring Activity was initiated in 1988, whereupon the aim was to explore the socio-economic and environmental impacts of river impoundment at Manantali on riparian communities in the Middle Valley. In 1998 OMVS created the Environmental Impact Mitigation and Monitoring Programme (PAISE), designed to address, monitor and mitigate the environmental issues related to power generation from Manantali power station. Establishment of an Environmental Observatory as part of PAISE was due in 2000. In 2002 the Senegal River Water Charter was signed amongst others with legal and regulatory frameworks for water allocation and use and environmental protection.

Environmental impact assessment, mitigation measures and public participation for the Senegal River Basin Development in general comply with today's standards, although some issues areas have been under scrutiny and criticism⁵¹.

6.6.5 Lessons Learned

The OMVS has demonstrated its effectiveness. It has been tested for more than 30 years, and was recently improved by the adoption of the Senegal River Charter in May 2002. This enables a collaborative management approach, with effective involvement of local stakeholders. It is also effective in collaboration amongst the riparian states, including Guinea. And the importance of working with riparian communities during all stages of the water resources development, particularly related to dam operation has been highlighted.

The OMVS and its framework has also established principles and terms of water sharing between the different usage sectors, based on the original concept of water distribution among the users and riparian states in which sharing the water resources is no matter of withdrawals but one of optimal satisfaction of usage requirements.

⁵¹ See for example Koopman 2004 and DeGeorges et al. 2006 on resettlement issues and impacts on recession agriculture.

The lesson from Senegal river is also that in mitigating flow alternations through artificial releases of floods, both livelihood and ecosystem health can be better of.

6.7 Xiaolangdi Multipurpose Project

6.7.1 General

The Xiaolangdi Analysis is based on the World Bank Project Performance Assessment Report, World Bank internet pages and official Xiaolangdi internet pages.

Xiaolangdi Project, a key Chinese national project, is located 40km north of the ancient city of Luoyang in central China's Henan Province. The project is the largest of its kind on the Yellow River, and is second only to the Three Gorges project on the Yangtze. Xiaolangdi is a multi-purpose project for flood control, ice control, dredging, industrial and municipal water supply and hydroelectric power. The region surrounding the lower reaches of China's second longest river is densely populated and a major agricultural area. This area has been subjected to devastating Yellow River floods, which China is determined to end. Xiaolangdi is one of 27 dams planned for the river.

Yellow River projects are especially challenging because of local conditions because of rapid loss of soil and erosion upstream builds up into high sediment levels downstream. This raises the river bed and affects floods.

The owner of the project is PRC, with the Yellow River Commission as the implementing agency.

6.7.2 Project description

The project consists of underground generating units, silt-discharge channels and a 1,317m -long, 154m - high dam.

The project's 12.8km³ reservoir extends some 130km. It is designed to trap sediment for the first 20 years of operation and then reach equilibrium. A complex system of 15 large tunnels with an underground powerhouse makes it possible to flush sediments by creating controlled floods in the main river channel. Three silt-discharge tunnels were completed ahead of schedule in spring 1999 to ensure the project could cope during the summer flood season.

The Xiaolangdi MPP constitutes the following salient features:

Technical data

Type of Dam	Rock-fill
Height	154 m
Crest length	1317 m
Power Station installed capacity	6 x 300 MW = 1800 MW



Figure 6.16. The Xiaolangdi dam and intake

(Source: The Xiaolangdi dam website)

Usage

The Xiaolangdi Multipurpose Project will

- Introduce flood control in the lower reaches of the Yellow River Basin to protect major infrastructure and 103 million people;
- Control siltation in the 800 km downstream channel of the river and prevent further aggradation so that levee heights need not be raised further during a period of 20 years;
- Provide water for assured irrigation for 2 million hectares and more stable water supplies for downstream cities and industries;
- Generate hydropower for supplementing the base load of thermal stations in Henan Province and the Central China Power Network.

Cost of Project and Financing Arrangements

The Xiaolangdi Multipurpose Project was designed as a two-phase operation. The initial Xiaolangdi Multipurpose Project, estimated to cost US\$2,294.0 million at completion of the second phase, was approved in April 1994 for a loan of US\$460.0 million and was closed on schedule in December 2000 fully disbursed. The Xiaolangdi Multipurpose Project I1 was approved in June 1997 for a loan of US\$430.0 million at which time total project costs had decreased to US\$2,855.8 million. The project was closed as scheduled

in December 2003 when US\$80.5 million was cancelled. Total project cost at closing was US\$2,688.8 million.

6.7.3 *Benefits and Impacts*

Benefits

Flood Control

Flood control is the priority of the Xiaolangdi project. Flood protection is provided to Henan and Shangdong provinces downstream with its infrastructure, towns and 103 million people mainly in the rural areas of the North China Plain. The Xiaolangdi dam and reservoir together now provide protects against all floods with a one in thousand year probability. Prior to the project, the existing infrastructure of dams and dykes only offered protection against floods with a one in sixty year probability. By means of careful water flow regulation, Xiaolangdi has also successfully prevented the formation of 'ice dams' that used to cause flooding in winter when downstream sections of the river froze.

Sediment Accretion and Flushing

Sediment accretion in the 800 km lower reach of the Yellow River has been halted and the river bed has been lowered through the planned release of artificial floods from the reservoir. It was estimated at appraisal that the reservoir would trap 7.5 billion cubic meters over its first 10 years of operation. This target has not been reached primarily because of the reduced inflow of sediment to the reservoir.

Managing the high sediment load of the Yellow River presents the Commission with complex and nearly unique challenges. The need to trap some coarser sediment while allowing finer silt to pass through the reservoir, was explicitly incorporated in the design, which envisaged a progressive filling up of the lower levels of the reservoir, while always preserving a substantial amount of live storage for flood control and water Sediment Flushing Operations.

The flushing operations have been remarkably successful. The flow capacity of the main channel of the river has been raised from 1,800 m³/sec to about 4,000 m³/sec as a result of the deepening of the channel by about 1 m on average. Total silt transported out to sea has been estimated at about 260 million tons as a result of the flushing operations.

Water Supply and Irrigation

Water shortages in the lower reaches of the Yellow River prior to the construction of the Xiaolangdi project were chronic. In the two decades prior to the project, it was not unusual for the river to dry up completely for weeks at a stretch. Yet despite drought conditions in 2000-02, the water stored in the reservoir and controlled releases throughout the year have meant that, since 2000, water flow in the lower reaches of the Yellow River all the way to the sea, has never been interrupted. The ecological benefits have been considerable: freshwater wetland areas have reappeared, as have fish species that have not been present since the 1980s. The availability of silt-free water downstream of Xiaolangdi is also beneficial as it reduces the cost of urban water treatment and sedimentation of irrigation canals diverting river water.

Although water supply for irrigation has been improved, it is below targeted levels because of overall water shortages induced by water tariffs that do nothing to reduce consumption, and upstream water diversions in the Yellow River Basin. In addition the provincial government failed in the second phase to increase power tariffs according to covenants and full-cost pricing of water released for downstream use has not been implemented by the Yellow River Conservancy Commission (YRCC).



Figure 6.17. Xiaolangdi – Flow discharging through tunnel outlet

(Source: *The Xiaolangdi dam website*).

Hydropower

Electricity production from the project rates last in the order of priorities, but is the sole source of revenues to pay off the construction debts and cover the running costs of the entire operations of the Corporation. At the same time the hydroelectric plant plays a vital role in the Henan provincial power supply system.

Xiaolangdi (1800 MW) is the largest generation plant in Henan and accounts for almost three-quarters of all hydro in the province. Xiaolangdi plays a valuable role in meeting peak electricity demand and in 2005 its capacity represented over a tenth of the total demand of 17,600 MW on the Electric Power of Henan (EPH) system. Its size also makes it a key plant for EPH in frequency regulation and maintaining grid stability. The fast response time of hydro generation units gives it an important role in ensuring uninterrupted supply in the event of unplanned shutdowns by thermal plants. Annual

generation plans take into account the water supply needs of urban and agricultural users and are jointly agreed between EPH, the provincial government and the Corporation. EPH is the Corporation's only client.

The first 300 MW unit went into service in late 1999 and the final one was commissioned two years later. Although total electricity generation by Xiaolangdi in the first three years was substantially below expectations, largely due to drought-induced low flow, it has exceeded 5,000 GWh in both 2004 and 2005 and is expected to continue at about this level in the next few years. This exceeds the targeted energy production of 4,773 GWh in the period 2002-08. At the current average sales price of about Y 0.32/kWh, this production gives the Corporation gross annual revenues of about Y 1.6 billion (US\$ 205 million).

Impacts

A full Environmental Impact Assessment to World Bank Standard was carried out before the project implementation. The Environmental Study Area (ESA) extends approximately 1000 km along the Yellow River. This area was divided into three areas for EIA study purposes: the reservoir area and surrounding region upstream to the Sanmenxia Dam, the lower river reaches, and the estuary and delta regions.

Although the EIA covered all environmental aspects, four issues were identified as being of critical importance: dam stability and safety, resettlement of the population, cultural heritage, and public health.

Dam stability and safety

The mass of the dam and its reservoir may increase the risk of induced earthquakes in or near the reservoir area. Because the project dam site is in a region prone to serious earthquakes, dam safety was given particular attention. The issue was the subject of extensive analysis by the YRCC and an International Panel of Experts. The assessments of, and provisions for, dam safety are believed to have been the most detailed ever undertaken anywhere in the world for a major dam. A wide range of safety features were provided in the project design including: (a) access road systems located so that if access to one bank is interrupted, access to the other bank would be maintained, (b) a comprehensive communications system, including microwave and radio wavelengths; (c) emergency power supplies; (d) an integrated reservoir flood regulation plan to utilize all reservoir capacities to minimize flood hazards under extreme flow conditions; (e) emergency response planning to account for possible failure of the coffer dam during construction; (f) a Flood Emergency Response System established and operational in the lower basin and elsewhere in the basin.

Resettlement

Resettlement planning and management represented a major effort that outweighed the rest of the environmental studies. A total of 182,000 people required resettlement from the reservoir area, and a detailed plan was prepared to carry this out in progressive stages. Account was taken not only of the population directly affected by the project (i.e. the people displaced by inundation), but also the host populations in the areas receiving resettled families, who also would be significantly affected. The two main objectives of the resettlement plan are that both the resettled and host communities will not be

disadvantaged by the project and will share in the project benefits. The salient criterion is that no families will be disadvantaged by the project.

To achieve the objectives for resettled families, they were re-established in new locations, where the house, yard and amenities would be at least as good as the family's previous situation, where the family's new earning potential would be at least as good as previously, and the family's expense and loss in income in making the transition would be duly recognized, accounted and compensated for. The resettlement planning included detailed evaluations of objectives by reviewing provisions and proposals in connection with economic effects, housing, amenities and public services, and social and cultural effects.

Adequate compensation provisions were calculated for the resettled families and the following outstanding issues were identified:

- Provision for the continuation of an agricultural life-style should only maintain current incomes (rather than increase them). Non-farm income sources were taken into account in assessing compensation.
- Successful relocation of the rural people from the three most affected counties would be dependent on timely completion of schemes to accommodate them. Early construction of these projects would be important.
- Care was taken not to over-estimate potential crop yields in resettlement areas, since this would tend to reduce the areas of land allocated to resettled families.
- Timely action would be required to complete agreements between resettled persons and host villages to enable resettlement action to match the scheduled program.
- Consideration was given to introducing preferential policies for rural resettled people and their hosts, including special status for scarce farm inputs, direct sales of farm products, training, exemption or reduction of grain quotas, priority for jobs in rural enterprises, subsidies and tax exemptions.

In summary, the project resettlement plan was, in its time, judged to be the most detailed and competent plan yet developed for any major dam project in a developing country, and it is believed, given the planned continuing periodic monitoring, that the plan will be successful not only in avoiding downgrading of socio-economics but also in actually enhancing the socio-economics for most of those people resettled. No one should be disadvantaged.

Cultural heritage

The Yellow River runs through the 'Cradle of Chinese Civilization' and archaeological relics are plentiful throughout the river basin, especially in the main population and farming areas of the middle and lower river reaches, but less so near the dam site. A detailed comprehensive archaeological exploration, classification and salvage programme has been undertaken to locate, recover and protect important underground and surface relics and cultural treasures in the inundated area.

Public health

The prevalent communicable diseases common in the study area include malaria, encephalitis, hemorrhagic fever, brucellosis, paragonimiasis, and sanitation-related enteric diseases including dysentery, hepatitis, and typhoid. The project markedly

changed the hydrology of the Yellow River by the creation of the reservoir, and also by increased irrigation of the surrounding and downstream agricultural areas. These changes modified the ecological conditions for vector-borne diseases such as malaria and encephalitis, and for communicable diseases such as dysentery, hepatitis, and typhoid. Inundation of the reservoir area also forced the mass out-migration of disease bearing rats, almost certainly resulting in an increased incidence of hemorrhagic fever in the surrounding population near the reservoir. In addition, the influx of construction workers increased the risk of both insect-borne and sanitation-related enteric diseases in the vicinity of the construction and host areas.

Other significant impacts

Other forms of impact which were analysed included: fisheries (in-stream, aquaculture, estuarine and coastal); water quality; land accretion in coastal areas; inundation of physical and ecological resources; landslides in the reservoir; reservoir seepage; reservoir area clearing; rare species and special habitats including wetlands; and global environmental issues. The analyses showed that the adverse impacts on these aspects of the environment would generally be small and/or controllable, hence would not result in significant adverse effects. Some forms of impact (e.g. on greenhouse gas emissions) were assessed as being positive.

6.7.4 Mitigation Measures, Public Participation and compliance with today's standards

Several environmental enhancement measures were included in the overall project, namely development of the immediate reservoir vicinity into a recreational/tourism area, including reforestation, and use of downstream river water to promote aquaculture and to furnish additional water to precious eco-wetlands. Work on institutional and economic aspects included evaluation of the attention in project planning to public participation (which included consultations with local community NGOs, especially on resettlement; evaluation of compliance of the project and its components with applicable environmental laws; and evaluation of effect of the costs of environmental protection measures on the project's overall economic/benefit-cost analysis.

Since the project closed the Corporation has had approval to construct a small re-regulating dam, Xixiyuan, 16km downstream of Xiaolangdi. This will provide daily water storage to iron out spikes in downstream water releases resulting from surges in power generation. It will thereby give the EPH dispatch centre greater operational flexibility and reduce the scope for conflicts between the use of water for power generation and non-power uses. The associated 140 MW power plant will also contribute modestly to electricity production by 500 GWh/year.

Environmental Management Plan

A salient feature of the recommended environment protection program is the establishment of an Environmental Management Plan which includes the provision of an Environmental Management Office that will have a lead and coordinating responsibility for implementing all the required environmental protection measures. These include the management of continuing periodic monitoring for assessing the actual effects of the project, and where indicated by the monitoring data, to plan and implement needed correction measures, with routine periodic reports (and special reports when needed) for

distribution to concerned government agencies and to the World Bank, all to be funded as part of core project funding.

6.7.5 Compliance

Safeguard compliance

The project raised three safeguard issues: dam safety, involuntary resettlement and cultural heritage. The dam lies in an earthquake-prone area and could be subject to an earthquake of magnitude 6.25 on the Richter Scale. Project design fully internalized this risk in the design of the dam and its embankments. A network of seismometers has been operational since 1995. A Dam Safety Panel has independent oversight of the facility. Satisfactory arrangements are in place for dam inspections and emergency preparedness. The project was less successful in imposing dam safety requirements on the Sanmenxia dam that lies upstream (the flood wave from the collapse or overtopping of this dam would threaten the safety of Xiaolangdi).

Resettlement of 184,040 people was subject to a stand-alone resettlement project that met the requirements of the World Bank's policies on involuntary resettlement (OP 4.12.).

The WB's recent evaluation of this rated it as satisfactory but with reservations on the cessation of Monitoring and Evaluation (M&E) activities on credit closure. Without continued M&E it is impossible to monitor the longer term impacts of enforced resettlement on the welfare and incomes of affected people and host communities. Lack of knowledge precludes establishment of measures to mitigate hardship and accelerate a return to normality.

Extensive archaeological investigations, classification and salvage programs were implemented and completed satisfactory.

6.7.6 Lessons Learned

Good planning has resulted in a sound economic-environmental development project for the Lower Yellow River Basin. Some lessons learned from the project, as stated in the WB Project Appraisal report, are:

- There is a need for policy discussions above the provincial level regarding China's water resources to evaluate the large incentives that are created by extensive agricultural water subsidies. Subsidies for irrigation and land management jeopardize water conservation effort, longer term sustainability of irrigation and land reclamation projects and water availability for towns, cities, industry and environmental management. Without such a change in the near future water shortages and environmental consequences of resource mismanagement will continue to grow to crisis proportions.
- Monitoring and Evaluation requires capacity building and reorientation to measure outcomes and impacts. There is little virtue in implementing development models for reclaiming degraded lands or for river basin management if impacts on welfare,

incomes and the economy cannot be accurately measured. While this is less of a problem for physical achievements it is a major problem for measurement of socio-economic outcomes and impacts. Much more attention has to be given to understanding the appropriate counterfactual and ensuring unbiased sampling.

- Much greater care is required in dealing with issues of attribution when estimating ex-post economic rates of return. Specifically this means clearer definition of the project counterfactual and a systematic accounting of the effects of exogenous actors and investment on project impact. Without such attention to these exogenous factors there is a danger that estimated ERRS give a false impression of project impacts. This, in turn, may lead to incorrect lessons on development effectiveness and the efficacy of policy, institutional and engineering measures utilized to achieve development objectives.
- The relatively successful resettlement planning for a large number like 182 000 people and archaeological studies carried out in the region is an important lessons learned from the project.

7. LESSONS LEARNED AND CONCLUSIONS

7.1 International Best Practice Guidelines

A decision to build or not build a multipurpose dam ideally emerges from a comprehensive and participatory assessment of the full range of policy, institutional and technical options, from the start of the planning process. Such a process starts with the assessment of needs and ends with the screening of all options to assess the most appropriate portfolio of actions (UNEP – Dams and Development 2007).

Identification of options comprises the collation and validation of the full menu of possible alternatives to meet the expressed needs. The range of options that can be included in strategic planning for water and energy development (including those for multipurpose projects) might vary widely and include structural and non-structural supply- and demand side management and efficiency measures. The inventory of options should pay attention to the scale of the intervention and the different time frame and lead times. Further, each of the options has to be sufficiently described in terms of technical, economic, financial, institutional, environmental and social attributes. This usually entails certain level of preliminary investigation not exempt from certain challenges. These challenges include disproportionate levels of information available across options and controversies around the basic features of their description that might impact their screening process (UNEP 2007).

Ideally specific provisions for multipurpose planning and options assessment should be embedded in national legal and regulatory frameworks. Furthermore, on the impact side is to introduce strategic environmental assessment at national and basin scale for multipurpose development with appropriate stakeholder involvement.

Thus, the identification and assessment of options, including stakeholder involvement, needs to be explicitly embedded in national legal or regulatory frameworks (or as for the case of Nile basin in regional harmonized regulatory frameworks) and its practice further integrated into the planning and management of the development of water and energy resources. This will reduce costs, improve stakeholder buy-in and reduce project risks.

7.2 Overall Lessons Learned from case studies

Overall lessons learned from the case studies of existing projects in the Nile Basin Countries and the Global projects has been listed in Annex 4 and constitutes highlighted issues within the following categories:

- (i) Benefits
- (ii) Cost and Financing
- (iii) Impacts
- (iv) Miscellaneous

The following issues represent the main lessons learned from these case studies (the findings are not prioritized)⁵²:

Maximizing benefits

1. Larger multipurpose projects can be as a driving force to establish national and or regional power pools. Specific examples are the Kariba dam and the Glommen and Laagen cascade system. For planned NBI multipurpose projects this is relevant for the Rusumu and Kakono dams complex in western Nile and the Baro, Karadobi and Mendaya complex in Eastern Nile.
2. Some of the older projects, e.g. Fincha and Koka dams were originally planned for hydropower only. Later on these have shown to benefit other users as domestic water supply and irrigation. Inclusion of multiple use in the planning process might have benefited other users even more. Thus in future planning of projects mainly for hydropower, all potential multiple uses should be investigated including secondary beneficiaries as for the Kariba dam.
3. Larger multipurpose projects, as especially with the case of HAD and the Senegal River Basin Dams, can provide significant contribution to national and regional economies sparking social and economic development, providing a sampler of functions including energy provision.
4. River Basin Organizations has proved to be effective institutions in the river basin development especially if there is a firm ownership for physical structures (e.g. multipurpose dams) and regulatory arrangements in place for coordinated operation. In transboundary water management this is of paramount importance, securing that benefits are properly shared between countries, e.g. as in the case of OMVS in Senegal river and in the case of the Lesotho Highlands Water Projects where regulation and management of the joint water resources is regulated by treaties, institutional structures are in place and where joint ownership by the water structures secures benefit sharing between the countries.
5. Multipurpose dams has proven successful in flood protection/management and inland navigation. Examples are High Aswan Dam and and the dams on Senegal river.
6. Plans for development of tourism should be considered during dam planning as these often become tourist attractions and spots for recreation and boating, e.g. as for High Aswan Dam and the Lesotho Highlands dams.
7. Most of the dams studied have proven important in development of fisheries and measures to strengthen this should be included in the planning of new dams.
8. Along with regional and national grid development, off takes to local grid systems, as for the case of Merowe in Sudan, should be strongly considered when developing multipurpose dams to provide energy to the local areas.
9. Developing multipurpose dams in cascades can provide for silt trapping, providing sedimentation benefits to downstream dams.
10. Developing multipurpose dams in conjunction with transport infrastructure (bridges, roads etc.), as in the case of Owen Falls and Kariba can increase accessibility thus affecting positively local and regional economies.
11. Multipurpose projects provide “clean” energy and can reduce CO2 emissions compared to the development of energy dependant of fossil fuels.

⁵² Miscellaneous has been embedded into benefits or impacts where relevant.

12. Proper resettlement as in the case of Xiaolangdi dam can enhance the socio-economics of those people resettled.

Benefits from multiple use functions

Water Supply

1. *Health benefits due to improved sanitation:* These benefits include avoided expenditure on treatment and care, avoided loss of working days, avoided time due to treatment and avoided death.
2. *Consumer benefits:* These include avoided expenditure on chemicals for water treatment, time savings related to water collection, increased property value by tap water instalment, savings related to avoided expensive sources of water.
3. *Agricultural and industrial benefits:* These benefits include avoided impact of sick workers, time savings, increased income-generating activities, and increased efficiency in land use.
4. Irrigation
5. *Increase in gross national agricultural income:* Irrigated agriculture increases gross national agricultural income significantly. Though implemented irrigation projects could be costly, most of the projects have a high rate of return, resulting in a positive net income.
6. *Increase in net farmer income:* Not only the returns from increased agricultural productivity but also increased employment opportunities result in a positive net farmer income.
7. *Reduction in dependency on rain-fed water sources for agriculture:* Irrigation increases crop yields as negative effects of seasonality are minimized. Minimizing rain-dependency is an important requirement for the economic development of drought-prone regions.
8. *Increase in crop diversity and value of output:* Irrigation enables farmers to diversify crops, especially by introducing of high-yielding cash crops. Farmers may also benefit from multiple harvests through out the year. Irrigation increases both farmer income and the raw materials available for export and industries.

Flood Control

9. *Maximized efficiency of use of the catchment:* Flood control not only minimizes flood losses but also enables efficient management of the catchment.
10. *Avoided crop losses:* Loss of crops, whether for local consumption or exports, is minimized since agricultural land is secured from flooding.
11. *Efficient use of agricultural subsidies:* Whether on inputs such as fertilizer and irrigation water, or on output prices, subsidies help support agricultural production. When the agricultural land is flooded, the subsidies are wasted as there is no economic benefit. Flood control increases the efficient use of subsidies.
12. *Improved management of agricultural land markets:* Floods sometimes result in the temporary or permanent removal of agricultural land from production. Flood control stabilizes the supply of agricultural land.

Tourism

13. *Additional income for local populations:* Recreational facilities, water sports, food and accommodation areas offer an income-generation option for the local residents. Increased employment opportunities and potential for small business investment enhance the economic activities of the area.
14. *Incentives for sustainable management:* When the dam site attracts tourism, it creates an incentive for maintaining environmental sustainability in the area.

Inland navigation

15. *Large-load and large-dimension cargo savings:* Larger loads could be carried per barge than highway or rail. It is cost-effective since number of barges decrease as load per barge increase. Volume constraints are also minimized and large-dimension cargo could be shipped easily.
16. *Fuel savings:* Railway and especially highway transportation consume more fuel than inland navigation transportation. Fuel savings minimize petroleum-dependency of transportation sector.
17. *Transportation cost savings:* When inland navigation becomes safer and risks such as current and changing river levels are lower, transportation costs minimize. This has a positive effect on the volume of trade.

Minimizing impacts

1. Integrated catchment management and protection will improve generation production, reduce siltation and environmental impacts. This has been highlighted especially for the Fincha and Koka dams in Ethiopia and the Roseires dam in Sudan but is also of great importance in the Senegal river basin and in the Lesotho Highlands Water Project.
2. Proper public participation from planning through implementation as well as when monitoring operation will increase the probability of success of the project and reduce the potentials for conflict and increase transparency. The project will thus stand better chances for implementation according to schedule, thereby having a cost related side to.
3. Resettlement planning needs to involve the affected people in the process to properly highlight their needs, create ownership and reduce conflicts. Conflicts about resettlement has hampered the development process of different projects to various degrees, and if not done properly even more so in the future. HAD rests as a case of generally good resettlement planning, although undertaken several decades ago, although one marginal group, the Arab pastoralists fell short of any compensation due to the fact that they were absentee of any land titles.
4. In general proper resettlement planning could minimize conflicts as outlined in 3 and also serve to solve other potential conflict areas, like land titling that might be hampering the development of the host country⁵³. A good example is the Xiaolangdi that not only focuses on resettlement but also re-creation of livelihoods and include longer-term planning regarding both the resettled and the host communities.
5. In general for most projects impacts on environmental and social issues could have been less if mitigation had been more comprehensively and systematically

⁵³ As for the case of the Arab pastoralists in the HAD project.

- planned for, e.g through an Environmental and Social Management Plan. Thus monitoring and evaluation in general need to be strengthened for multipurpose projects
6. Artificial releases of floods (or flows) from dams, to partly mimic the natural flow regime and mitigating flow alternations, has shown to improve livelihood⁵⁴ and aquatic, floodplain and riparian ecosystem health. This is especially the case of the Senegal river basin but has also been comprehensively studied in the Lesotho Highlands Water Project, where the DRIFT methodology was developed for measuring conditions for different flow scenarios and set river health targets for the affected rivers. The last mentioned has also resulted in a National Policy for Instream Flow Requirements. In the case of the Glommen and Laagen basin, Norway, flow regulation has also resulted in a high flood prevention effect.
 7. More recently developed projects focus more on negative impacts than the older projects. This is mainly due to the fact that full comprehensive EIA's were not included in multipurpose and hydropower planning before late 80's early 90's. However when focusing on the negative impacts the chance to do proper mitigation planning will increase.
 8. Some places, as for Xialoangdi dam in China, better coordination between the various uses of the multipurpose dam, could have reduced impacts on the environment and prevented water shortage⁵⁵.
 9. It can be seen that it is important to have legal frameworks in place for PPP or other. As seen in the Norwegian Glommen and Laagen case, longer durations for a project may also cause a need to re-adopt the changes in any concerned law. Also, accountable and sound management process is a must, as seen in Casecan case where criticism was raised concerning violation of BOT law.
 10. Measurement of socio-economic impacts is an important initial step before minimizing them. There should be pre-discussed evaluation methods to specify the costs and quantify them with minimum bias. This could be an issue of its own as it is an additional cost and requires expertise.
 11. Archaeological sites that could be flooded by the planned dams are also of crucial importance. Any planning included in the project plan would serve to minimize impacts. There have been cases where such sites alone became major conflict areas. For example, Zeugma and Allianoi archaeological sites in Turkey created public opposition against dams as there were no mitigation plans in the dam project regarding these sites which are very important for the world history. The private company and the public utility are sued several times and construction stopped or delayed in line with the court decision. Surely, African countries also have a similar record for important archaeological sites especially when the history of the Nile is concerned. Tourism is generally a very important economic activity in the region. A similar concern applies to the religious/spiritual sites of the local people, where resettlement would not be enough to compensate the loss of socially important areas.

Cost and financing

1. Equal ownership of MPPs in transboundary waters, regulated by treaties, will benefit and affect positively the member states of the treaty. Such ownership

⁵⁴ E.g. for example to sustain recession agriculture.

⁵⁵ In this case subsidies for irrigation and land management jeopardize the chance for proper water conservation.

- may give member states equal commitment and guarantees for loans , and spark donor involvement for other projects. Such development has been seen for OMVS and the LHWP.
2. In developing financing models for private and public-private multipurpose projects lessons can be learned from the Philippines, e.g. In the case of San Roque which is one of the few larger multipurpose projects financed as a public private partnership. In this project San Roque Power company was responsible for construction of the power station and reservoir dam with spillway. Upon construction completion, ownership of spillway and dam was transferred to the National Power Corporation as it contributed funds for the non-power components (e.g. irrigation, flood control and water quality improvements) on behalf of several agencies. Furthermore, the Casecnan Multipurpose project in the Philippines is one example of a genuinely private funded partnership. This project is viable in the private sector because of the high value attributed to irrigated water which accounts for 45% of the revenue, and because it also has a strong revenue stream from the sale of power. It is also a RoR project generating less conflict than large dams.

Regional cooperation

1. Water supply could emerge as a key motivation for regional integration
2. Egypt could play a key role in provision of funding projects in Ethiopia
3. Power trade can best be developed in steps; first bi-lateral, then in the sub-regions, and at last for the whole region.
4. Analysis shows that sub-regional integration has been more successful than partnerships across the whole NBI region as a whole.
5. Geographical and historical context influence power structures among the countries
6. Upstream-downstream tension has set different priorities
7. Planned transmission line expansion strengthen this trend
8. Lack of full integration between the two sub-regions causes limitation on intra-region financing opportunities

Specific issues related to Hydro Power and MPPs

1. Difficulty in structuring procurement contracts,
2. Potential conflict between the interests of the system and the private developer,
3. Unusually high construction risk
4. Environmental sensitivity and costs
5. High front-end costs
6. High proportion of local costs
7. Heavily capital-intensive nature
8. Long payback periods
9. Necessary to agree upon how to share risks for hydrology, construction, geology, capital investment, marketing, production, operation

A more in depth survey of the best financing structures for multipurpose projects are given in the following chapter and is also a bridging issue as the best options for financing optimal coordination regimes in the Nile Basin as discussed in the Issues Paper.

8. BEST FINANCING STRUCTURES FOR MULTIPURPOSE PROJECTS

8.1 Introduction and Background

8.1.1 Balance Sheet Financing

Large infrastructure projects, multipurpose dams and hydropower in specific, have gone through an evolution of financing structures. Public funding for large infrastructure dates back to the late 19th century, as exemplified in the case of Suez Canal. The traditional model of financing was a legacy of étatism in the early 20th century, especially after the Second World War, where all funding was from the public sector. In the developing countries, likewise, public sector provided the capital for these investments, owned the asset and also participated actively in the operation of these investments upon completion⁵⁶. Certain state enterprises were formed solely for this purpose. International bilateral and multilateral funds were mobilized for supporting governments. The projects remained dependent on the availability of public funds at every level. However, such massive infrastructure investments carried out only by the public sector had certain drawbacks:

- i) Limitations on funding created misallocation of the public budget, resulting in internal and external debt.
- ii) Lack of expertise, especially in management, operation and technology, caused inefficiencies and faults which have been manifest as cost overruns.
- iii) Non-diversification of the project finance left the private sector out of the picture.

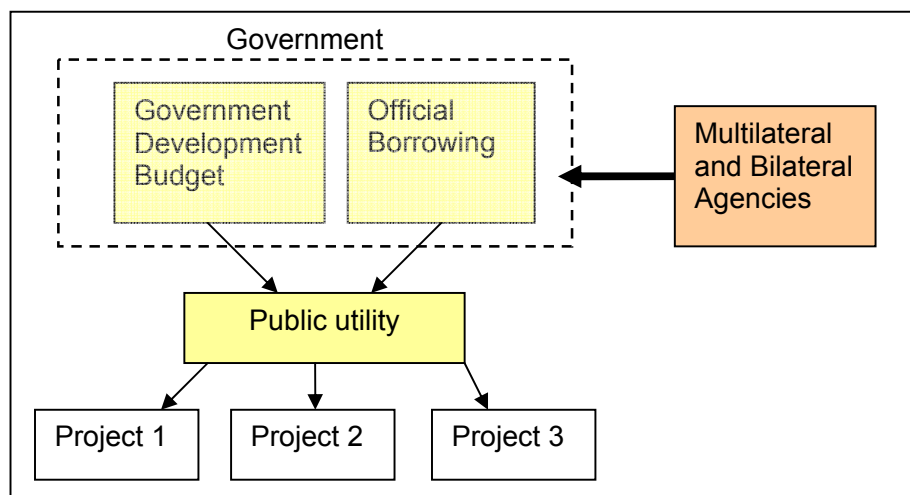


Figure 8.1. Balance Sheet Financing

⁵⁶ <http://www.norad.no/items/9506/38/0370788909/Fin%20Models%2021%2008%2007%20Annexes%201-5.doc>

Such large infrastructure projects were not limited only to construction. Majority of the electricity supply was dependent on public sector. The same was true for transmission and distribution, through state-owned utilities. In the literature, this traditional form of financing is called **Balance Sheet Financing**⁵⁷, and its basic structure is illustrated in the below chart, where governments either supplied all the necessary funding or borrowed from multilateral and bilateral agencies towards this aim and purpose.

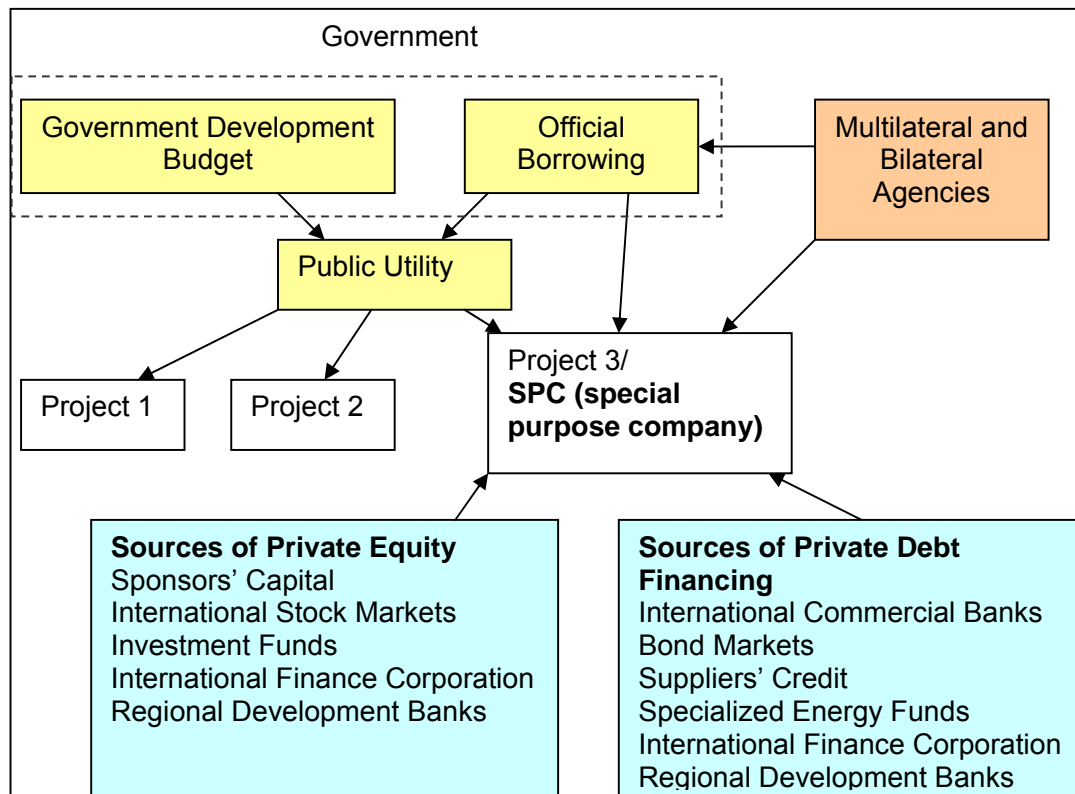


Figure 8.2. Private Project Financing and SPC.

8.1.2 Project Financing

By 1980s, a reactionary solution occurred. The private sector started becoming increasingly involved in project financing, sometimes aiming to undertake the complete project implementation as well as provide for its finance. However, access to international funding still required government guarantees and standards, while the private sector involvement needed certain enabling legal action and reforms in the host country. Huge exogenous project risks, like hydrology and cost overruns were discouraging factors, and more so for multi-purpose projects. Additionally, the public sector was not ready to privatize large infrastructure projects as operational revenues accruing from these investments were important sources for the public budget. The

⁵⁷ Ibid.

private sector recognized the necessity of public involvement for risk-sharing and guarantees, whereas the public sector also recognized the necessity of expertise and private capital.

When the private sector is involved in asset ownership, financing arrangements exhibit a higher degree of complexity. This is the so-called **Project Financing**. In private project financing, generally a special-purpose company (SPC) is formed to be able to manage the joint venture and funds more efficiently. This approach provides for flexibility benefiting both parties of the partnership.

As shown in the chart, governments and public utilities are still largely present in the picture, whereby the role of the private sector is associated with the wholesale financing and implementation of a specifically designated project. Here, project financing is organized at the company (SPC) level, where the Government may still hold a stake, or own shares.

The most common sources for project-financed investments are:

- equity from private/foreign investors plus host government
- international, mainly commercial, sources, incl. export credit agencies, IFC etc.
- local bonds and other financial markets
- international and domestic guarantees

Although traditional public financing and project financing are clearly defined in different terms, they tend to converge when it comes to the sources of funding in developing countries. As far as multipurpose hydro projects, there is ample evidence of public-private cooperation for water supply and power generation projects at the level of project operation and management, but not during the development stage of the water resources or dam construction. Similarly, irrigation efforts are not usually funded by the private sector during development of the water resources or dam construction. As a consequence of the differences in ownership and management, project financing mainly applies in a rather restricted sense, such as the case of generation projects, while traditional utility financing dominates for transmission and distribution investments.

8.1.3 Emergence of a Different Type of Partnership - PPP

To confront the pitfalls of sole public financing (balance sheet financing) and private sector financing (project financing), a compromise or hybrid solution was needed. This hybrid solution would blend the features and elements from both the public and private sector. This is the so-called **Public-Private Partnership (PPP)** which has arisen to address the specific needs. Another very important reason for the emergence of the PPP model is that public resources were no longer sufficient to cope with the massive funding needs of large infrastructural projects, including multipurpose hydro projects, and the experience from project financing have largely discouraged the private sector from assuming and sustaining such a high profile and high risk role.

In order to implement such partnerships between the private and the public sector, safeguard the interests of the concerned parties as well as effectively deal with the possible disputes, appropriate legal and contractual arrangements are necessary. As it stands, PPPs can be undertaken via several types of contractual arrangements, varying by the level of involvement of parties and the role each party plays. Today, PPP has already become a very common financing model in both developed and developing countries. Over the years, the PPP model became recognized as an established mechanism providing for the basic social and business infrastructure to manage the enterprise as well as attract the necessary financing.

Multipurpose hydro projects or dams present a difficult and interesting case as far as financing. These projects usually embody irrigation, power generation, and water supply, plus other purposes such as flood control, recreation, navigation etc. WCD studies have revealed that these projects have some common features. About half of the multipurpose hydro projects involve irrigation, while a little more than a third involves power generation and water supply. These are the top three purposes with some implication for private sector involvement. Such projects have their own unique financing requirements due to the different purposes they serve.

8.2 Possible Legal Contract Forms of PPP

The PPP idea represents a multifaceted blending of the pure public sector financing (balance sheet financing) and pure private sector financing (project financing) of large infrastructural projects. PPPs can show wide variation depending upon asset ownership, operation, management, capital investment and risk-sharing. Some commonly-used PPP contract forms are introduced below, with relevant examples for each. Each of these contractual arrangements may imply a different type of financing arrangement.

8.2.1 Service Contract

Service contract is an O&M type of PPP. Private sector supports public sector in service delivery whereas asset ownership, capital investment and commercial risks are carried by the public sector (Chiplunkar, Public-Private Partnerships, 2006⁵⁸). Most of the cases include service delivery contracts regarding drinking water and electricity supply. Service contract duration is generally 1-2 years and consists of services regarding the “front-end” costs. Front-end costs include transaction expenses for legal, financial and due diligence services. They also include engineering costs, technical and environmental consulting fees, environmental mitigation and the developer's own expenses (Head, 2000, page 65⁵⁹). An example would be the case of a French corporation, Veolia (formerly Vivendi Water), having a five-year water support and service contract of Ziga Dam, Burkina Faso, heavily financed by the World Bank. The contract covers the management of customer service and financing.

⁵⁸ Presentation for Infrastructure Development Corporation Limited, <http://jnurm.nic.in/presentation/PPP.pdf>

⁵⁹ Chris Head, 2000. Financing of Hydropower Projects. World Bank, http://info.worldbank.org/etools/docs/library/240335/Financing%20of%20Private%20Hydropower%20Projects_.pdf

8.2.2 Management Contracts

Private sector handles full management of a project under PPP whereas asset ownership, capital investment and commercial risks are carried by the public sector. The contract duration is around 3-5 years (Chiplunkar). An example would be the case of Bethlehem Hydro (Pty) Ltd, a special purpose company registered in South Africa as a BOO (Build, Own, Operate). Bethlehem Hydro has contracted NuPlanet BV (from the Netherlands) to manage the development and implementation of the project (small hydropower plant) on its behalf. Management includes technical management, billing, business administration and accounting.

8.2.3 Lease

Capital investment and asset ownership fall on the public side whereas private sector not only handles operation and management but also assumes the commercial risk. The contract duration is 8-15 years. It could be an alternative to privatization, as completed projects could be offered to the private sector in the form of leasing where the operator effectively refinances the project on the basis of the revenue stream, leaving its ownership in the public sector. Head, on page 96, cites the example of DenAmerica which leases in beaver Dam project paying a percentage rent.

8.2.4 Concessions Involving Build-Own-Operate-Transfer Arrangements

Depending upon the particular nature of the concessions arrangements, the public may or may not end up owning the asset. For the most part, the private sector takes on the O&M task, furnishes the capital investment and takes the commercial risk. It is a long term partnership that lasts around 25-30 years (Chiplunkar). The public sector completes the project definition studies (technical feasibility, site investigation, and so on) and then brings in the private sector to finance, design, construct and operate the project (Head, page 96). The majority of the private projects falls in this category although there might be some shortcomings regarding risks and optimality for the private sector. These concession agreements are also known as BO (build and operate) arrangements, as elaborated below.

Build and operate arrangements can take different forms such as BOT, BOO, BOOT and BO. These types of partnerships are the most common when it comes to hydropower and multipurpose dam projects with a public subsidy for the "non-power" elements. Private sector gets fully involved in all levels of the project and the duration is around 25-30 years. EPC (engineering, procurement and construction) contracts consists an important part of BOT agreements. It is usually the largest capital expenditure and it has the highest cost overruns.

- BOT (Build-operate-transfer): Private sector builds and operates the asset and transfers it to the public sector when the concession ends. Majority of dam financing is BOT. Example: San Roque and Bakun, Philippines .
- BOO: Build-own-operate: Unlike BOT and BOOT, private sector does not transfer the ownership to the public sector.

- **BOOT: Build-own-operate-transfer:** Private sector builds, owns and operates the asset. Like BOT, the ownership is transferred to the public sector after duration of time. Example: Casecnan, Philippines.
- **BO: Build and operate:** Private sector builds and operates the asset, whereas the commercial risk is in the public sector. Example: Thermal power plants in Turkey sign an offtake agreement with the Turkish Electricity Corporation. They hold ownership of the asset and operative rights for 20 years, whereas the public body carries the commercial risk of electricity. Unlike BOT, the ownership is not transferred to the public at the end of the duration.

The underlying notions of the BOs constitute a procurement concern for some multilateral donors. For instance, the World Bank and Asian Development Bank have developed detailed BO-related provisions and procurement guidelines which sometimes supersede the national legislation, and help with the local legal void if there is any.

Table 8.2. Characteristics of various PPP contracts

Principal Types of Contracts	Asset Ownership	O&M	Capital Investment	Commercial Risk	Duration (Yrs)	Example
Service Contract	Public	Private & Public	Public	Public	1-2	Veolia holds service contract of Ziga Dam, Burkina Faso ⁶⁰ .
Management Contract	Public	Private	Public	Public	3-5	Management of Bethlehem Hydro project (Lesotho) of small hydropower given to NUPlanet BV (Netherlands) ⁶¹ .
Lease	Public	Private	Public	Private	8-15	Beaver Dam: Wisconsin Lease ⁶² .
Concessions or Build and Operate Arrangements						
BOO	Private	Private	Private	Private	25-30	Theun Hinbun- Lao PDR ⁶³
BOT	Public	Private	Private	Private	25-30	San Roque, Bakun- Philippines
BOOT	Public/ Private	Private	Private	Private	25-30	Casecnan- Philippines
BO	Private	Private	Private	Public	25-30	Thermal power plants and TEAŞ, Turkish electricity corporation, signed a BO agreement for 20 years.

Source: Chiplunkar, slide 1, <http://jnnurm.nic.in/presentation/PPP.pdf>

⁶⁰ http://www.citizen.org/cmep/Water/cmep_Water/reports/burkina

⁶¹ http://www.dme.gov.za/pdfs/energy/cabeere/case_bethlehem.pdf

⁶² <http://sec.edgar-online.com/1997/11/13/12/0000950131-97-006756/Section13.asp>

⁶³ C.Head,2000, page 102

8.3 Various Distinct Types of Financing Models

Each contract type may entail a different mix of financing models. Major financing models are equity financing, debt financing, the support of the public sector, and power purchase agreements (PPA), as defined by Chris Head (2000). These different financing models introduce various tools for private and public participation in project financing. The majority of private sector involvement is through equity financing, whereas public sector mostly prefers debt financing, although this is flexible. Multilateral development banks, commercial banks, export credit agencies, bond issues, government guarantees to reduce risk, tariff structures are all important components of project finance. Types of financing models and how they are utilized for each contract type is introduced below.

8.3.1 Equity Financing

The lender's perception of the risk is an important determinant of the amount of equity that a developer has to put into a project. The higher gearings (i.e. lower equity proportions) were achieved on projects when the project company did not carry the most of the risk. Public equity holding is around 30% in general. Main source of this money is multilateral development banks, either in the form of loans to the host utility or as a direct equity holding by the multilateral bank (Head, 2000, page 46⁶⁴).

8.3.2 Debt Financing

It is a method of financing in which a company receives a loan and gives its promise to repay it. Debt financing includes both secured and unsecured loans, and most lenders ask for security⁶⁵. Part of a firm's total financing, it commonly comprises of short-term bank borrowings, cash raised through debt instruments (such as bonds), off-balance-sheet financing (such as operating leases) and trade credit⁶⁶.

Debt typically provides 75% of the project costs, raised in the form of direct lending and guarantees from a number of sources. Sources of debt (Head, pages 48-49) include:

- *Export Credit Agencies* (ECAs), provide direct loans and guarantees in support of bank lending under terms regulated by OECD and administered by the appropriate government agencies in the principal exporting countries. This is an accessible form of credit widely used for power projects in general. Yet, volume of support is limited for hydropower due to relatively low export content, which can change by power trading. ECA support for non-recourse power projects can be up to 14 years from the start of commercial operations.
- *Multilateral Development Banks* (MDBs) such as the World Bank the Inter-American Development Bank (LADB) and the Asian Development Bank (ADB) have a crucial role in the provision of debt financing in 70% of all projects reviewed by direct loans (such as IFC "A" Loans) and through acting as the Lender of Record for syndicated loan facilities (such as IFC "B" Loans). Another aspect of MDB participation is guarantees and insurance facilities (for example, the guarantee programs of the World Bank and political risk insurance of MIGA). Loan tenors are similar to that of ECAs.

⁶⁴ <http://info.worldbank.org/etools/docs/library/240335/Financing%20of%20Private%20Hydropower%20Projects..pdf>

⁶⁵ <http://www.entrepreneur.com/encyclopedia/term/82206.html>

⁶⁶ <http://www.businessdictionary.com/definition/debt-financing.html>

- *Cofinancing* may take place through bilateral funds, mostly soft loans, to the project company. One other type is grants to the government for the coverage of social and environmental costs. Although it is a minor source of financing, like multilateral funds, it is important as a catalyst for mobilizing other sources of debt. In certain economies government agencies and local public funds play an important role.
- *Commercial banks* provide loans under the ECAs, and in the form of pure commercial debt, although very small. In many markets commercial debt is severely limited. One reason for that is the combination of short maturities with high prices, making it less attractive. Debt denominated in local currency often carries very high interest rates. International commercial debt is often raised on the back of ECA funding, and the relatively low proportion of the ECA eligible component in hydro projects affects the prospects for commercial loans.
- *Bond issues* for hydro schemes are still relatively rare. Casecanan is known to be the first major scheme of this type on the US bond market.

8.3.3 Support of Public Sector

Public sector support for financing the projects could be in form of debt (loan or credit) but other forms of support, such as guarantees and risk-sharing, are equally important. Public utilities attract multilateral funds by increasing the accountability.

The most obvious support has been in the form of (Head, page 50):

- provision of guarantees by the host government, particularly in respect of payment obligations of the utility,
- provision of funding and guarantees by the MDBs: despite some MDBs, like IFC, directly work with the private sector, such funds might require host government involvement. For example, IMF funds are given to the host governments to be later allocated to the related projects, similarly MIGA and Regional Development Banks also require a level of host government involvement and guarantee. Inter-governmental organizations provide loans as long as certain risk guarantees are provided by the host authorities. Therefore, involvement of MDBs is highly dependent on the credibility of the host governments and funding is allocated through the host public bodies.
- the ECAs of a number of governments: Similarly, export credit agencies require a certain level of involvement of the host government, either in funding or provision of risk guarantees. Therefore, ECA support is gained via the involvement and support of the public sector.

Some extended functions could be listed as (ibid):

- Participation as an equity holder on the basis of concessionary funding provided by external agencies
- Provision of loans through public financial institutions or the utility, or directly by the government. These have sometimes been funded by loans from external agencies.
- The government enters into buyout obligations if the project company fails.
- The assumption of hydrological risk through the provision of funds to cover shortfalls in revenue.

8.3.4 Offtake Agreements/ Power Purchase Arrangements

Hydropower projects consist of three parts: generation, transmission and distribution. Public sector can get involved in the project finance through power purchase arrangements (PPA) especially by defining the tariff structure. Market risk, hydrology risk and transmission liability are important components. Transmission and distribution are of crucial importance especially for NBI countries that have sufficient sources for hydropower but facing challenges in electrification of the country. Resettlement and environmental costs appear as important areas of bargaining and conflict when it comes to power trading projects with more than one government included.

Hydro-specific considerations for PPA (Head, page 38):

- The role of the project (such as peaking, base load);
- Powers of the parties in terms of reservoir operation and dispatch;
- Pass-through of construction risk where tariffs are cost-related;
- Apportionment of hydrological risk (such as variations in production);
- Allocation of environmental and resettlement costs;
- Servicing of the debt burden in the early years of operation; and
- Tariff structure (energy, capacity, ancillary benefits)

Table. 8.3. PPA for some example cases from Head (2000, page 39)

Project	Basis of Tariff	Duration of Agreement (years)	Offtake Obligations (Market Risk)	Hydrology Risk	Energy Price	Defining Currency	Transmission Liability
Casecnan	Energy +Water	20	Take-or-pay (100%)	Shared	15.50 ^a	US\$	Utility
San Roque	CRF+ OF ^b	25	Guaranteed minimum	Shared	n/a	US\$+Yen	Utility
Bakun	CRF+ OF ^b	25	Take-or-pay (95%)	Shared	n/a	US\$	Utility
Theun Hinboun	Energy	30	Take-or-pay	Owner	4,30	US\$+Baht	Shared
Nam Theun II	Energy	25	Take-or-pay	Owner ^c	4,50	US\$+Baht	Shared

^a Excludes uplifting and existing hydro stations and water tariffs

^b CRF + OF= Capital Recovery Fee and Operating Fee

^c Indicates principal risk carrier

Below, we introduce specific examples for project financing of PPP contract forms discussed in section 1.

Table 8.4. Illustrations on Financing Models for Different Types of PPP Contracts (all Multipurpose Projects)

Financing Model	Example case	Equity Financing	Debt Financing	Support of Public Sector	Off Take Agreements /PPA
Types of Contracts					
Service Contract	Ziga Dam, Burkina Faso: Veolia holding the service contract	N/A	World Bank loan for water support and service contract	N/A	N/A
Concession	Cana Brava, Brazil ⁶⁷ : Aneel (Brazilian Electric and Energy Agency) gave the concession to CEM, Companhia Energética Meridional	30%: Tractebel Energia, Brazil	70% IADB: Inter-American Development Bank BNDES: Brazilian National Development Bank	N/A	Tractebel Energia: Main offtaker

⁶⁷ <http://siteresources.worldbank.org/INTENERGY/Resources/WBEnergyLecture2005TEGI050124VFCBiebuyck.pdf>

BO Arrangements (all examples are from Head, 2000)					
BOO	<p><i>Theun Hinbun, Lao PDR</i></p> <p>EdL:majority shareholder</p> <p>partnering agreement sponsored by MDX Lao of Thailand and the utilities of Norway and Sweden,</p> <p>EGAT: offtake agreement.</p>	<p>Share: 39% Of which:</p> <p>20%: Nordic hydropower</p> <p>20%: MDX Lao of Thailand</p> <p>60%: government (largely financed by soft loans from ADB)</p>	<p>Share: 61% Of which:</p> <p>59%: commercial debt by six Thai banks</p> <p>30%: ECA</p> <p>11%:, Lao PDR and Nordic Investment Bank</p>	<p>the provision of political risk cover by a variety of ECAs to support the Lao government risk equity holder</p>	<p>EGAT (Thai utility) commits itself to purchase 95 percent of the output on a take-or-pay basis.</p> <p>EGAT is obligated to construct and operate the transmission line on the Thai side of the border.</p>
BOT	<p>1)<i>San Roque, Philippines</i></p> <p>San Roque Power Corporation (SRPC).</p>	<p>Share of Equity: 25%</p> <p>All held by the sponsor (JEXIM)</p>	<p>Share of debt: 75%</p> <p>68% of the loan: 15-year untied loan to the government from JEXIM (overseas investment credit)</p> <p>32% of the loan: Commercial-base lending (Years 11 to 15).</p>	<p>political risk guarantees from JEXIM for NPC (power utility) offtake obligations provision of loans</p>	<p>Power utility is obliged to buy all power generated by the project for the concession period of 25 years, under a government-backed guarantee. Irrigation utility will use the water that requires no offtake agreement.</p> <p>NPC shares part of the hydrological risk. Payments for the delivery of electricity consist of US dollar- and Japanese yen denominated Capital Recovery Fees (CRF), and Peso-denominated Operating Fees</p>

					(OF). The CRF is fixed, but the OF is escalated according to a local index.
	<p>2) <i>Bakun, Philippines</i></p> <p>Shareholders (all equal): Aboitiz, PacifiCorp Development Corporation, Pacific Hydro Limited.</p>	<p>Share: 30%</p> <p>All held by the sponsors</p>	<p>Share: 70%</p> <p>A consortium of local commercial banks and a group of foreign banks</p> <p>(NO public funding)</p>	<p>Performance Undertaking by the Philippines Department of Finance</p>	<p>NPC's payments for the delivery of electricity consist of :</p> <ul style="list-style-type: none"> • Capital Recovery and Service Fees, • Energy Fees • Operating Fees • Watershed Management Fees. <p>Capital Recovery Fees will be paid only during the first ten years of generation.</p> <p>The obligations of the NPC include:</p> <ul style="list-style-type: none"> • the provision of the associated transmission line • rights-of-way for the project site and the access road • rights to use water. <p>The hydrological risk is allocated to LHC along with the financing, construction and operating risk.</p>

BOOT	<i>Casecnan, Philippines</i> shareholders: 35% California Energy 35%: Peter Kiewit & Sons 30%: local holding	Share: 28% . All by the sponsors	Share:72% Private debt: three tranches on the 144A bond market (\$281 million fixed rate with 10- to 15-year maturity; \$75 million floating with 7-year maturity)	N/A	NIA will purchase all power and water on a take-or-pay basis, with all payments (except local value-added tax) denominated and paid in US dollars.
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8.4 Impact of the Liberated Power Sector on the Financial Structures

World Bank lists the stages of full-scale power sector reform⁶⁸ as:

- (i) Obliging electricity enterprises to operate according to commercial principles.
- (ii) Restructuring of the electric power supply chain to enable the introduction of competition.
- (iii) Development of economic regulation of the power market that is applied transparently by an agency that operates autonomously.
- (iv) Privatization of the unbundled electricity generators and distributors under dispersed ownership.
- (v) Development of competition in the generation and supply segments by development of power exchanges.
- (vi) Focusing government's role on policy formation and execution.

Each NBI country is at a different stage of the reform, but the majority of the member states are keen on reform. Newly liberalized power and water sectors in majority of the Nile Basin countries enable the setting for attracting private investment. However, private sector still needs some guarantees and incentives from the governments to ensure efficient work and lower risk. While the private sector has a major role to play in easing the access to electricity and water in Africa, it is clear that governments have a major responsibility in leading the process, devising appropriate policies and regulations, and ensuring compliance with the rule of law. (see: Information bulletin of ACP business⁶⁹). Reforms in the energy sector will serve to maximize benefits by lowering production problems and increasing transmission. The financing structures will be more flexible. Private sector involvement increases accountability of projects by eliminating faults in management, operation and accounting as more sound systems are introduced. On the other hand, public sector, both host governments and international agencies that work with the governments, introduce certain environmental and social standards and responsibilities to minimize costs in these areas. These standards maintain that the multipurpose hydropower projects are not only a profit-generation source for the private sector but mainly a development tool for host communities.

Multipurpose dams generally serve two commercial purposes: water supply and electricity production, and indirect economic benefits are drawn from irrigation and flood control. In the Nile basin, there is growing demand for both water consumption and access to electricity. In the Great Lakes region, 52% of electricity generation is hydroelectricity. Some countries have more experience with hydropower and related legislation whereas the others are currently developing legal frameworks to attract and promote investment in power and electricity sectors. Therefore, planned projects require context-specificity regarding the private power sector, government support and country experience. When power-trading develops in the region, the table introduced below may go through changes in the distribution of energy sources in some countries.

⁶⁸ John E. Beasant-Jones, (Sept 2006). Reforming Power Markets in Developing Countries: What Have We Learned?, Energy and Mining Sector Board Discussion Paper, No:19, World Bank Document, page 11.

⁶⁹ <http://acpbusinessclimate.org/documents/E-Zine5-EN3.pdf>

Table 8.5. NBI countries and the distribution of sources of energy

NBI Countries	Energy Sources (% share)		
	Biomass and coal	Electricity	Petroleum
Burundi	86	2	11
DRC ⁷⁰	88	4	8
Egypt	0	25	75
Ethiopia	2	98	0
Kenya	3	10	86
Rwanda	95	1	4
Sudan	0	31	69
Tanzania	91	Together adds up to 9	
Uganda	92	1	7

Source: the Economist Intelligence unit, Country reports (Uganda figures updated by information from Country representative)

Different energy sources also reflect underutilization of certain potentials in some countries. For example, in the case of Uganda, the country has the biggest hydropower potential (from US Energy Information Administration web page), yet 90% of the energy requirements are met from charcoal and fuel wood (African country profile- the Economist). On the other hand, full dependency on hydropower creates vulnerabilities to seasonality of rain, such as droughts in the case of Ethiopia. These underutilization or excess-dependence problems are related to the broader problems of the power sector in Africa. Certain problems of the power sector in Africa are inadequate tariff levels, East African droughts, poor utility management, inappropriate investment choices, excessive technical and commercial losses, and serious under-investment in energy in the 1990s and early 2000s (Information Bulletin of APC). Today, if countries welcome public-private partnerships in infrastructure investment, problems related to capital, management and operation could be overcome by involvement of the private sector expertise and resources.

However, development of PPP regulation varies from country to country. Egypt is the country with the most experience in PPP, as state monopoly over power sector was removed in 1984 by a sector reform to include private capital. Ethiopia (1997), Sudan (1998), Uganda (1999), Burundi (2000) followed Egypt. Kenya has completed the power sector reform by 2005, whereas Tanzania had taken very little step towards reform by the same date. DRC still lacks any policy document on the issue. Rwanda initiated its plans for a sectoral reform (NBI SVP, Regional power trade project PAD 2005- Annex 11). Therefore, the different levels of reform also limit the involvement of private sector in project financing, especially when power trading is considered. Majority of the countries already welcome private capital (as in the form of IPPs) and continue to launch reforms related to ownership and operation.

⁷⁰ http://www-wds.worldbank.org/servlet/WDSContentServer/IW3P/IB/2007/03/13/000104615_20070313144224/Rendered/INDEX/RDPMP010PID010Appraisal0Stage0March013.txt

Table. 8.6. Electric power and investment in NBI countries

NBI Countries	Level of Power Sector Reform	Consumption per capita (kwh)	Transmission and distribution losses (% output)	Investment in energy infrastructure projects 2000-05 (\$ millions)
Burundi	Completed in 2000	No data	No data	No data
DRC	Lacks any policy document on the issue	98	3	No data
Egypt	Completed in 1984	1215	12	678
Ethiopia	Completed in 1997	33	10	300
Kenya	Completed in 2005	140	17	189*
Rwanda	Initiated sectoral reform plans (by 2005)	No data	No data	0
Sudan	Completed in 1998	92	16	No data
Tanzania	At the initial level of reform (by 2005)	53	23	372**
Uganda	Completed in 1999	No data	No data	142

* where 2000-05 data is not available, 1995-99 data is used.

** Tanzania has experienced 100 % increase in energy infrastructure within a decade, which is worth mentioning. This could be explained by privatization of enterprises rather than new investment.

Source: World Development Indicators 2007, the World Bank Publications and Project Appraisal Document for Regional Power Trade Project, NBI SVP, Nov 2005

As presented in the table above, both consumption per capita and investment in infrastructure projects are correlated with the level of sector reform in the country. Loss of transmission and distribution may vary as it can also be related to the amount of available transmission lines.

One important step in the liberalization of power sector is division of generation, transmission and distribution components of energy. This division enables the introduction of private sector expertise and capital when necessary. Private sector involvement cannot be limited only to construction aspect of a hydropower project and needs to be expanded to transmission and distribution, especially when power trading is concerned. Poor transmission infrastructure in majority of the riparian countries of the Nile basin reflects a need for further PPP in this field to support development in the countries by electrification. DRC is a striking example to reflect this concern⁷¹. The country has 13% of the global hydropower potential but electrification is at 4% in the country as the majority of the production is traded with neighboring countries and the country itself lacks proper transmission lines. Going back to Table 2.1, it could easily be argued that the problems with transmission and distribution further limit the realization of country potentials.

All riparian countries experience steady rises in demand for electrification (for example, 6% annual demand increase in Uganda). Transmission problems and fluctuations in production decrease the consumption levels despite this massive increase in demand. Without private sector participation, governments lack funding and expertise to overcome these problems and as a result, certain risks, like seasonality, have multiplied effects.

⁷¹ http://www-wds.worldbank.org/servlet/WDSContentServer/IW3P/IB/2007/03/13/000104615_20070313144224/Rendered/INDEX/RDPMP010PID010Appraisal0Stage0March013.txt

APPENDIX 1: MAJOR EXISTING MULTIPURPOSE AND HYDROELECTRIC DAMS ON THE RIVER NILE

Project name	Owner	Country	Purpose	Installed Capacity MW	Relevance for the study
<i>High Aswan Dam</i>		<i>Egypt</i>	<i>Multipurpose. Flood protection, hydropower, irrigation, storage, fisheries</i>	<i>275 MW</i>	<i>Example study on the river Nile for Multipurpose</i>
<i>Roseries Dam</i>		<i>Sudan</i>	<i>Multipurpose. Hydropower, irrigation of the Gezira plains, fisheries</i>	<i>250 MW</i>	<i>Supports commercial fisheries and thus a good example of secondary utilization of the reservoir</i>
<i>Sennar Dam</i>		<i>Sudan</i>	<i>Multipurpose. Irrigation and Hydropower</i>	<i>15 MW</i>	<i>Primary role is irrigation</i>
<i>Khashm El Gibra Dam</i>		<i>Sudan</i>	<i>Multipurpose. Irrigation, water supply and hydropower</i>	<i>13 MW</i>	<i>Primary role is irrigation</i>

Project name	Owner	Country	Purpose	Installed Capacity MW	Relevance for the study
<i>Merowe Dam</i>		<i>Sudan</i>	<i>Multipurpose. Hydropower, irrigated agriculture, flood protection, silt trapping.</i>	<i>1250 MW</i>	<i>Prime usage is hydro power</i>
<i>Finchaa Dam</i>		<i>Ethiopia</i>	<i>Multipurpose. Hydropower and irrigation</i>	<i>100 MW</i>	
<i>Koka Dam</i>		<i>Ethiopia</i>	<i>Multipurpose/ Hydropower</i>	<i>107,2 MW (Awash II and III)</i>	<i>Prime focus on hydropower but the reservoir area is used for recreation and fisheries, thus important secondary functions. Sedimentation is a problem thus catchment management is needed</i>
<i>Owen Falls</i>		<i>Uganda</i>	<i>Hydropower</i>	<i>180 + 120 MW</i>	<i>Have the potential to affect Lake Victoria Water levels. The bridge over the dam is an important transport link.</i>

APPENDIX 2: SELECTED GLOBAL MULTIPURPOSE PROJECTS

Project name	Owner(s)/ Operator(s)	Country	Purpose	Project specifics	Relevance for the study
<i>Kariba</i>		<i>Zambia/ Zimbabwe</i>	<ul style="list-style-type: none"> ▪ <i>Hydro Power</i> ▪ <i>Fisheries</i> ▪ <i>Tourism</i> 	<p><i>1320 MW</i></p> <p><i>Storage capacity 180 km³</i></p> <p><i>Dam height 128 m</i></p>	<i>Transboundary project in the Zambesi River, Southern Africa. Although designed for hydro power alone, fisheries and tourism became important benefits. The Dam has also impact on irrigation WCD case study</i>
<i>Senegal River Basin Development</i>	<i>OMVS (Organization for the Development of Senegal River)</i>	<i>Guinea, Mali, Mauritania, Senegal</i>	<ul style="list-style-type: none"> ▪ <i>Hydropower</i> ▪ <i>Irrigation</i> ▪ <i>Navigation</i> ▪ <i>Fisheries</i> ▪ <i>Ecological flows</i> 	<p><i>2 Dams, Manantali (upstream) and Diarna dam in the delta.</i></p> <p><i>Manantali = 200 MW</i></p>	<i>Transboundary multipurpose project in Senegal River basin covering 4 countries. A good example from Africa also including impacts assessment and mitigation measures related to the dams development in the river. Impacts and benefits across states are also of concern as well as challenges related to stewardship and governance</i>
<i>Xiaolangdi</i>	<i>Yellow River Commission</i>	<i>China</i>	<ul style="list-style-type: none"> ▪ <i>Hydro Power</i> ▪ <i>Flood Control</i> ▪ <i>Siltation Control</i> ▪ <i>Irrigation</i> ▪ <i>Water Supply</i> 	<p><i>1800 MW</i></p> <p><i>Dam height 154 m</i></p>	<i>World bank financed project PRC. resettlement of 171000 people</i>
<i>Casecnan</i>	<i>Casecnan Water and Energy Company, Inc.</i>	<i>Philippines</i>	<ul style="list-style-type: none"> ▪ <i>Hydro Power,</i> ▪ <i>Irrigation,</i> ▪ <i>Water Supply</i> 	<i>150 MW</i>	<i>One of the very few privately financed multipurpose projects</i>

Project name	Owner(s)/ Operator(s)	Country	Purpose	Project specifics	Relevance for the study
<i>San Roque</i>	<i>San Roque Power Corporation</i>	<i>Philippines</i>	<ul style="list-style-type: none"> ▪ <i>Hydro Power</i> ▪ <i>Irrigation</i> ▪ <i>Flood Control</i> ▪ <i>Water Quality</i> 	<p><i>345 MW</i></p> <p><i>Dam height 200 m</i></p>	<p><i>Private owned multipurpose project completed in 2003.</i></p> <p><i>BOOT with power purchase contract</i></p> <p><i>Discrepancies between reports from project owner and NGOs</i></p>
<i>Pak Mun Dam Mekong River Basin</i>	<i>EGAT</i>	<i>Thailand</i>	<ul style="list-style-type: none"> ▪ <i>Hydro Power</i> ▪ <i>Irrigation</i> ▪ <i>Fishery</i> 	<p><i>136 MW</i></p> <p><i>17 m high dam</i></p>	<p><i>Highly criticized project by NGOs and affected people due to environmental and social impacts, and that benefits did not meet expectations. Lessons to be learned. WCD case study</i></p>
<i>Orange River Development Lesotho Highlands Development</i>		<i>Lesotho, South Africa Botswana Namibia</i>	<ul style="list-style-type: none"> ▪ <i>Hydro Power</i> ▪ <i>Irrigation</i> ▪ <i>Water Supply</i> 		<p><i>Orange River constitutes more than 22% of South Africa's water resources.</i></p> <p><i>Irrigation schemes started in the 1920s.</i></p> <p><i>Formal plan for Orange River Development 1962</i></p> <p><i>Several dams and power stations</i></p> <p><i>Development is still going on.</i></p>
<i>Tungabhadra</i>	<i>Karnataka and Andhra Pradesh states</i>	<i>India</i>	<ul style="list-style-type: none"> ▪ <i>Irrigation</i> ▪ <i>Water supply</i> ▪ <i>Hydro Power</i> ▪ <i>Fisheries</i> 	<p><i>72 MW</i></p> <p><i>Dam height 49 m</i></p> <p><i>Dam length 2441 m</i></p>	<p><i>Multipurpose project where irrigation is the main purpose.</i></p> <p><i>Regulates water supply to two states</i></p> <p><i>Two states carry out common maintenance.</i></p>
<i>Glomma and Laagen Basin Development</i>	<i>Municipalities counties, private companies</i>	<i>Norway</i>	<i>Hydro Power Flood Control</i>	<i>Totally installed capacity 2165 MW</i>	<p><i>Development of a whole river basin with an integrated system of 40 reservoirs and 51 hydro power stations.</i></p> <p><i>Development has been carried out gradually over more than 100 years WCD case study.</i></p>

APPENDIX 3: SELECTED PLANNED MULTIPURPOSE PROJECTS

(Most relevant projects outlined related to transboundary nature)

Project name	Owner	Country	Purpose	Installed Capacity MW	Relevance for the study
Nile Equatorial Region					
<i>Bujagali</i>		<i>Uganda</i>	<i>Hydropower mainly</i>	<i>200 + 50 MW</i>	<i>Impacts on recreation and whitewater rafting, cascade effects with Owen Falls</i>
Kakono		Tanzania	Multipurpose (HP, Water Supply and Irrigation)	53 MW	Multipurpose and cascade with Rusumo
<i>Masigira</i>		<i>Tanzania</i>	<i>Hydropower mainly</i>	<i>118 MW</i>	<i>Environmental flow very important. Lake Nyasa.</i>
Rusumo Falls		Tanzania, Rwanda, Burundi	Multipurpose	61,5 MW	Will benefit 3 countries (Tanzania, Rwanda, Burundi), storage during dry periods, irrigation, environmentally sensitive
<i>Mutonga</i>		<i>Kenya</i>	<i>Hydropower mainly</i>	<i>60 MW</i>	<i>Sedimentation problems. Catchment management important</i>
<i>Songwe</i>		<i>Tanzania, Malawi</i>	<i>Multipurpose cascade</i>	<i>Total 330 MW</i>	<i>River basin development with 3 reservoirs. Flood protection and storage. Transboundary in nature, but not part of Nile.</i>

Project name	Owner	Country	Purpose	Installed Capacity MW	Relevance for the study
<i>Stieglers Gorge</i>		<i>Tanzania</i>	<i>Multipurpose but main focus hydropower</i>	<i>2100 MW</i>	<i>Size, environmental controversy, flood protection, irrigation</i>
Egypt					
<i>Assiut, Damietta and Zefta projects</i>		<i>Egypt</i>	<i>Hydropower + irrigation</i>	<i>40 MW, 13 MW and 5,5 MW respectively</i>	<i>Multipurpose. Cascade development with Aswan high and old dams</i>
Ethiopia					
<i>Halele Worabesa</i>		<i>Ethiopia</i>	<i>Main focus on hydropower. Flood protection</i>	<i>Stage 1:96 MW Stage 2: 326 MW Total: 422 MW</i>	<i>Multipurpose. Development of two cascade projects</i>
<i>Chemoga Yeda</i>		<i>Ethiopia</i>	<i>Hydropower</i>	<i>Stage 1: 162 MW Stage 2: 118 MW Total: 280 MW</i>	<i>Development of 5 dams. Impact on environment and flows. Resettlement (Not very attractive to this discussion?)</i>
<i>Baro 1, 2 and Genji</i>		<i>Ethiopia</i>	<i>Multipurpose but focus on Hydropower</i>	<i>200, 500 and 200 MWs respectively</i>	<i>Basin development, big size and environmentally sensitive. Close to Sudan hence may have benefit of silt minimization</i>
<i>Karadobi</i>		<i>Ethiopia</i>	<i>Multipurpose</i>	<i>1000-1600 MW</i>	<i>Includes flood control, irrigation, and navigation potential on the Nile in Ethiopia, Sudan and Egypt</i>

Project name	Owner	Country	Purpose	Installed Capacity MW	Relevance for the study
<i>Mandaya</i>		<i>Ethiopia</i>	<i>Multipurpose</i>	<i>1620-2400 MW</i>	<i>The Mandaya project offers high potential for multi-purpose benefits through integrated planning taking account of potential for flood alleviation and regulation of flows for downstream areas and users. Thus it is transboundary in nature.</i>
<i>Geba 1 and 2</i>		<i>Ethiopia</i>	<i>Multipurpose</i>	<i>215 and 157 MWs respectively</i>	<i>Multipurpose – Hydropower and Irrigation. Close to Sudan hence may have benefit of silt minimization</i>
<i>Awash IV</i>		<i>Ethiopia</i>	<i>Multipurpose</i>	<i>38 MW</i>	<i>Multipurpose. Irrigation of land and water for domestic use</i>
<i>Border</i>		<i>Ethiopia</i>	<i>Multipurpose?</i>	<i>1000-1400 MW</i>	<i>Located at the border to Sudan</i>
Sudan					
<i>Sabaloka</i>		<i>Sudan</i>	<i>Multipurpose?</i>	<i>90 MW</i>	<i>Close to confluence of white and blue Nile. Problems with flooding due to reservoir construction</i>
<i>Sherei</i>		<i>Sudan</i>	<i>Multipurpose?</i>	<i>315 MW</i>	
<i>Dagash</i>		<i>Sudan</i>	<i>Multipurpose?</i>	<i>285 MW</i>	
<i>Rumela</i>		<i>Sudan</i>	<i>Multipurpose</i>	<i>30 MW</i>	<i>Prime function is irrigation with the possibility to include 3x10 MW Francis Units</i>

Project name	Owner	Country	Purpose	Installed Capacity MW	Relevance for the study
DRC					
<i>None multipurpose project/issues identified</i>					

APPENDIX 4: LESSONS LEARNED MATRIX

Project name	Benefits	Cost and financing	Environmental and Social Impacts	Misc.
Aswan	<ul style="list-style-type: none"> ▪ Significant contribution to Egypt's social and economic development ▪ Nubian's more integrated in the society and economy of Egypt because of initiatives sparked related to resettlement and compensation 	<ul style="list-style-type: none"> ▪ Superpower politics heavily affected financing arrangements 	<ul style="list-style-type: none"> ▪ Some environmental impacts less than predicted. ▪ Social impacts could have been mitigated more effectively if affected people had taken part in the policy and planning process, and some people were not excluded in the compensation process (e.g groups without land titling) 	Today there would have been transparency in EIA process, more public participation, more focus on mitigation and monitoring
Finchaa and Koka	<ul style="list-style-type: none"> ▪ Although planned for hydropower solely the dams have become useful to regulate floods/droughts, downstream irrigation and water supply. Thus for future dams developments opportunities for this should always be assessed 		<ul style="list-style-type: none"> ▪ Integrated catchment management should be undertaken to reduce erosion and siltation ▪ Need to enhance resettlement planning to prevent international criticism 	
Merowe	<ul style="list-style-type: none"> ▪ The anticipated flood protection from the dam needs to be re-assessed due to the planned daily 	<ul style="list-style-type: none"> ▪ Funding is from Chinese and Arab funds. This might have affected the compliance with today's standards related to 	<ul style="list-style-type: none"> ▪ EIAs should be undertaken by an independent consultant to avoid criticism and heavy scrutiny from 	

Project name	Benefits	Cost and financing	Environmental and Social Impacts	Misc.
	peak operation	mitigation and environmental assessment as per WB guidelines	international organizations. <ul style="list-style-type: none"> ▪ Mitigation planning and implementation as well as public participation could have been undertaken more comprehensively reducing conflicts with local people and criticism from international organizations. ▪ The resettlement and cultural heritage planning and implementation rests as a case to be better planned. 	
Owen Falls	<ul style="list-style-type: none"> ▪ Uganda is too dependent of Owen Fall for electricity generation and should reduce this dependency to be able to better control Lake Victoria water level during drought 		<ul style="list-style-type: none"> ▪ Water release at Jinja should be made according to the agreed release policy curve ▪ High sedimentation. Integrated catchment management should be undertaken to reduce erosion and siltation ▪ Lake level variation, including those induced by the dam operation, include all multiple uses of the lake affecting local communities and economy especially 	<ul style="list-style-type: none"> ▪ Uganda should invest in alternative sources of energy to be less independent on hydro generation that can affect the lake level
Roseires	<ul style="list-style-type: none"> ▪ The benefits, especially related to power 			

Project name	Benefits	Cost and financing	Environmental and Social Impacts	Misc.
	generation, will decrease without proper catchment management			
Casecnan		<ul style="list-style-type: none"> ▪ Private funding is possible for a multipurpose project. Run-of-river development and one off-taker have made financing easier. 	<ul style="list-style-type: none"> ▪ Participation of all stakeholders and a transparent planning process would have made implementation smoother and avoided delays and law suits. 	
Glomma and Laagen	<ul style="list-style-type: none"> ▪ Regional distribution of income from hydropower is ensured by a system of taxation, license fees, compensation and income from sale of licensed energy. 	<ul style="list-style-type: none"> ▪ Most of the power stations are developed with public funding, but some are developed by private entities (industry with the need for power) 	<ul style="list-style-type: none"> ▪ Combination of moderate regulation and flood operation procedures has high flood prevention effect. ▪ Flexibility in authorization of mitigation and co-operation has yielded effective measures to compensate for negative impacts. ▪ Step by step development has reduced potential conflicts. 	<ul style="list-style-type: none"> ▪ Periodic Planned Re-Evaluations ▪ Protection and Master- Plans for Water Resources have been important tools. ▪ The G&L Water Management Association has played an important role I regard to power production. Flood protection and environmental mitigation. ▪ Monitoring and data sharing is an important tool.

Project name	Benefits	Cost and financing	Environmental and Social Impacts	Misc.
Kariba	<ul style="list-style-type: none"> ▪ The projects have shown to have far more positive implications than originally anticipated. Roads, to isolated areas, development of fishing industry, formation of wildlife sanctuaries, tourist attraction, basis for electricity interconnection. ▪ Continuous lower electricity tariffs. ▪ Kariba facilitated the creation of a regional power pool. 		<ul style="list-style-type: none"> ▪ Man made reservoirs can cause earthquakes when constructed in tectonically active areas. ▪ Many negative impacts could have been avoided if impact assessment had been applied systematically at the time of implementation. ▪ It is important to ensure that land right of affected people are not lost as a result of the project. ▪ Involuntarily resettlement requires full participation of affected people. Planning process to be carried out well ahead of resettlement. Adequate infrastructure in new areas is necessary. Community fragmentation should be avoided. ▪ Ensure that resettled people are familiar with agro-ecology in new areas. ▪ Continuous support over many years is necessary. 	<ul style="list-style-type: none"> ▪ Design of spillways should make allowance for hydrological uncertainty. For safety, the spillway should be designed for Probable Maximum Flood (PMF). ▪ Affected people must enter into legal binding agreement with developer. to avoid misunderstandings. ▪ Effective institutional structures must be established to monitor and attend to all negative impacts. ▪ International projects require, but also give opportunities to develop regional cooperation.
San Roque		<ul style="list-style-type: none"> ▪ One of the few larger hydro power projects financed as a public private partnership. 	<ul style="list-style-type: none"> ▪ The project has been controversial particularly due to relocation of large 	

Project name	Benefits	Cost and financing	Environmental and Social Impacts	Misc.
		<ul style="list-style-type: none"> ▪ San Roque Power Company (private) was responsible for construction of the power station and reservoir dam with spillway. Upon construction completion, ownership of dam and spillway was transferred to National Power Corp. SRPC will own and operate the power generating facilities for 25 years, after that transfer ownership to NPC. 	<p>groups of people.</p> <ul style="list-style-type: none"> ▪ The following preconditions should be secured before financial closure: ▪ Confirm numbers of affected people ▪ Secure remedies for affected people ▪ Establish monitoring system for environmental and social issues 	
Senegal River	<ul style="list-style-type: none"> ▪ Joint ownership of the physical structures of the OMVS secures that benefits are properly shared between the riparian countries. ▪ Guinea which is outside the OMVS agreement has not benefited in the same way related to the basin development 	<ul style="list-style-type: none"> ▪ Equal guarantees for the loans from the riparian states in OMVS sparked donor involvement 	<ul style="list-style-type: none"> ▪ Mitigating flow-alternations through artificial releases, livelihood and ecosystem can be improved. ▪ Recession agriculture benefits from artificial flow release 	<ul style="list-style-type: none"> ▪ The Organisation for the Development of the Senegal River (OMVS) has demonstrated its effectiveness and enables collaborative management and stakeholder participation. ▪ OMVS has established principles and terms of water sharing based upon the original distribution between users and riparian states.
Xiaolangdi		<ul style="list-style-type: none"> ▪ Exogenous factors should be included when calculated the economic rate of return (ERR). Without the exogenous factors the ERR might give a false impression of project 	<ul style="list-style-type: none"> ▪ Subsidies for irrigation and land management jeopardize water conservation, and long time sustainability. Water shortage and environmental 	<ul style="list-style-type: none"> ▪ Good planning has resulted in a sound economic and environmental development. ▪ A need for policy discussions on governmental level about allocation of water resources.

Project name	Benefits	Cost and financing	Environmental and Social Impacts	Misc.
		impacts, which again might lead to wrong impression of development effectiveness.	impacts might be the result.	<ul style="list-style-type: none"> ▪ Monitoring and evaluation is important and need capacity building. Physical interventions are easy to measure, while socio-economic outcomes and impacts are difficult to measure.

APPENDIX 5: INITIAL REVIEW OF NBI REPORTS

S/No.	Document	Relevance to the Study	Remarks
1	<i>Institutional, Regulatory and Cooperative Framework Model for the Nile Basin Power Trade</i>	<i>A sampler of studies/deliverables of the institutional, regulatory and cooperative frameworks relevant for developing a power trade system in the Nile Basin and its riparian states.</i>	<i>As development of new multipurpose projects are supposed to be connected to the regional proposed grid systems the study is of relevance</i>
2	<i>Review of Environmental Impact assessment Frameworks and Procedures in Regional Power Investments projects</i>	<i>The review was undertaken to ensure that the development of regional power trade and markets among the NBI countries will be implemented according to sustainable development principles and to guide the environmental agencies of the NBI countries, project proponents and EIA practitioners to implement the proposed harmonized EA process for all regional power projects</i>	<i>The EIA framework will have to be adopted in developing the selected and planned multipurpose projects</i>
3	<i>Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in the Nile Equatorial lakes Region</i>	<i>The study identifies the power needs in the NELSAP region for different development options and recommends prioritized projects to meet the increasing demand for power. One of the key recommendations is to develop a backbone transmission system to link the three power systems in the region and permit power interchanges.</i>	<i>The study is based on technical/economic, environmental and social impact assessment. where decisions were developed from stakeholder consultation. The study looks primarily into the power demand and how to meet this demand and it does not reflect multipurpose use of the projects.</i>
4	<i>PBWS - Virtual Project Activity Room (VPAR)</i>	<i>Designed by SNC Lavalin. Constitutes a collection of reports, also "living documents", within the field of energy and water resources</i>	<i>Some of the other reports commented here can be found in this virtual room</i>

5	<i>Draft Requirement Analysis and DSS Design Report</i>	<i>Study on the needs and outlining of a conceptual design for a Decision Support System for the Nile River Basin and its states. Energy development and power systems will also be part of the DSS.</i>	<i>The study has been designed in a highly participatory way, thus the stakeholders has participated in the design, also ranking energy development high.</i>
6	<i>Water Policy Guidelines and Compendium of Good Practice</i>	<i>Elaborated to assist NBI countries to formulate and implement policies that fully incorporate the transboundary aspects of water and further the commitments they have made to cooperative development of shared water resources on the basis of the principles of IWRM. Development of multipurpose regimes in the Nile should follow the principles of IWRM and be coordinated towards the national and regional policies at stake</i>	<i>Constitutes suggestions on harmonization of policies between sectors, energy being one of them. Constitutes principles of catchment management plans, important for protection of multipurpose reservoirs. The document also constitutes a separate section for dams and development.</i>
7	<i>Baseline Needs Assessment of National Water Policies of the Nile Basin Countries: A Regional Synthesis</i>	<i>Undertaken to assess the current status of water policy status and development in Nile basin countries. It is intended to help in planning future development and implementation of the water policy process and the various sectors affected by the policy development, including energy</i>	<i>Discusses various policy, regulatory and institutional issues for the basin states relevant for development of multipurpose projects and power trade</i>
8	<i>East African Power Master Plan</i>	<i>Through East African Community (EAC). The overall objective of the study is to determine whether further interconnection of the power systems of Uganda, Kenya and Tanzania is technically feasible and economically viable as growth in demand occurs over the next 20 years. Presents details of the generation and transmission system expansion planning for the region indicating the possible benefits that could be obtained by increasing the interchanges of electricity amongst member states.</i>	<i>Would be a sub-system in the Regional Power Trade Grid and highly relevant for the multi purpose plans as part of this study</i>

APPENDIX 6: INITIAL REVIEW OF OTHER RELEVANT LITERATURE

S/No.	Document	Relevance to the Study	Remarks
1	<i>World Commission on Dams (2000): Dams and Development, The Final Report, the Knowledge Base (case studies, thematic reviews, cross-check survey, submissions)</i>	<i>Comprehensive study of major dams and their impact on the environment. including case studies of 8 major existing projects, 2 country studies (India and China), one briefing paper (Russia and NIS countries, thematic reviews of environmental, social, economic, and institutional issues and options assessment, and a cross-check survey of dams in 52 covering 52 countries in 6 major regions</i>	<i>Findings in the WCD will be used as background information for the findings and analysis made in this study It is proposed to use 4 of the 8 case studies as examples of good practice/lessons learned from global multipurpose projects, as detailed data is already available for these projects.</i>
2	<i>World Bank (2003): Water resources and environment, Technical Note. G.3, Wetlands management, Prepared by Davis R. and Rafik H., Series Editors, Washington, DC</i>	<i>Adding knowledge on current scientific and technical principles for integrated watershed management applicable to LVB</i>	<i>Ought to be understood related to the context of development in the NBI Region</i>
3	<i>Norwegian Ministry of Foreign Affairs – Power Sector Task Force (2005): Proposed Strategies and Actions to promote Norwegian effort for the Power Sector in developing Countries (Main Report and Working Papers)</i>	<i>The task force was appointed to look into strategies to promote the Norwegian Power Industry (Owners, operators, contractors, equipment suppliers and consultants) for work in developing countries. Several working papers were produced among other estimates of investment needs, investment barriers, reform needs etc.</i>	<i>The findings, particularly from the working papers regarding investment needs and investment barriers will be useful background material for this study.</i>

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