THE ROLE OF LARGE SCALE ARTIFICIAL WATER STORAGE IN THE WATER- FOOD-ENERGY DEVELOPMENT NEXUS

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List of abbreviations

ADB- Asian Development Bank
AfDB- African Development Bank
DFID- UK Department for International Development
DRC- Democratic Republic of Congo
EAC- East Africa Community countires
EAPP- East Africa Power Pool
EIRR- Economic Rate of Return
ENSAP- Eastern Nile Subsidary Action Programme
FIRR- Financial Rate of Return
GTZ- Deutsche Gesellschaft fur Technische Zusammenarbeit
HEP- Hydro Electric Power
HSAF- Hydropower Sustainability Assessment Forum
IFI- International Financial Institutions
IHA- International Hydropower Association
IWRM- Integrated Water and Resources Management
MW- Mega Watt
NBI – Nile Basin Initiative
NELSAP- Nile Equatorial Lakes Subsidiary Action Programme
RRFP- Regional Rusumo Falls Hydroelectric Power Project
RSA- Republic of South Africa
SAPP – Southern Africa Power Pool
SEA- Strategic Environmental Assessment
SSEA- Strategic/Sectoral Social and Environmental Assessments
SIWI- Stockholm International Water Institute
UNDP- United Nation Development Program
USAID- United States Agency for International Development
WAPP – West Africa Power Pool
WB- World Bank
WCD- World Commission on Dams

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1 Overview

This study reviews the current status of medium to larger scale artificial water storage development with a focus on Africa. It assesses best practices in water storage development and management infrastructure for building sustainable livelihoods and mitigate climate change. It also analyses the linkages between water, energy and food security, and the role of water storage facilities in this nexus.

1.1 Key findings

- **Large-scale water storage plays an increasingly important function as a buffer against rainfall variability in support of economic development and building water security[1].** Several examples at the global level demonstrate how water storage has supported rapid socio-economic development in many countries and regions such as Sweden and Norway. There are more than 45 000 large dams around the world. Almost half of them were built in China during the 20th century to meet growing demand for water and electricity. Increases in irrigated agriculture land areas have fostered greater food security, and electricity generated from hydropower has contributed to large scale grid-based electrification to boost industrial outputs and contribute to economic growth and human development. Hydraulic infrastructure and dams play an important part in controlling unpredictable hydrological variability and mitigate against floods and droughts. A strategic management response to establish water security and mitigate against long term climate change should, thus, include well designed large scale water storage.

- **There are substantial potential benefits from effectively planned , well built dams and their related development outcomes.** Evidence supports the statement that many dams do not reach their expected potential predicted at pre-commissioning stages. Social and environmental tradeoffs may overtake the economic benefits. Hydropower dams, however, seem to be the dam type that, more than other dams, exceeds the targets of achieving economic returns and development outcomes. Existing hydropower electricity generation capacity can be strengthened through technical improvements during the project's life-cycle. Reasons for lower than expected outputs are often found at the initial planning stages of dam projects, they tend to affect subsequent project stages, ultimately leading to chronic operational problems. Increasing the efficiency of existing storage schemes provides a major opportunity for increasing output, due to improvements in water storage technology. Run-of-the-river hydroelectricity generation is an example of how the natural flow and elevation at a specific site can be used with minimal environmental impacts.

- **Large scale water storage favours regional integration and benefit sharing.** Evidence points towards an important role for larger scale water storage in promoting regional integration and the sharing of benefits from cooperative development. Major co-owned water storage schemes have functioned during times of civil strife and can serve as a rationale for further integration in other areas. Power pools and markets linked to hydropower generation as a source of fuel provides base or peak load and binds countries together through effective benefit sharing schemes and regional stability.

- **Climate change brings a new dimension to the role of water storage and there is potential in developing hydropower to mitigate climate change impacts through wider use of renewable energy.** Developing regions, and particularly those in Africa, have

[1] Water security is defined as the "availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies." Grey and Sadoff 2007

significant potential in their hydropower sectors; only 7 %[i] of the sector's potential technical capacity is currently exploited in Africa. By developing the sector to include national and trans- national electrical grid networks, regions and nations can realize large gains in social and economic benefits. First, the development of power pools to distribute electricity between countries will contribute greatly to steering Africa towards a path of sustainable energy development to replace fossil fuels. Second, developing power pools will promote regional integration and increase peaceful cooperation in some of the most volatile parts of the world. Third, the generating "hub- nations" will become regional exporters of electricity. This would bring in much needed foreign cash to support much needed socio economic development. Partner countries are clearly expressing their needs for additional financing to address the impacts of climate change while, at the same time, maintaining their aid commitments and disbursements to improve livelihoods.

- **Environmental and social tradeoffs and challenges at the local and regional levels need to be addressed up-front when developing water storage.** Issues of resettlement, compensation and environmental degradation are critical factors to consider in medium and large scale water storage projects. In many cases, projects will affect people and ecosystems, often significantly. Consequences include livelihood losses, impacts on traditional and cultural values, and degradation of public health. Compensation to rectify these tradeoffs has at times proven unsatisfactory. Lessons learned demonstrate good strategies for engaging affected populations and creating meaningful livelihoods.

- **There are several ways in which tradeoffs from water-storage projects can be mitigated. These are found both in project design and implementation but more often upstream in the early planning stages.** Environmental and social impacts should be addressed through proven governance and technical solutions at the early planning and design stages. Strategic Environmental Assessments (SEA) are, for example, gaining increasing attention globally as an instrument to bring upfront environmental and social issues of major development programs into the planning, project development and investment finance process. This includes bringing onboard representatives of project affected people earlier in the planning process at the detailed project design stages (pre-and full feasibility) as well as the implementation and financing stages. Methods and techniques to ensure good project planning have been developed actively since the World Commission on Dams reported its findings in 2000 by many key actors.

- **Donor organisations at the bilateral level are not typical sole financiers of large-scale water storage projects.** There are high capital costs associated with large scale water storage that often are well beyond any normal aid budget managed by bilateral donor organisations. As illustrated in several policy documents among major donors, most often push for policy reform on climate change, renewable energy and safeguarding the environment rather than the infrastructure investment per se. Water storage projects are often built up by complex schemes of interconnected and related infrastructural functions and linked social and environmental development opportunities within a multipurpose context. This allows for a wide range of project design involving many financiers with different comparative advantage offering different types of finance.

- **Bilateral funding can play an important role in financing good water storage.** New estimates indicate that Africa's annual financing requirements for water could be US$ 50bn, for drinking water and sanitation, wastewater, desalination, irrigation and water management, hydropower and multipurpose storage. Compared with this need, current financial flows are deficient in many respects. Bilateral grant financing can play an important role in leveraging domestic and external public and private financing by lowering political and technical risk.

Donor financing can target less commercial components of water storage projects by focussing on the social and environmental issues and building a pipeline of investment projects at a pre- and full feasibility level. Underutilized financing particularly in Developing Financing Institutions (DFI) such as MIGA, GuarantCo and Swedfund can be unlocked and optimized with bilateral grant financing.

- **Engaging in water storage.** The attitude towards investment in water storage is changing amongst IFIs with evidence found in the report from the UN Johannesburg Summit 2002, the General Assembly Resolution on reliable and stable transit of energy and its role in ensuring sustainable development and international cooperation, in the World Bank's water strategy and in the policy framework on water, climate change and energy amongst many bilateral donors. A common characteristic of these policy frameworks is that they recognise the need to increase investment in water services, water management and development and water governance. This entails investment in hydraulic infrastructure, watershed management, energy development and the integration of markets especially in the power sector.

Box 1. Definition of large scale dams and their role in economic development (ICOLD)

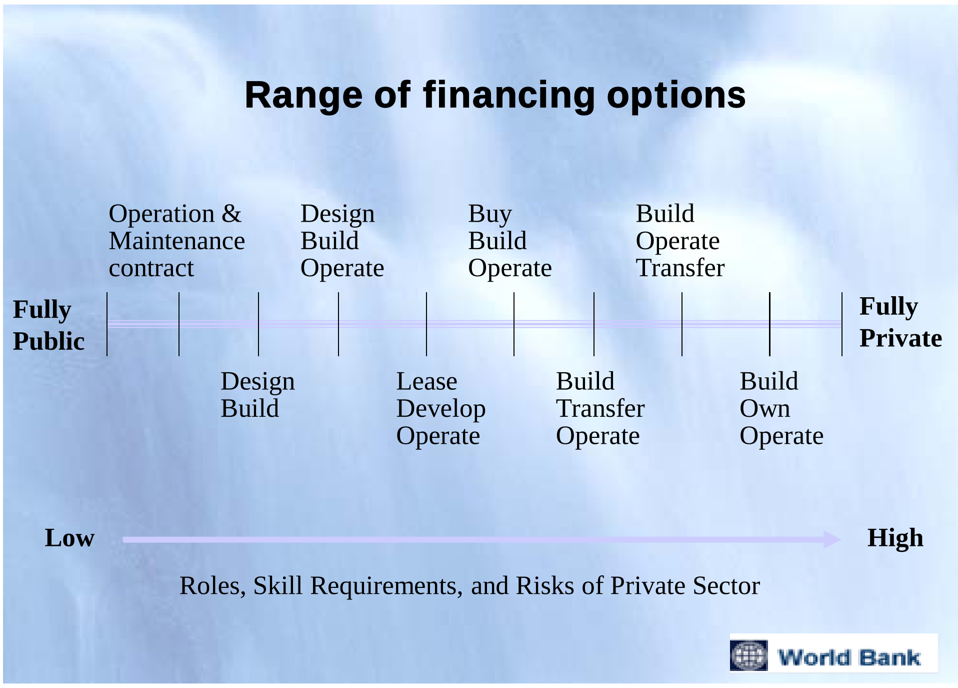
According to ICOLD (International Commission on Large Dams), a large dam is a dam with the height of 15 m or more from the foundation. If dams are 5-15 m high and have a reservoir volume of more than 3 million m^3, they are also classified as large dams. Using this definition, half of the world's large dams were built exclusively or primarily for irrigation. An estimated 30-40% of the 277 million hectares of irrigated lands worldwide rely on dams. As such, dams are estimated to contribute to 12-16% of world food production. Hydropower supplies contributes 2.2% of the world's energy and 19% of the world's electricity needs. In 24 countries, including Brazil, Zambia and Norway, hydropower covers more than 90% of national electricity supply.

1.2 Looking forward

a. Lowering risks and building the project pipeline – the role of bilateral grant financing in water storage schemes

- **Capital intensive projects.** Large-scale water storage projects are capital intensive and normally financed through public-private funding arrangements, often as combined efforts of major IFIs, investment banks, private sector partners and public funding at the state level providing dept, loans and equity (figure 1). These transactions are complex and involve project structures which share risks, responsibilities and returns between the public and private sectors. Whatever financing model is chosen, a more commercially accountable approach is today advocated in large scale water infrastructure projects.

Figure 1.



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- **Lowering risk.** It is not conceivable that single donor organizations would directly invest in water storage construction because that would require financing exceeding most development sector or project budgets. However, co-financing is an important strategy to promote effective development and to lower the perceived risks amongst financiers. Bilateral co-financing can contribute to the support of an enabling environment for private and commercial involvement in water storage. IFIs hence have an important function to manage and lower risks and promote good project identification, preparation, design, planning, implementation in the planning stages, as well as effective operations upon completion of the projects. In many parts of Africa different forms of risks are perceived by financiers as too large to engage in project development thus causing many projects to stall already in preparatory stages.

Box 1. Typical risk assessment
Risks assessed in the context of large scale hydropower projects include:

- Political risk - is there a political commitment to the project and in the case of multi-country projects are project development agreements in place?
- Water rights risk - is there a water resources management framework in place?
- Hydrology and sedimentation risk- how will rainfall variability and climate change alter the generation potential and how are watersheds being managed?
- Environmental and social compliance - is the necessary legal framework in place and is it being enforced?
- Technical and construction risk- are there guarantees that norms have been followed in technical design?
- Lack of a suitable enabling environment - is the necessary legal framework in place for a long term investment and is the institutional capacity adequate to operate the storage scheme?
- Payment/offtake risk - will future customers be able to pay for electricity generated, and is a power purchase agreement in place or being negotiated?
- Exchange rates/devaluation risk - can interest on loans be paid off?
- Reputational risk - have all social and environmental issues been taken into consideration to avoid corporate reputational risk?
- Corruption risk - Because large scale infrastructure projects are always at risk for corruption,is an anti-corruption strategy in place and is it being reinforced?

- **Building project pipeline.** Bilateral financing is essential in building a project pipeline through project preparation grants and is the key to facilitating project transactions. There is, in general, a huge financing gap upstream in the project identification process at the strategic planning level, with the result that few good projects are identified. The private sector is risk-averse and not willing to contribute capital to project identification in politically and financially unsecure environments. The long term planning phase of dam projects needs to be considered with the typical planning, design, financing and construction periods of 6-8 years of large scale projects. Hence, well developed pipeline of projects identified and analyzed at the pre-investment stage can accelerate investment.

b. *Investment opportunities in the implementation of the infrastructure component of water storage – "hard"*

Bilateral grant financing can support and leverage additional financing in complex storage schemes tackling issues such as:

- **Increase effectiveness**. Major opportunities exist in making existing projects more effective. Investments can be made in upgrading existing technology (modernising outdated control and communication systems, rehabilitating generating equipment and powerhouses, replacing cables and transformers etc.) in order to harvest greater power generation from existing plants without expanding actual storage volumes.

- **Technology development**. Investments can be made in modernising irrigation schemes relating to infrastructural components of irrigation networks such as pipelines, pumps and canals, thus ensuring the functionality of these elements. Water storage technology improvement is another key area that is developing rapidly with run-of-the-river technology gaining acceptance as a way to reduce the need for large scale water storage.

- **Mitigating environmental tradeoffs**. Mitigating environmental impacts is appropriate for development finance and can include project components focussing on watershed management, environmental flows and other technical aspects. Adaptive measures to help areas cope with new conditions can include creating spawning areas for fish and wildlife to introduce species suited for new environments and potentially valuable as sources of livelihood.

c. *Investments in the governance aspect of water storage – "soft"*

Upstream planning and institution building is critical in developing good water storage schemes. Some key areas to consider to support include:

- **Institution and capacity building**. Investigate support to administrative and institutional capacity building in connection to dam schemes and structures. There are several areas to consider support including: water resources management, watershed management, anti-corruption efforts, transaction advisory services, communication skills, stakeholder engagement , and technical expertise. In the context of transboundary initiatives such as the Nile Basin Initiative (NBI), support for regional institution building is essential. In the case of in-country projects, such as irrigation schemes, there is a need to take a more project specific approach and evaluate institutional functions, cost recovery, the role of markets, and decision making.

- **Resettlement**. Increase efforts to find normative and sustainable frameworks for addressing resettlement and compensation issues.

    - A general increase in resources to develop resettlement schemes should not only focus on the short term but also on the long term. Effective schemes should be equipped with suitable timeframes, making sure that short term needs (like new dwellings) and basic services are well in place before resettlement occurs. Longer term livelihood options should include assessments of diversified income possibilities. Planning that can support these features should be conducted in close cooperation between target groups and implementers allowing for substantial input from groups to be resettled early on in the process.

    - Best practices show that regulating frameworks need to be structured in a more standardised manner to ensure participation in developing compensation schemes. Resources should first be allocated to institutional functions dealing with compensation issues in order to have enough capacity to implement and support systems for compensation whether they are of economic, judicial or any other character. Secondly, the need to develop systems that provides consensus and legitimized processes are important. Resources to develop normative frameworks on how to create sustainable partnerships between implementers and affected groups seem essential and are in need of further studies.

- **Strategic Sectoral, Social and Environmental Assessment.** Resources can be allocated to develop and enhance strategic and project environmental impact assessments. Upstream Strategic Environmental Assessment (SEA) that takes a programmatic overview on financial, economic, environmental, social and technical feasibility should be promoted. SEA supports good decision making by clients and financiers, and can build project pipelines.[ii]

- **Regional integration and power market development to deepen regional integration**. Analyses, assessments and support for the emerging power pools in Africa (SAPP, EAPP, WAPP) is essential to achieve reliable and cost efficient power systems in areas were markets are small and scattered and where production of electricity is expensive. The Scandinavian power market model (NORDPOL) has provided a good example of the lessons learned for this type of development. Cross border cooperation through power pooling brings efficiency to power systems, lowers costs of generation, and promotes regional integration and stability. In order to enhance energy benefits (climate change mitigation and overall development outcomes) investments in hydropower generation, transmission and distribution is essential. Boosting electricity generation and access at low cost and with high reliability at local and regional levels helps create job opportunities, greater health, education and livelihoods.[iii]

2 Introduction

2.1 Study objectives

Large-scale dams have for many years served as a lever to promote development and economic growth in many parts of the world. Sweden is a country where hydropower since long constitutes one of several pillars that has generated and still generates growth and prosperity[iv]. They have the ability to change the landscape of opportunities to push through agendas of modernisation and industrialisation. Dams can serve as guarantors for providing reliable water services to growing urban and industrial centers and water for agriculture, thereby increasing livelihood outcomes. Dams can offer mitigation to natural hazards and generate renewable electricity to offset the demand for fossil fuel. Hence they are preferred structures in developing countries. More recently, water storage in general has also been moving up on the agenda amongst IFI's and other development organisations due to the climate change debate and the greater understanding of the role of electricity for development.

This study reviews the current status of medium to larger scale artificial water storage development, with a focus on Africa, and defines best practices and cases for efficient investment. By doing this, the study will analyse the linkages between water, energy and food security and the role of water storage facilities taking into consideration the views of developing countries and IFIs. The study will provide information on large-scale dams, including their purposes and impacts as well as their potential roles in a developing world, foremost Africa.

The study will describe different types of dams and the present status of their outcomes as well as the current trends and attitudes among financiers and implementers. Best practises in dam implementations will be assessed.

The study will also present the challenges associated with large-scale water storage projects that arise beside the various benefits provided by dams. It will point to opportunities for supporting informed decision making and engagement in water storage projects.

Ultimately the aim of the report is to provide a comprehensive view of benefits and challenges connected to large-scale water storage projects. Conclusions derived from the report might assist in evaluating where, how and when support is to be extended in water storage development in order to strengthen benefits even further and make implementation strategies more effective for livelihood improvement in developing regions.

2.2 The need for water storage in the water-energy-food nexus

There are around 1300 large to medium scale dams in Africa, 54 of which had a storage capacity of over 1 billion m^3 [v]. Rapidly growing population numbers put an increasing pressure on existing natural water, food, and power resources. Developing countries often face a two pronged challenge: providing basic means for people to survive on a day-to-day basis and at the same time making the strategic long term investments that enable development aimed at lifting entire populations out of poverty and achieving new levels of growth and living standards. To provide water services for domestic consumption, industrial use and food production there is a growing need to control and manipulate water resources. Food, energy and water security are at the core of development, and water storage plays an important role to achieve such security.

The implementation of new and better management of existing water storage structures can, if implemented correctly, offer a solution to the growing demand for water for production and to maintain ecosystem values. The ability to store and divert large quantities of water can support livelihoods in areas previously unconditioned to do so, thus providing economic opportunities for growing populations. Various types of large scale dams that usually have multipurpose functions contribute to these developments at the regional scale. New threats to development are posed by climate change. Over millennia, flood control dams have functioned as regulators of river flows by levelling seasonal peak flows, reducing risks of flooding and ensuring reliable water supply during dry seasons. Large scale dams with larger capacity to store water can play a greater role when climate change sets in and rainfall variability increases. The transitions from fossil fuel based energy to renewable energy sources are essential to reduce global emissions of green house gases. Many developing parts of the world are rich in hydropower potential and can stand to gain considerably from developing this source of energy. Major dam projects have the potential to electrify cities or large parts of entire nations. Regional power pools can be created connecting nations, increasing cooperation and benefit sharing and, at the same time, curbing potential destructive development paths that are likely to add to emission discharges by relying on expensive fossil fuel such as in the case of the SAPP, WAPP and the coming EAPP.

However, benefits from water storage can also be reduced by negative social and environmental impacts. The following sections will analyse the role of water storage in economic development, tradeoffs from dam development, lessons learned on best practice in water storage construction, and the view of developing countries and IFIs.

Box. 2 Examples of positive impacts of large-scale dams in Africa (see chapter 4 for a description on tradeoffs from development)

Short case descriptions

Aswan dam- Egypt

The construction of the Aswan dam meant that problems of droughts and floods that had devastated Egypt since ancient times were successfully mitigated. Potential flooding disasters were avoided in 1964 and 1973 and kept Egypt safe from the droughts in 1972 and 1973 and again in 1983 and 1984 when much of East Africa faced an unprecedented humanitarian catastrophe[vi]. When hydropower production first started Aswan supplied half of Egypt's electricity demand, enabling the electrification of most Egyptian communities for the first time ever. Lake Nasser also became the centre for a new fishing industry creating livelihood opportunities to local populations.

Kariba dam- Zambia/Zimbabwe

The electrification capacity brought by the Kariba dam solved the problem of a growing energy crisis and heightened energy demands of Zambia and Zimbabwe starting in the sixties continuing on through the eighties. This provided especially energy intense industries like the mining industry and fertilizer industry (and others) to grow considerably, providing significant growth in job opportunities. This also translated in to economic growth as over 80 % of Zambia's foreign exchange revenue came from the copper industry between 1965-1980[vii]. Even during several periods of civil strife in the region, technical cooperation has continued between Zambia and Zimbabwe.

The Volta dams- Ghana

Only few years after construction of Akosombo dam on the Volta River, massive development and industrialisation took place in Ghana, particularly in its major cities. Subsequent increases in power demand led to the construction of a second dam further down stream from Akosombo. The combined outputs from the two dams have been able to help to answer Ghana's increased energy demands over time. Other benefits brought by the Volta projects include augmented fishery, better navigation possibilities, an increase in tourism, and better utilization of irrigation systems for agriculture[viii].

Gibe III (and other projects) - Ethiopia

Ethiopia is presently conducting a string of investments in dam constructions, aiming to capitalize on its topography suitable for hydropower. The Gibe III project now under construction will be the largest such project in the country to date. It is likely to halt current and frequent electricity cuts in the country that create massive economic losses annually. The dam is also predicted to lift the current per capita income value for the entire country by bringing in much needed foreign cash flow to Ethiopia through the sale of electricity to Egypt. The dam is further designed to control the floods of the Omo River that recently as 2006 killed hundreds of people and thousands of livestock in the river basin[ix].

3 Dams for different purposes- providing development outcomes

The following section explores the different uses and impacts of dam projects foremost in the developing world and with particular relevance for Africa. Projects will be described according to their functions and how well they can be considered to deliver intended development outcomes and benefits for users, including their general profitability. It will describe components or characteristics of projects that can be considered crucial factors in project design.

3.1 Irrigation

The productivity and efficiency of dams used for irrigation purposes is subject to many, often intertwined, circumstances that sometimes extend beyond the formal area of water storage construction. Potential benefits also relate to wider agricultural systems, quality of irrigation systems (water channels, canals, access to technological assistance etc) and the overall socio-economic functions of rural sectors. According to WCD[x] there are three typical indicators to measure the performance of large scale dam projects for irrigation:

- physical performance for water delivery, area irrigated and cropping intensity;
- cropping patterns and yields, value of production;
- net financial and economic benefits.

Among large water storage projects that constitute the WCD knowledgebase (52 subjects), almost half did not achieve planned targets regarding physical performance and areas actually irrigated. In the initial phases these projects seem prone to poor performance while they experience increases in irrigated areas of 30% between year five and year 30 (from 70% to 100%)[xi]. Values reflecting crop intensity seem to be more consistent with envisioned targets[xii]. Within the WCD sub- sample group of dams, close to half of the investigated projects achieved or exceeded expected targets from the first year of operation. The sizes of dams play a part in how well they met targets relating to water delivery, actual cropping intensity and proportions of irrigated areas. According to WCD, dams of smaller size (still large scale however) usually perform better. Dams corresponding to heights less than 30 m and reservoir areas smaller than 10 m^2 generally show greater consistency in fulfilling required outcomes, while 90 % of projects that failed to meet their targets were of larger dimensions.

The main reasons for poor performance of large scale water storage project for irrigation are generally found at the administrative or institutional levels. These include insufficient distribution networks, lack of decentralised (or rather too great a presence of over- centralised) administrative systems regulating financing for canal developments, unclear divisions regarding fields of institutional responsibilities and synchronisation disabilities between planning agencies vis-a-vis the incentives driving the dynamics on the ground in agricultural communities. There is also a technical aspect to the complex of problems usually related to unsatisfactory pre-studies and surveys, faulty or inadequate hydrological surveys as well as overly-optimistic projections of potential outcomes.

The second criteria of poor performance is connected to production values and actual yields of agricultural activities. There tends to be a rather substantial variability in actual outcomes compared to planned outcomes in terms of agriculture outputs primarily related to human behavioural factors. Lower crop yields are observed when agricultural activities and crops are pre-determined in planning stages of the projects. Higher yields or gross values of production are more frequently observed when farmers are free to react to changing market behaviours and have greater flexibility to adapt their planting to more high-value crop types. Other reasons for variations in outputs relate to inefficient farming methods, usage of sub-standard quality crop types and usage of farmland of uneven standard. Poor storage facilities, underdeveloped drainage systems, unfit irrigation, pest infestations, and severe weather conditions are other commonly referred to reasons for poor performance.

To measure net profitability of irrigation dam projects conventional FIRR and EIRR assessments are applied by the WCD. The EIRR is best linked to humanitarian development as it assesses overall economic welfare/ well being from a societal perspective. It is suggested that in developing economies EIRR values over 10 % are to be considered as satisfactory.[xiii] Of examined projects the average EIRR value was about 10, 5 % with a considerable amount of evaluated projects reaching as values as low as 5 %. It should, however, be noted that all results were evaluated at relatively short time periods after commissioning, keeping in mind that irrigation dams seem to reach optimized functionality after several years of operation.

3.2 Hydropower

The benefits of large scale dams designed for hydropower purposes are examined by WCD foremost on their ability to meet power delivery targets. Hydropower dams seem to meet pre-determined targets to a greater extent than irrigation dams according to the WCD knowledgebase. Close to 50 % of the projects within the WCD knowledgebase exceeded pre-determined targets[xiv]. Among top producing hydropower plants reaching higher than expected outcomes, most projects installed extra generation capacity after commissioning. About 25 % of examined dams with higher outputs than expected had installed more than 100 % of the capacity planned for in respective feasibility studies[xv] which demonstrates the possibility to make the projects more effective over time.

There are also cases where outputs are lower than expected, with some 5 %[xvi] of examined hydropower dams in the WCD reference base falling well below expected outcomes. The reasons for lower than expected results differ. In general, the time spans for hydropower dams to reach expected outcomes are shorter than with irrigation dams, averaging 80 % of the expected capacity reached within the first year of operation, and subsequently increasing over years two to five to reach close to 100 % realization of expected targets.

Similar to irrigation dams many problems related to poor performance can be traced to the planning phases of the projects. Errors or changes at early development stages show clear linkages to greater delays in reaching expected power generation targets in early years of operation[xvii]. This might include delays in filling up reservoirs, postponements of components in construction phases, and design changes or inabilities to get turbines up and running according to the initial planning.

There are also natural circumstances causing variability and reliability in power delivery of large dams once operational. Changes in weather conditions, precipitation and hydrological patterns might yield considerable differences in annual energy outputs due to weakened river flows. In several cases huge variations in power production can be traced to drought seasons in specific regions[xviii]. Even greater variations in power generation capacities are possible effects of even more unpredictable conditions brought about by climate change. Land use changes in catchments upstream can increase erosion, leading to siltation that reduces storage capacity and hence the power generation head.

Regarding profitability of hydropower dams, conclusions can be drawn from a variety of case studies performed by the WCD. Even if a number of projects fall short of predicted targets very few projects can be considered economically unprofitable[xix]. It can also be stated that the number of projects falling slightly short of planned profitability are matched by a number of projects that actually outperform their original estimates of profitability, with specific projects reaching respectable EIRR values even after decades in operations. An example is the Kariba dam with an EIRR value of 14, 5%[xx]

3.3 Water supply

Dams designed primarily with the purpose of bulk water supply can be assessed and evaluated according to their ability to meet pre-determined targets of water delivery. Water supply dams often have a longer development cycle than previously discussed dam types which can be a reason to why these dam projects often seem to fail to meet initial targets. According to the WCD knowledge base samples, roughly 25 % of dams had reached less than 50 % of initially planned supply targets[xxi]. While other discussed dam types have shown a somewhat solid ability to catch up and sometimes exceed intended targets over time, water supply dams on the other hand do not show similar features, with some 70 % of sample subjects not reaching their intended targets even over considerable time periods.

Contrary to other single purpose dam types that usually meet their targets, water supply dams show deviating characteristics. In all investigated cases where bulk water supply exceeded expected outcomes, supply functions were part of multipurpose dam schemes[xxii]. The other determining factor relates to reservoir sizes of dam facilities. According to WCD, demand for water supply tends to grow even in connection to dams not specifically built for that purpose because they often foster population growth and economic expansion.

The general economic profitability of single purpose supply dams can be considered to be rather unsatisfactory. Poor performances with EIRR values well below 10 % seem to be the norm of examined subjects within the knowledgebase. These results are also echoed somewhat in general findings regarding water supply and sanitation projects of different organizations. The ADB has reported a large number of projects failing to meet both FIRR and EIRR targets[xxiii]. A WB analyses of 129 supply and sewerage projects reported that practically all delivered EIRR values were below 10 %[xxiv]. Insufficient tariff systems and pricing mechanisms are common reasons for poor economic returns. Of examined projects in the knowledge base, 35 of 50 utilities carried their operation and maintenance costs through tariff acquirements[xxv]. However, several studies point to the fact that there is a general willingness, even in developing nations, to pay for satisfactory services regarding supply and sanitation deliverables. In many cases, people already pay water- vendors many times the price in comparison to potential operation and maintenance costs of a piped supply system[xxvi].

3.4 Flood control

Ambitions to control river flows for improved agriculture and industry and to protect populations and property from flooding are a fundamental aspect of water resources management.

Traditionally dams regulating river flows operate by storing varied volumes of flood waters in constructed reservoirs and then controlling the timing of water discharge over time. By doing this it is possible to regulate peaks in tributary river flows, thus preventing such peaks from coinciding and adding unwanted water quantities to the main body of a river. This constitutes a main mitigation device to flooding that helps other mitigation installations such as levees, protective walls, dikes to withstand heightened water levels. Measurement variables to assess performances of flood control dams thus relate to the actual reduction of flood peaks and the subsequent reductions in negative impacts on economic, property, societal and health values[xxvii]. According to the WCD knowledgebase, flood control dams generally achieve their purpose of reducing levels of peak floods, reducing risks to downstream values of any kind considerably at times of extreme hydrological pattern changes. Even when maximum storage capacities are breached in extreme cases, the delays[xxviii] provided by the dams often create a essential early warning time for evacuations and rescue operations.

Problems related to the functions of flood control dams are often confined to physical or technical aspects of construction. Documented risks include faulty operational procedures of reservoirs in times of quick changes in external conditions or mechanical mal-functions of dam components like flood gates flood control structures. As peak-flow regulations may only be needed a few times each year, flood control dams are often combined with other purposes. Consequently there may be risks for competing and conflicting utilization where flood control requires empty reservoirs for flood control and irrigation and hydropower requires reservoirs to be as full as possible basically at all times. In the

WCD case studies the most common conflict involving flood control dams related to this dynamic, resulting in situations of perceived exposure to flood risks of downstream communities.

Another significant issue raised with regard to existing facilities is in the context of emerging challenges related to climate change. Existing dam structures are designed for existing or earlier conditions and weather patterns. There may be a need to re-evaluate the current capabilities of dam structures in combination with new assessments of changing hydrology due to climate change.

Consequently an overall reassessments of dam functions as a tool for flood control both with regard to safety aspects and improved flood performances[xxix] seem to win ground in contemporary water resources management. As identified by the WCD[xxx] ,some structural concerns in taking steps from mere flood controlling functions to a wider integrated flood managing system include the high costs of developing fully reliable control systems, the capacity reductions over time due to sedimentation, and the potential positive impacts that floods generate for many ecosystem services.

3.5 Multi-purpose use

Several water storage schemes and dams serve many of the typical water management functions described above. These are known as multipurpose dams. Regions served by different water storing facilities are often in need of more user needs and benefits than single purpose dams can provide. It could also be strategic to try to incorporate as many features as possible when deciding on large scale investments due to the high capital costs involved. As mentioned earlier, alternative needs connected to water resources also often emerge around single purpose dams as natural parts of population and societal developments promoting multipurpose use over time.

Single purpose dams are expected to perform better when compared to multi-purpose storage because it is less complicated to improve performance in one area compared to managing tradeoffs from several user needs. With regard to achieving physical targets, the performance of multipurpose dams is therefore difficult to evaluate.[xxxi]. With regard to economic targets, multipurpose dams show a slightly larger scale of variation in achieving expected results. A WCD study conducted on 12 projects financed by the WB, ADB and the AfDB demonstrated that all generated slightly lower (roughly around 4 %) EIRR values than projected in pre-operational phases.

Multipurpose structures, arrangements and layouts are, by definition, more complex than single use models that might induce operational incompatibilities. How to combine different uses (for instance hydropower versus flood control/management) that requires alternative reservoir functions in an optimal way might be considered a key component in maximizing benefits from multipurpose schemes. The WCD concludes that the impacts of conflict water use arising between different operational uses of multi- benefit dams are underestimated as influencing factors in operational performances. In contemporary water storage design, however, multiple uses will always be considered. Ecosystem services and socio-economic development schemes will usually be part of project design even in a single purpose scheme.

4 Managing tradeoffs from water storage schemes in an African context

There are strong arguments for developing water storage and hydropower put forward by developing countries, considering the large potential, climate variability, agriculture, water supply and overall energy benefits to economic development. The lack of strategic multi-sector program planning has, however, sometimes led to devastating environmental impacts from dam projects. Understanding the potential negative environmental impacts from dam projects and how to mitigate these are essential in optimizing outcomes of dam projects

4.1 Environmental impacts

4.1.1 Flow regimes

Flow regimes, are crucial to aquatic ecosystems. Flora and fauna both depend on the regularity, timing and regular floods in order to survive. Effects of dams on ecosystems depend on their storage capacity combined with the chosen operational method. Consequently flow regulation normally decreases flood peaks and increases low flows[xxxii], normally leading to reductions of overbank flooding. In the wetlands of Hadejia-Nguru region in Nigeria, annual flooding approximated at 3000 km^2 before dam constructions started in the region and was subsequently reduced to less than 1000 km^2 after construction[xxxiii]. Water temperatures and chemistry compositions are also affected by alternate flows induced by storage facilities. Consequently water let out from dams is often of a different chemical make-up than inflowing rivers. Surges of organic material and nutrients into reservoirs, often as consequence of human activities in the catchment, area is a cause for eutrophication leading to worsened water quality, water hyacinth growth and overall water quality and environmental degradation. How water is released from the reservoir might play part in the overall water quality[xxxiv]. Water released from surface levels are nutrient depleted while water released from the bottom of the reservoir often is oxygen depleted but nutrient rich and potentially high in elements such as iron, hydrogen sulphide and manganese. At early stages of withdrawals from the Volta reservoir in Ghana water had to be treated to remove high levels of manganese and iron[xxxv].

4.1.2 Sedimentation

Water storage in reservoirs tends to reduce water flows and velocity. The reduced speed of flowing water leads to greater sedimentation. The extent and degree of sedimentation is often dependant on several factors such as specific dam operational methods as well as surrounding land use practises in the catchment area. Downstream areas are potentially exposed to erosion as result of lower sediment loads. Successive dam constructions such as the Aswan dam in Egypt have reduced the amount of sediments reaching the Nile Delta. Tangible impacts of this are rapidly eroding coastlines with an annual decline of 5-8 metres and in specific areas more than 240 metres[xxxvi]. Effects of less sediment deposits in combination with wave erosion have severely affected coastlines of Togo and Benin with annual reductions of 10-15 metres due to reduced water velocity induced by the dam Akosombo on the river Volta in Ghana[xxxvii]. Other downstream effects of degrading character as consequences of sedimentation alterations are the reduction of nutrients and destruction of natural habitats for different species of flora and fauna (particularly fish).

4.1.3 Primary production and fisheries

Effects of storage functions, changes in water flow, chemistry or temperature, can often be detected at the very primary levels of natural production systems especially downstream from dam structures. Dam developments in Nigeria have resulted in major growth of aquatic plants of different character whether emergent, submergent or of floating types. Silted areas in the Old Hadejia River have severely obstructed water flows to the Yobe River flowing in to Lake Chad through Nigeria and Niger[xxxviii]. Aquatic plants reduce light penetration and as they decay they deplete oxygen. This might hinder or alter production of types of plankton, algae or other aquatic microorganisms that normally constitute the very foundation of food chain structures, thus causing severe consequences further down the food chain. Alterations in water compositions due to dam development on the Niger River have led to a significant increase of water hyacinth, an invasive species. The thick weed has affected approximately 5 million people due to restriced fishing, navigation, irrigation and linked health impacts (as it provides excellent environments for mosquitoes)[xxxix].

Different species of fish are normally only adjusted to either lotic (rivers, springs, streams) or lentic (lakes, swamps, ponds) ecosystems. Dam installations can function as a transformer between the two systems. They might also act as barriers, disconnecting rivers floodplains, and migration routes as well as induce earlier mentioned changes in water compositions, all of which impact living organisms in different aquatic ecosystems. Losses in downstream fishing outputs due to dam constructions have been registered for several African river basins. Losses in fish (as measured difference in annual catch) reported from the Senegal River system amounts to an annual 11250 tonnes due to dams[xl]. According to the WCD knowledgebase other areas affected by less fish stocks as consequence of dam developments include the Yaeres[xli] wet plains of Cameroon, the Pongolo flood plain in South Africa, and the Niger River below the Kainji dam. Other tangible impacts have further been recorded from the lower Volta region, the Nile delta and the Zambezi River[xlii]. Less freshwater flows to deltas and estuaries increases salinity levels, affects nursery habitats for many fresh water species, and enables predatory species to enter these ecosystems. These impacts reduce the catches of specific commercial fish species, which is evident in the coastal waters of the Mediterranean due to the Aswan dam and in the Zambezi delta where reductions in shrimp catches have been estimated to 10 million USD annually[xliii].

4.1.4 Mitigation

Alterations of flow regimes, water compositions and ecosystems are negative tradeoffs. However, changes to the water regime can also bring about new possibilities as one ecosystem transforms to another, enabling new life forms previously not adapted to a specific environment to thrive. Dams can be utilized as reservoirs for commercial fisheries by adapting to new conditions and introducing species capable of existing in the altered environment brought about by dam construction.

By avoiding planning of dam projects in isolation from, taking an ecosystem approach and incorporating comprehensive pre- studies there are several ways to substantially mitigate negative environmental impacts of dam construction. Measures that can be employed upstream and within the dam reservoirs should be incorporated under the overarching concept of catchment management. Some of these are listed below:[xliv]

- <u>In order to address water quality and thermal issues the following measures can be considered</u>
    - Alterations and adjustments of inlet functions, artificial mixing of water by methods of compressed air, reduce residence times by flushing, pre-impoundment reservoir clearing, re-aeration of reservoir, inflow treatments, construction of smaller “pre-reservoirs”.

- <u>In order to avoid sedimentation the following measures can be considered</u>
    - Form debris dams (structures placed across well defined channels that hinder stream flows and provide basins that catch floating debris), implement shore-line erosion control, dredge (physical removal of mainly riverbed or lakebed sediment).

- <u>In order to reduce weed accumulations the following measures can be considered</u>
    - Mechanical cutting, bio manipulation, and chemical control.

- <u>In order to lessen effects on regional and local fish stocks the following measures can be considered</u>
    - Construct spawning areas, physically remove sand banks and bars across tributary inflow areas, introduce alternative species to new aquatic environments, construct alternative shallow water habitats.

4.2 Dams and social impacts

Large scale projects pose many challenges from a spatial, geographical, financial and social point of view. It is important to make a proper stakeholder analysis and identify how projects affect people. Stakeholders that gain will usually be those that benefit from commercial agricultural production or in urban settings, while negatively affected stakeholders are those that are forced to undergo substantial changes to their existing lifestyles.

Dam projects are often planned as components of national development programs or regional growth poles. They often carry elements of nationalistic pride as well. In this context it is critical to safeguard vulnerable populations including[xlv] resettled people (people forced to move as consequence of dam projects), hosts (people inhabiting lands that receive resettled people) and people downstream (people inhabiting lands below dams that get livelihoods, mainly cultivation systems, disrupted as consequence of altered river flow regimes). Specific mitigation and compensation schemes need to be part of project design.

4.2.1 Resettlement and compensation

One of the most significant negative social impacts of dam construction, not least in an African perspective is the problem of involuntary resettlement. An estimated 400 000 people have been resettled as direct consequence of dam constructions on the African continent[xlvi]. The resettlement issue provides a significant set of difficult issues to resolve. At the same time these issues can be considered opportunities as they provide a field for “soft” development interventions related to dam constructions with the potential of generating great benefits in the dam construction process that do not require costly or overly complicated methods. The resettlement process incorporates critical elements that have not been appropriately addressed in an African context. The compensation of resettled populations is a critical topic that needs considerable attention in order to minimize negative social impacts of relocation. There are many aspects to consider. Firstly the form of compensation needs to be determined. Mere cash settlements between project drivers and resettled groups have proven generally insufficient as the option has tended to leave beneficiaries in a worse off once the first down payment has been spent. [xlvii]. Consequently, the allocation, division, and definition of compensation are important components to sort out in order to optimize resettlement processes.

Evidence from Africa demonstrates deficiencies and discrepancies in terms of how and when compensations have been dispersed. Official governmental relocation programs include options for moving to pre-constructed official resettlement areas or plain cash compensations for individuals seeking alternatives outside relocation programs. In the latter case, tendencies seem to point towards protractions or unwillingness to disperse funds, where in some cases delays of up to five years have been noticed[xlviii]. The compensation policy delays seem to be a common feature, 15 years after relocation some 40 % of Aswan relocated people had not received proper compensation[xlix]. In rare examples commercial farmers have been paid compensation to resettle at market price values for their farms, but these have, in turn, chosen not to buy new farms, thus leaving uncompensated farm workers with no source of income[l]. Also, issues regarding compensation for land have proven difficult due to registration technicalities. In the case of the Aswan dam and other examples, large populations were not given any compensation due to the fact that their land was not individually registered, which essentially prompted the government to regard the land as state property lifting the obligation to compensate[li]. Other indications show that host populations are generally not compensated to any extent for encroachments on their lands by resettling populations. In cases people have settled in areas demarcated for water storage development making registration of beneficiaries even more difficult.

4.2.2 Participatory planning

Despite tangible improvements due to a wider acknowledgement of participatory processes there are examples where lack of inclusiveness of concerned and affected parties has lead to conflict. The inclusion of downstream communities at early stages generates a greater potential for dam projects to be implemented more efficiently. Successful cases from the African continent demonstrate that a key element in achieving this is to have proper project timeframes[lii] to allow for stakeholder analysis and dialogue. This enables surveys and evaluations to be thoroughly conducted and the outcomes of these to be included in the actual planning processes. The wider use of relocation as a term describing a process that includes more than just providing new dwellings for resettlers has helped to clarify issues[liii]. Thus there is a need for inclusive, integrated planning processes for long term development addressing issues of how to reinvigorate local economies once resettlement have taken place. Other basic humanitarian issues relating to housing, water supply and sanitation all need to be part of the long term planning[liv] process.

4.2.3 Opportunities for improving livelihoods

Well managed projects incorporating participatory planning processes, sufficient timeframes and sound measures of compensation have great potential of becoming successful. As concluded in the introductory section of this chapter there are social benefits interwoven into basic dam functions that can be strengthened by focused pre- studies of the specific project context. By examining regional and local contexts, projects might contribute extensively to ongoing development efforts and mitigate potential harmful impacts.

Indirect economic advancements at local and regional levels can be encouraged by drawing resources for construction/maintenance and related infrastructural development from the local resource base. This will aid local populations and create new livelihood opportunities. Efficient surveys incorporating local opinions can provide further input on developing resettlement schemes in order for resettling communities to make transitions to new areas possibly with opportunities to enhance their source of income. Other aspects of dam construction include the opportunity to incorporate recreational values for local and regional populations and also increased tourism revenue.

Resettlement does provide opportunities as well as challenges. A number of African examples show that project affected groups that moved to other lands and were provided with basic opportunities managed to strengthen livelihoods through income diversification. In the case of the New Halfa scheme (resettlement area) of the Aswan dam, resettled people that previously primarily engaged in pastoral activities managed to combine their original source of income with new livelihood opportunities provided by the scheme. [lv]. Other opportunities for project related incomes can be provided during the construction phases of dams and connected infrastructure. By employing locals, as was the case in the construction of Manantali dam on the Senegal River[lvi], substantial cash flows provided by workers in their respective villages were sources of significant development.

4.3 Best practises in developing water storage

Considerable experience from various water storage projects around the world during decades of large scale constructions have been gathered and assessed by many stakeholders and lessons have been learned. Consequently, frameworks for what can be considered good practises have been produced for consideration by developers and financiers.

The following section is a compilation of best practise in the field of implementing water storage projects building on lessons learned by the UN and WB, WCD, IHA- HSAF and SIWI.

4.3.1 Initial stages- best practices of option identification and assessment

Water storage projects will undoubtedly have several stages where options of various natures have to be identified in order to choose the best project from an economic, financial, technical, social and environmental point of view.

In this regard, it is crucial to include stages of option identification as early on in the overall process of water storage projects as possible. Evidence show that early identification of project options tends to reduce project costs, increase stakeholder involvement and minimize the overall reduction of risks associated with project development[lvii]. Ideally, steps of option identification should not be a one- time occurrence but rather be a repetitive process where project components and options are analysed in an iterative manner in order for decisions to be based on the most updated findings in fields of technology and science. Stakeholder participation is to be considered an integral part of identification processes in order to legitimize these and gain broadly-based input and acceptance[lviii]. Identification of options should take into account the existing legal regulatory frameworks in energy- and water utilizations. External financing (donors organisations, IFI:s) project support frameworks could, when applicable, be linked to initial planning processes and as such serve as a motivating for best practise in the comprehensive planning stage[lix].

According to a recent framework prepared by the Hydropower Sustainability Assessment Forum (HSAF) focussing on hydropower development strategic assessments are divided into several sub-themes:[lx]

Demonstrated need/demand

The scale of investments in water and energy infrastructure must be motivated by an underlying need and demand analysis as services provided by these affects a several sectors. The assessment protocol points to the existence of “viable markets of water and energy services” as indicators to the existence of demand.

Options assessment

The need to identify options early on and in a strategic manner is essential for sustainable project implementations especially in energy developments. Option assessment in this regard entails a sustainability perspective through which a range of alternatives should be investigated using a multiple social, economic, environmental and technical criteria. This ensures that a hydropower project can be considered as a viable prioritized option. Comparing different sources of fuel and projects of different size and scope further builds the case for selecting the best viable option for subsequent detailed project analysis. The SEA approach (see below) can be a useful tool in upstream project identification and option assessment.

Regional and national policies and plans

All intended projects need to be harmonised with existing policies in a national and regional context that encompasses environmental and social issues . This ensures that current guidelines regarding different values, not least humanitarian, are not overstepped in project development processes. National plans and policies are to function as a helping measure to promote sustainable development of water storage projects.

Institutional capacity

Water and energy projects are heavily dependent on the quality and functions of related institutions of various kinds; governmental, financial, supply, labour etc. Pre- assessment studies should therefore strive to determine where such capacities are lacking in order to strengthen institutions where necessary.

Risks

This theme relates to different early identifiable risks that need to be addressed in order to avoid "systematic" failures affecting a potential project development. These can be risks associated with social, environmental, technical or financial issues. Such analyses ensure that no major investments are undertaken without knowing to the fullest possible extent that they have not been made in vain or that decisions regarding these aspects do not have to be turned back, and that all project developers are well aware of the potential risks prior to initiating the project preparation and financing process.

Typical risks assessed in the context of large scale hydropower projects include:

- Political risk - is there a political commitment to the project and in the case of multi-country projects are project development agreements in place?
- Water rights risk - is there a water resources management framework in place?
- Hydrology and sedimentation risk- how will rainfall variability and climate change alter the generation potential and how are watersheds being management?
- Environmental and social compliance - is the necessary legal framework in place and is it being enforced?
- Technical and construction risk- are there guarantees that technical designs meet established norms?
- Lack of a suitable enabling environment - is the necessary legal framework in place for a long term investment and is the institutional capacity adequate to operate the storage scheme?
- Payment/offtake risk - are coming customers able to pay for electricity generated, is a power purchase agreement in place or being negotiated?
- Exchange rates/devaluation risk - can interest on loans be paid off?
- Reputational risk - have all social and environmental issues been taken into consideration to avoid corporate reputational risk?
- Corruption risk - large scale infrastructure projects are always at risk for corruption. Is an anti-corruption strategy in place and is it being reinforced?

4.3.2 Strategic and project specific environmental assessments

The concept of strategic and project specific environmental assessment and impact analyses have developed and expanded considerably thus raising a broader range of issues than mere mitigation and monitoring during project implementation phases. Strategic Environmental Assessments (SEA) are widely used globally to analyze impacts of development programs early in the development planning process and encompass the issues raised in the section above. The SEA can be used by national governments, project specific proponents or regional entities in analyzing benefits from cooperation the cumulative impacts of several development interventions. This brings a strategic perspective to planning compared to a project specific approach. The SEA raises environmental and social issues of major development programs early on in the planning, project development, and investment finance process. An SEA is defined as "the formalized, systematic, and comprehensive process of evaluating the environmental effects of a policy, plan, or programme and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making"[lxi]. In 2003 the World Bank Water Resources Sector Strategy and the WCD's core values require that alternatives to water storage schemes be assessed before implementation. An SEA will not replace the project specific feasibility study and environmental and social impact assessments which are necessary for project implementation.

Successful comprehensive environmental planning should entail a certain set of characteristics[lxii]:

1) In order for environmental planning in to be successful there should be substantial commitments from all involved parties and stakeholders. Institutional capacities must be given the proper time and resources needed to include environmental management planning in processes, thus making sure that environmental management concerns run through the entire project including contracts, agreements and certificates.

2) Aspects of environmental management should be evaluated in the wider scope of project planning including environmental management costs in overall project budgets and analyses such as in an SEA approach

3) Environmental management plans should be subject of continuous monitoring and oversight schemes to determine their effectiveness. Possible changes and corrections should be outcomes of these monitoring schemes in order to improve environmental performance as project conditions change.

4.3.3 Stakeholder involvement and project preparation

Wide stakeholder involvement is essential to bring in relevant perspectives on ecological, social, economic or other areas for all large scale water storage schemes. It is important that all areas of society get the proper information of planned actions and are offered a genuine chance to influence the situation. According to UNDP; best practises of stakeholder involvement correspond to the following conditions[lxiii]:

- Sustainable decisions can only be reached when the needs of all involved interest groups are attended to, including those of decision makers;
- stakeholders should be able to affect decisions with potential to affect their way of life; consequently their involvement must be actively sought and promoted;
- stakeholders should be provided with sufficient information in order for them to contribute to processes and they are also to be informed on how their views have been treated and how they influenced the decision outcomes.

Effective stakeholder involvement employs stakeholder analysis methodologies and plans for participation. These should be incorporated early on in any water storage project in order to map out and engage all potential stakeholder groups. The analyses should identify people or organizations existing close to an intended project site with particular attention to lifestyles, livelihood opportunities, and cultural customs, working conditions or other determining factors that might be affected in either a positive or a negative way. The UNDP suggests a five level scheme on how to most effectively go about stakeholder involvement[lxiv]:

Communication

Information about a project should be communicated to stakeholders. Information provided should be balanced and objective in order to help stakeholders fully understand the problems and potential solutions. Information can be distributed in various ways such as web based tools, factsheets, newsletters or through o community events.

Consult

Stakeholders should be consulted in an interactive manner to gain their reactions and feedback. Surveys, polls, interviews and public meetings are different ways of interaction with various types of stakeholders.

Involve

The public should be directly involved in different steps of the process. This ensures that information distances between public and decision makers are kept short and that opinions can quickly be incorporated in alternative plan developments. Interactions can take place through workshops and seminars or other easily accessible common forums.

Collaborate

It is important that the projects proponents not only inform and involve the public they must also engage stakeholders in an advisory role. Stakeholder input should always be considered seriously at any level in project design. Tools to achieve such engagement can be citizen based advisory councils or other knowledge sharing functions.

Empower

Empowering might constitute the most critical step regarding stakeholder involvement because it puts a measure of decision-making power in the hands of affected stakeholders and populations. This entails providing a public mandate in processes that could actually prevent certain actions that would otherwise be deemed unavoidable. Different democratic approaches such as voting processes or citizen based jury functions might be the best way to realise this.

4.3.4 Compensation

Implementing the right mechanisms to find proper compensation, especially when resettling project affected people, requires strong institutional capacity. Compensation for resettlement demands comprehensive and long-term planning so that the measures are in place and resolved before actual construction begins. Project institutions should have the ability to create and manage resettlement schemes/programs and be able to disburse direct compensation. This can include land preparation, providing job training, access to credit facilities, and output based aid that ensures sustainable humanitarian and economic developments. One creative and potentially sustainable way of economic benefit compensation is by reaching partnership/shareholder agreements between project implementing parties and affected groups.

5 An African mitigation strategy to tackle global climate change – hydropower

Impacts of climate change are already felt in many parts of the world with unpredictable weather patterns, variations in hydrological conditions, and alterations in average temperatures for different regions. These conditions are likely to increase without sufficient and decisive mitigation measures. Few continents display greater variability in weather patterns than the African continent with limited capacity to cope with change. The poor segments in society are usually affected the most.

Previous sections have explored different purposes of dams and how they can help societies to adapt to the effects of climate change through mitigation and buffering functions of water storage. Regions affected by high rainfall variability, droughts and floods need to invest to build water security. In periods of heavy rainfall flash floods, mudslides, and landslides can be prevented by flood control dams coupled with investments in watershed management. Human induced climate change can be mitigated by offsetting carbon based fuels through renewable energy initiatives including hydropower.

There are considerable opportunities advocated by African nations to develop hydropower for economic development, to providing electricity for growth and for export and to mitigate climate change. Africa is estimated to have massive potential for hydropower. Only about 7 % of the technically feasible hydropower potential has been developed on the continent[lxv]. Already, demand is outstripping supply and many countries are utilizing expensive fossil fuelled based thermal electricity generation. Regional power trade is central to a growth strategy in electricity generation by providing options to balance generation centres with different sources of fuels and exports[lxvi]. The SAPP, WAPP and emerging EAPP are examples of growing power markets promoting regional integration for growth and stability.

Southern Africa, including more central parts such as DRC that is part of SADD, has a good potential to mitigate climate change through hydro-energy. The Grand Inga site in the DRC alone has an estimated potential of 36000 MW-100000 MW[lxvii]. The current suppressed demand in DRC is only 600 MW[lxviii]. Angola, Zambia and Mozambique have a combined potential of 70000 MW-135000 MW[lxix] to add to the SAPP. South Africa alone has a current assessed demand of 39145 MW (2009)[lxx]. Regional cooperation regarding hydropower is a sound strategy to lower greenhouse gas emission because most of South Africa's energy demands today are met by coal. The strategic location of the Grand Inga site and its vast potential has led to the extension of the SAPP transmission network via Zambia to South Africa and with plans for linking Malawi and further across the continent to Egypt ("Cape to Cairo concept)[lxxi]. This could interconnect the entire continent in one giant power pool in which hydropower would provide the base or peak load depending on the system needs.

The other major potential power pool identified on the continent is located in East Africa with Ethiopia as the main supplier. Ethiopia is estimated to have more than 30000 MW[lxxii] of hydro power potential of which only about 2 % is exploited[lxxiii]. Egypt, Sudan, Kenya and the other East African Community countries (EAC) are the most obvious partners in developing the EAPP. The Nile Basin Initiative (NBI) is promoting good water management and hydropower development in a multipurpose context. Uganda, centrally located on the Nile, has major hydropower potential in addition to the ongoing Bujagali Falls HEP scheme.[lxxiv].

In West Africa existing HEP in Ghana can be a source for regional distribution and electricity supply to Burkina Faso, Mali and the Ivory Coast[lxxv].

Box. The Nile Basin Initative and the preparation of the Regional Rusumo Falls Hydroelectric and Multipurpose Project[lxxvi]

The Nile river basin encompasses an area of about 3 mil-lion square kilometres. Ten countries, with a total estimated population of 300 million people share the Nile river basin: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The population in the basin countries is expected to reach 600 million by 2025. Human security is strongly linked to poverty reduction. The rationale for improved water resources management aims to contribute to sustainable economic growth and poverty alleviation. The total potential annual direct gross economic benefits of Nile water utilization in irrigation and hydroelectric power generation are estimated to be on the order of US$ 7–11 billion). The Nile riparian countries took a major step to establish the NBI in 1999, an initiative that includes all Nile countries and provides an agreed basin-wide framework to fight poverty and promote socio-economic development in the region. The initiative is guided by a shared vision "to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources." The Nile riparian countries seek to realize their shared vision through a strategic action programme, comprising basin-wide projects and joint investment projects at the sub-basin level. This programme seeks to exchange experience, build capacity and trust and create an enabling environment for investments. Seven basinwide projects address issues that are common for all the riparians. These includes: transboundary environmental concerns, regional power trade, agricultural production, water resources planning and management, communication, applied training, socio-economic development and benefit-sharing.

To unlock the development benefits, the riparian countries are exploring investment opportunities in multipurpose water management and development by collaborating in two Subsidiary Action Programmes. The two programmes are the *Eastern Nile Subsidiary Action Programme*, which includes Egypt, Ethiopia, and Sudan and the *Nile Equatorial Lakes Subsidiary Action Programme* (NELSAP), which includes Burundi, Democratic Republic of Congo, Kenya, Rwanda, Tanzania, Uganda, Egypt and Sudan. Approaches taken to increase joint investments include pre-investment studies, such as *Strategic/Sectoral Social and Environmental Assessments* (SSEA), and the design of far reaching multipurpose programmes in areas such as IWRM, flood management, power generation and interconnection, and irrigation and drainage. The decision-making process is strong with the Nile Council of Ministers for Water Affairs serving as the highest decision making body of the NBI. The core cost of this arrangement is supported by the Nile Basin countries through payment of annual dues with supplemental funding for regional project activities through a multi donor trust fund in which Sida is a key stakeholder.

Currently detail feasibility work on the Regional Rusumo Falls Hydroelectric Power Project (RRFP) (shared by Burundi, Rwanda, and Tanzania) is ongoing in parallel with work to establish a sub-regional water management framework on the Kagera river basin in which the project sits. This is an example on how strategic donor financing has promoted the use of SEA techniques for options assessment to build a project pipeline subsequent detailed work on a project feasibility study taking best practise on water storage development into account. Transaction advisory services are undertaken in parallel to the feasibility study to seek the investment necessary for the implementation phase. The RRFP preparation phase and the work on a Kagera basin water management framework are a good example of how donor financing coupled with the strength of a major IFI can support good project preparation which should lead to financial close and construction. The need for donor financing for softer elements of the project in the investment phase should be explored.

6 The changing view of the role of water storage schemes among financiers

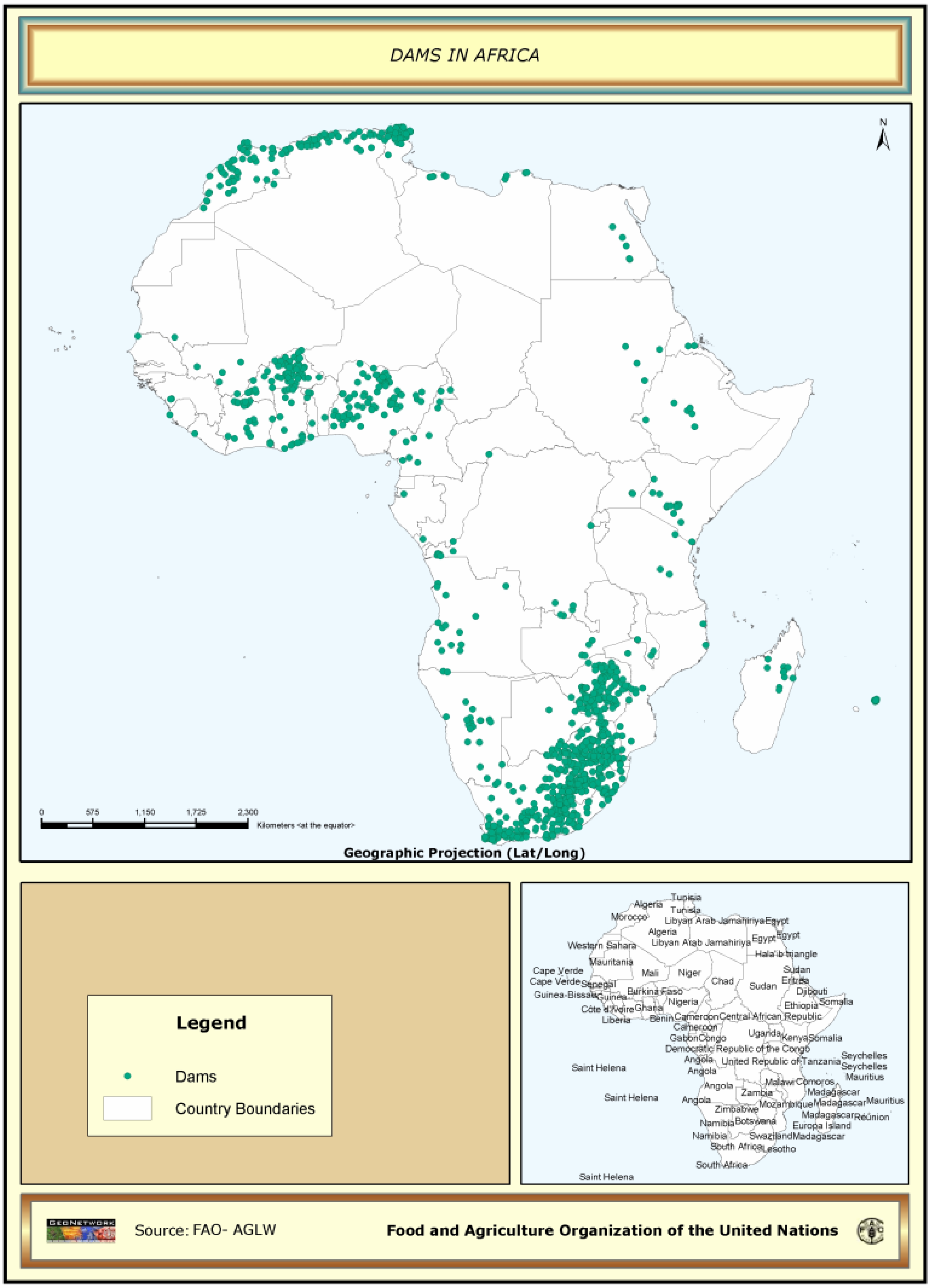
The attitude towards investment in water storage is changing amongst IFIs. Evidence of this is found ,inter alia, in the report from the UN Johannesburg Summit 2002 in which it is stated that it is key to ”develop critical water supply, reticulation and treatment infrastructure, and build capacity to maintain and manage systems to deliver water and sanitation services in both rural and urban areas”. Further, in the General Assembly Resolution on “Reliable and stable transit of energy and its role in ensuring sustainable development and international cooperation” (63/210) it is stated that ” stable, efficient and reliable energy transportation, is a key factor of sustainable development” and an ”interest of the entire international community”. The GA ”Welcomes international cooperation in developing transportation systems and pipelines” to provide ”energy for sustainable development”. Broad-based water service interventions in water supply and energy utilities, water and sanitation and irrigation services benefit everyone including the poor and play a major role in reaching some of the Millennium Development Goals[lxxvii .]

The World Bank [lxxviii] asserts that to build sustainable societies countries need to take action on several fronts. First, nations must increase their capacity to manage water resources and provide security against climatic variability, floods and droughts. This entails broad based interventions including major infrastructure projects, such as dams and inter-basin transfers, which provide local, national, and regional benefits. While industrialised countries have invested significantly in major hydraulic infrastructure many developing countries have not. In hydropower development, for example, industrialised countries use most available hydroelectric potential as a source of renewable energy. Many developing countries harness only a small fraction of available hydropower potential. Interventions and investments that improve and restore catchments are needed to ensure their capacity to retain and release water. Improving water services delivery and treatment for industry and domestic users is also critical to sustain and develop economies and livelihoods. [lxxix] Many of the major donor organisations such as USAID, DFID, and GTZ also have clear and ambitious targets in combating rural poverty through improved irrigation schemes, electrification of rural societies as well as achieving overall development ambitions by augmenting water supplies to improve access to water and sanitation conditions.

The climate change mitigation and adaption agenda is strengthening the need for substantial investment in water. Helping partner countries to improve planning and management capacity to tackle climate change and to mitigate impacts of natural hazards will be key. Dam structures are potentially applicable and functional components in many of these strategies. Furthermore the general willingness of many donors to pursue development of renewable energy as a mean of sustainable development and to offset green house gas emission reaching emission provide additional justification for investment in water storage and hydropower.

7 Appendix

7.1 Dams in Africa



Source: FAO Aquastat Dams Africa

7.2 Large dams by river basin in Africa

Large dams by river basin in Africa (Source: FAO-AQUASTAT)

River Basin	Countries in basin	Number of existing large dams (> 1 billion m^3)	Height of dams (m)	Reservoir capacity range (billion m^3)	Total reservoir capacity (billion m^3)	Main purpose*
Senegal	Guinea, Mali, Mauritania, Senegal	1	70	11.3	11.3	I
Niger	Algeria, Benin, Burkina Faso, Cameroon, Chad Côte d'Ivoire, Guinea, Mali, Niger, Nigeria	6	23 - 79	2.2 – 15.0	31.4	I, H
Lake Chad	Algeria, Cameroon, Central African Republic, Chad, Niger, Nigeria, Sudan	4	14 - 48	1.9 – 6.5	16.6	I
Volta	Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Togo	2	? - 134	1.4 – 148.0	149.4	H
Nile	Burundi, DRC, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda	6	22 - 111	0.9 – 162.0	174.9	I, H
Zambezi	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe	3	70 - 171	4.9 – 188.0	231.9	I, H
Orange	Botswana, Lesotho, Namibia, South Africa	5	? - 185	1.3 – 5.7	14.2	I, H
Limpopo	Botswana, Mozambique, South Africa, Zimbabwe	2	48 - 65	2.3 – 11.2	13.5	I, H
Congo	Angola, Burundi, Cameroon, Central African Rep, Congo, DRC, Rwanda, Tanzania, Zambia	2	50 - 58			H
Rift Valley	Djibouti, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, Uganda	2	42 - 155	1.6 – 1.9	3.5	I, H
Save	Mozambique, Zimbabwe	1	67	1.4	1.4	I
Incomati	Mozambique, South Africa, Swaziland	1	46	1.3	1.3	I, H
Cunene	Angola, Namibia	1	58	2.6	2.6	I, H
Mono	Benin, Togo	1	44	1.7	1.7	I, H
Other basins:						
Bengo,	Angola	2	41	1.5	1.5	I
Djerem, Mape, Noun	Cameroon	3	17 - 34	1.8 – 3.2	7.6	H
Bandama, Sassandra	Côte d'Ivoire	2	37 - 58	8.3 – 27.7	36.0	
Tana	Kenya	1	70	1.6	1.6	H
El Abid, Inaouene, Ouergha, Oum R'Bia	Morocco	4	72 - 133	1.2 – 2.8	9.1	I, H
Lurio, Pungoé, Revué	Mozambique	3	40 - 75	1.2 – 2.5	5.3	H
Nuvejaarspruit, Pongola	South Africa	3	?	2.5 – 3.2	8.3	I
Great Ruaha/Rufiji	Tanzania	1	45	3.2	3.2	H
TOTAL		**53**	**14 - 171**	**0.9 – 188.0**	**726.3**	

Source: FAO- Aquastat

7.3 Countries in Africa with large Irrigation schemes

Countries in Africa with large irrigation schemes (> 10 000 ha) (Source: FAO-AQUASTAT)

Country	Area under irrigation (1 000 ha)		
	Total	Large schemes (> 10 000 ha)	Area of large schemes as % of total area
Algeria	569	150	26
Côte d'Ivoire	73	10	14
Egypt	3 422	2 800	82
Ethiopia	290	50	17
Libya	470	40	9
Madagascar	1 086	70	6
Mali	236	130	55
Morocco	1 443	650	45
Mozambique	118	50	42
Nigeria	293	30	10
South Africa	1 498	500	33
Sudan	1 863	1 700	91
Tunisia	394	100	25
Zambia	156	20	13
Zimbabwe	174	20	11
Total	**12 085**	**6 320**	**52**
Total for Africa	**13 403**	**6 320**	**47**

Source: FAO- Aquastat

Large dams (> 1 billion m³ or > 1 BCM) by river basin in Africa

River Basin	Status	Name of dam	Dam located in river	Dam located in country	Dam properties Capacity (billion m³)	Height (m)	Use*
SENEGAL	Existing	Manantali	Bafing	Mali	11.270	70	I, N
		- Irrigation potential from Manantali Dam: 10 000 ha in Mali, 125 000 ha in Mauritania, 240 000 ha in Senegal (incl. Diama dam with 0.250 BCM capacity) - Irrigated from Manantali Dam: 300 ha in Mali, 20 000 ha in Mauritania, 50 000 ha in Senegal - According to integrated development master plan of left bank of Senegal river (1990) 131 500 ha is expected to be irrigated in 2025: 33 000 ha flood recession cropping, 10 500 ha irrigated industrial crops, 88 000 ha food crops - In Mauritania is Foum Gleita Dam on the Gorgol noir with 0.5 BCM capacity, for irrigation purposes					
	Planned						
GAMBIA	Existing						
	Planned	Kekreti Dam in Senegal for hydropower and irrigation of 15 000 ha in Senegal and 55 000 ha in Gambia					
NIGER	Existing	Sélingue	Sankarani	Mali	2.170	23	I, H, F, N
		Sotuba & Markala	Niger	Mali			I
		Lagdo	Benue	Cameroon	7.800	40	H, F, N, R
		Jebba	Niger	Nigeria	3.600	40	H
		Kainji	Niger	Nigeria	15.000	79	H, F
		Dadin Kowa	Gongola	Nigeria	2.855	42	I, H, S
		- Sélingue Dam is mainly used for hydropower and 60 000 ha irrigation - Diversion dams used to irrigate 56 000 ha of Office du Niger (Markala Dam of 0.175 BCM for rice) - Lagdo Dam is mainly used for hydropower, but could also be used for irrigation of about 20 000 ha About 1 000 ha is at present irrigated in Cameroon from this dam					
	Planned	- Fomi Dam on the Niandan River in Guinea for irrigation and hydropower However, negative environmental impact expected. - Tala & Djenné Dam on the Bani River in Mali for irrigation However, drying up of water resources requires re-examination - Tossaye Dam on Niger River in Mali for irrigation - Kandadji Dam on Niger River in Niger for multi-purpose use, including about 140 000 ha irrigation - In Nigeria, two proposals exist for water transfer schemes from Niger basin to Lake Chad basin					
LAKE CHAD	Existing	Tiga	Kano	Nigeria	1.874	48	I, F
		Mohammadu Abuya	Kano	Nigeria	5.535	16	I, S
		Jekara	Kano	Nigeria	6.519	14	I, O
		Kafin Zaki	Bonga	Nigeria	2.700	40	I
	Planned	- Two sites for dams on upstream branches of Logone in Cameroon and Chad planned for irrigation However, this would be to the detriment of water use for hydro-electric power generation and for irrigation outside Yaére lowlands. - Due to lowering of Lake Chad plans exist to transfer water from Congo basin by 170 km long canal in CAR					
VOLTA	Existing	Akosombo	Volta	Ghana	147.960	134	H
		Kompienga	Oualé	Burkina Faso	1.400		H
	Planned						
NILE	Existing	Roseires	Blue Nile	Sudan	2.200	60	I, H, F
		Sennar	Blue Nile	Sudan	0.930	48	I, H
		Jebel Aulia	White Nile	Sudan	3.500	22	I, H, F, N, R
		Khashm el Girba	Atbara	Sudan	1.300	35	I, H
		High Aswan	Nile	Egypt	162.000	111	I, H, F
		Old Aswan	Nile	Egypt	5.000	53	I, H
	Planned	- Plans exist to increase the height of Roseires dam in order to have an additional capacity of 4 BCM. - The Sennar Dam is used for irrigation of the large Gezira Managil scheme (870 750 ha) - About 152 260 ha is irrigated in Sudan from the Jebel Aulia Dam - Over 2.9 million ha is irrigated in Egypt using water from the Aswan Dam - In Tanzania, plans dating back from the German colonial period exist to transfer water from Lake Victoria to the Vembere Plateau to irrigate 88 000 -230 000 ha of cotton. Project is still at planning stage, but costs expected to be high - In Kenya plans exist to transfer water from Lake Victoria to drier areas, such as Kerio (in Rift Valley)					
ZAMBEZI	Existing	Kariba	Zambezi	Zambia, Zimbabwe	188.000	128	H
		Itezhitezhi	Kafue	Zambia	4.925	70	H
		Cahora Bassa	Zambezi	Mozambique	39.000	171	I, H, F
		Many small dams are located in Zimbabwe, mainly for irrigation purposes					
	Planned	Series hydropower cascade dams on mainstream Zambezi (Batoka Gorge, Devil's Gorge and Mupata Gorge					

Source: FAO- Aquastat

ORANGE	Existing	Bloemhof	Vaal	South Africa	1.264		I, S
		Gariep (H. Verwoerd)	Orange	South Africa	5.674		I, H, S
		P.K. Le Roux	Orange	South Africa	3.237		I, H
		Vaal	Vaal	South Africa	2.122		
		Katse (LHWP)	Malibamatso	Lesotho	1.950	185	H
	Planned	- Mashai Dam (3.3 BCM), Tsoelike Dam (2.22 BCM) and Ntoahae Dam in Lesotho within framework of the Lesotho Highlands Water Project (LHWP) - Due to Lesotho's commitments through the LHWP, its water resources will have reduced from 5.23 BCM/yr to 3.03 BCM/yr in 2020 - LHWP transfers 2.2 BCM/yr water to South Africa (Vaal River), while providing Lesotho with facilities to generate its own electricity					
LIMPOPO	Existing	Mapai	Limpopo	Mozambique	11.200	65	I
		Massingir	Elefantes	Mozambique	2.256	48	I, H, F
		Many smaller dams are located in the Limpopo basin in South Africa, mainly for irrigation					
	Planned	- In South Africa plans exist for water transfer from Incomati to Limpopo, Usutu to Limpopo, and Orange to Limpopo - In Botswana plans exist for north-south water carrier from Shashe river to Notwane river (both located in the Limpopo basin)					
CONGO	Existing	Inga I	Nkokolo/Congo	DRC		50	H
		Inga II	Nkokolo/Congo	DRC		58	H
		- Due to lack of maintenance during the civil war, these dams are heavily silted and operate on only 30% of their capacity					
	Planned	- Inga III on the Nkokolo/Congo, with a height of 60 m, for hydropower - Grand Inga on the Congo, with a height of 150 m, for hydropower					
RIFT VALLEY	Existing	Koka	Awash	Ethiopia	1.900	42	I, H
		Turkwel	Turkwel	Kenya	1.645	155	H
	Planned						
SAVE	Existing	Kyle	Mutirikwi	Zimbabwe	1.425	67	I
	Planned						
INCOMATI	Existing	Corumana	Sabié	Mozambique	1.273	46	I, H, F
	Planned	Driekoppes Dam in Komati River in South Africa and Maguga Dam (0.332 BCM) in Komati in Swaziland					
CUNENE	Existing	Gove	Cunene	Angola	2.574	58	I, H
		- The Gove Dam Also provides water to Namibia for water supply to population					
	Planned	Epupa Dam between Angola and Namibia for hydropower with capacity of 7.3 BCM					
MONO	Existing	Nangbeto	Mono	Togo	1.710	44	I, H
	Planned						
ANGOLA Coastal basin	Existing	Quiminha	Bengo	Angola	1.560	41	I, S
	Planned						
CAMEROON Several coastal basins	Existing	Mape	Mape	Cameroon	3.200	34	H
		M. Bakaou	Djerem	Cameroon	2.600	30	H
		Bamendjin	Noun	Cameroon	1.800	17	H
	Planned						
CÔTE D'IVOIRE Several coastal basins	Existing	Bandama	Bandama	Côte d'Ivoire	27.675	58	H
		Buyo	Sassandra	Côte d'Ivoire	8.300	37	H
	Planned						
KENYA Coastal basin	Existing	Masinga	Tana	Kenya	1.560	70	H, F
	Planned						
MOROCCO Several coastal basins	Existing	Bin El Ouidane	El Abid	Morocco	1.384	133	I, H
		Idriss 1	Inaouene	Morocco	1.186	72	I, H
		Al Massira	Oum R'Bia	Morocco	2.760	82	I, H, S
		Al Wahda	Ouergha	Morocco	3.730	88	I, H
		- Thirteen structures exist in Morocco for water transfer between basins, total quantity over 2.7 BCM					
	Planned						

Source: FAO- Aquastat

MOZAMBIQUE Several coastal basins	Existing	Chicamba Real	Revué	Mozambique	1.536	75	H, F
		Monte Hombe	Pungoé	Mozambique	1.246	60	H
		Lurio o Cua	Lurio	Mozambique	2.500	40	H
	Planned						
SOUTH AFRICA Several coastal basins	Existing	Sterkfontein	Nuvejaarsspruit	South Africa	2.617		S
		Pongolapoort	Pongola	South Africa	2.501		I
		VanderKloof		South Africa	3.237		
	Planned						
TANZANIA Coastal basin	Existing	Mtera	Great Ruaha/Rufiji	Tanzania	3.200	45	H
	Planned						
			Total large dam capacity (> 1 billion m³)		**726**	**billion m³**	
			Total dam capacity in Africa is ±		**785**	**billion m³**	

Use * I = Irrigation, H = Hydroelectricity, S = Water supply, F = Flood control, N = Navigation, R = Recreation, O = Other

Source: FAO- Aquastat

7.4 Draft Terms of Reference

22 September, 2009

THE ROLE OF ARTIFICIAL WATER STORAGE IN THE WATER- FOOD-ENERGY NEXUS

Current approaches and the views of developing countries and IFIs

1. BACKGROUND

Artificial water storage has over centuries played an important in the provision of water for water supply, food production and energy. Storage has been an important strategy for many countries to mitigate against rainfall variability and to manage against the devastating impacts of floods and droughts. At the same time, water storage also has major social and environmental implications to society. A global debate on how to plan, finance, build and mitigate against tradeoffs from water storage has been ongoing for over ten years. An emerging consensus is emerging on improved planning, management, stakeholder engagement and focussing on the multi-purpose development benefits including energy generation, fisheries, recreation and environmental services.

The issue of scale is important. Storage of water can be achieved through small rainwater harvesting schemes, mini hydropower schemes, and medium to large scale dams. Increasing storage can also be realized by improving the natural infiltration capacity in the landscape through green water technologies. Smaller schemes can often be implemented in a decentralised manner at local or community levels thereby putting more decision-making abilities in the hands of people closely affected by the impacts of new schemes. This also provides new opportunities for economic growth at the local level. Large schemes also play a role in certain systems and can be critical to regulate flows and providing water e.g. for growing urban areas. Managing the watersheds and river basins are in all cases key to success for all water storage schemes schemes.

The approach to identification and assessment of new storage schemes has been extensively modified since the issue of the World Commission on Dams (WCD) report in 2000). In 2003 the World Bank approved its Water Resources Sector Strategy, which supports renewable energy and renewable efficiency. This strategy specifically supported the WCD's core values and seven strategic priorities, one of which is "Comprehensive Options Assessment". This strategy requires that alternatives to dams be assessed as part of the process to determine the appropriate development response to increasing demand for water and energy. This requires "comparing options using a comprehensive and participatory assessment of the full range of policy, institutional and technical options, with social and environmental aspects having the same significance as economic and financial factors".

The medium-and long term impacts of climate change are putting increasing stress on water systems and add another complex dimension to forecasting the hydrology of water systems and design of hydraulic infrastructure. Storage schemes can act as regulators of water flows thus preventing natural hazards like floods, mud- slides, lake overflows and protection of vital infrastructural instalments that enable day-to-day life for millions of people in exposed regions. At the same time major storage schemes can also be a source of green house gases if located in areas with large amounts of biomass.

Recognizing the major opportunities with increased storage for economic growth and poverty alleviation combined with less impacts on the climate it is important to assess strategies for implementing water storage infrastructure in a socially and environmentally responsible way . The role of IFIs in supporting such schemes should be assessed.

2. SCOPE OF WORK

SIWI has been requested by Sida to conduct a study with the overall aim to assess and review the current status of artificial water storage developments from **small to large scale** with a **focus on Africa** generating best practices and cases for efficient investment by Sida.

2.1 Objective

The general objective is to put forward the linkages of water, energy and food security related to the implementation of water storage facilities and assess the role of these in the wider concept of development, including views of developing countries and IFIs. The outcome of the study will be policy suggestions for Sida to consider.

2.2 Methodology

Assess the following areas:

1) The impact of artificial water storage in the water-energy-food nexus and the potential for further strategic investment by Sida.

2) The social and environmental impacts of water storage implementations, including effects on social benefits, poverty reduction, natural habitats and ecosystems.

3) merging issues in the sector as a consequence of increased climate variability and unpredictable weather patterns and the potential role that water storage facilities might play in mitigation efforts.

4) Best practise in planning the implementation of water storage facilities.

5) The potential development trends and investment opportunities or restrictions that can be assumed and assessed by analysing contemporary views of IFI:s and perceived opinions of concerned developing nations.

Make conclusions and recommendations not limited to:

1) Policy suggestions in the area of investment in water storage projects and programmes for the identification, prefeasibility, feasibility, financing, construction and management stages in multipurpose schemes addressing food and energy. In this context also address

strategies for mitigating against climate variability and medium to long term climate change

2) Identify stages and levels of planning/implementation processes where support can most favourably be allocated.

3) Make recommendations on how to optimize and utilize synergies between public and private financing and how to best approach critical financing issues.

3. REPORTING

The language of the reports shall be English.

a. About 25 pages plus appendices
b. Graphs and pictures as relevant to convey complex messages
c. Key messages making the case for water investments

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