THE ZAMBEZI VALLEY
DAMNED BY DAMS

BY:

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The Zambezi River is the heart of Mozambique, pumping life into one of the most productive and biologically diverse tropical floodplains in Africa. The 2.660km long Zambezi River drains seven countries and has a total catchment area of 1,570,000 km^2 [24,33]. This makes it the fourth largest river system in Africa and the largest system flowing into the Indian Ocean[24]. The Zambezi River's water flow can reach a massive 22.000 m^3/s [23].

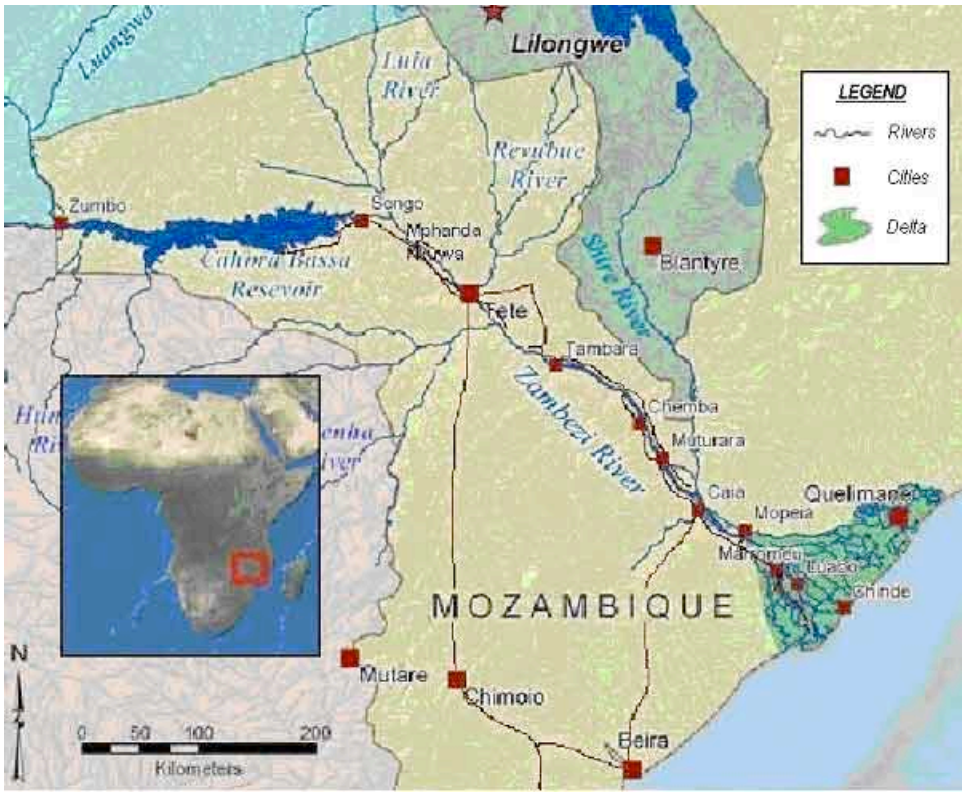

Figure 1: Adapted Map of the lower Zambezi River. Based on an original map from Dorn Moore, International Crain Foundation .

The lower Zambezi in Mozambique feeds the largest delta in East Africa and directly supports around 2.8 million people, most of whom are rural villagers [63]. This lower region has a highly diverse landscape changing from narrow gorges to mobile sand-braided deposit zones to anabranching channels and finally ending at a 290km wide coastal distributary zone that forms an 18 000 km^2 Delta [2,24,60].

As mighty as the Zambezi River is, past and present mismanagement of dams is slowly killing this life line of resources and diversity [20,24]. The once vast wetlands of the Zambezi delta and massive herds (70 000 head [24]) of water Buffalo are slowly becoming a thing of the past [8,29]. The first changes started about 100 years ago with the construction of dyke walls to constrain the river and prevent flooding of the sugarcane plantations [8]. The impacts of the dykes, however, pale by comparison with the impacts of the Kariba (1958) and most of all the Cahora Bassa (1974) dams [8].

Cahora Bassa Dam

The Portuguese Colonial Government constructed the Cahora Bassa Dam between 1969 and 1974. With a 250km long reservoir covering an area of 2700 km^2 and a structural height of 171 meters, it was considered the fifth largest dam in the world [24,51]. As was typical of this era, the Environmental Impact Assessment (EIA) was seen as an informative document. Performed late in the project development, the EIA had no influence on the project design and even though the assessment indicted major faults in the project, these were generally ignored and still are being ignored to this day [19-26].

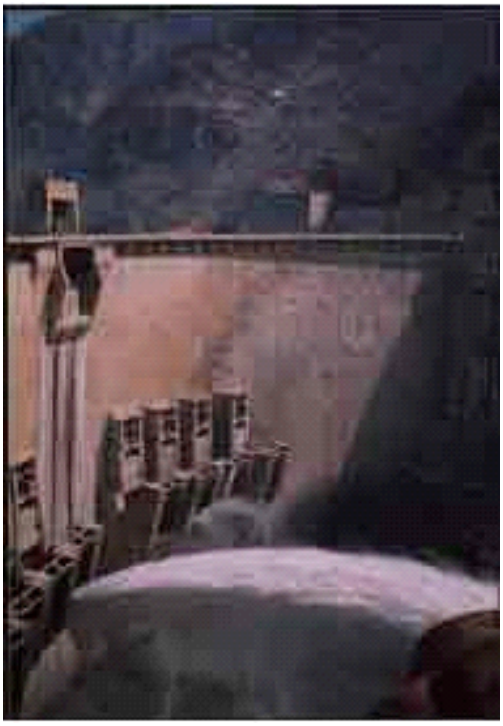

Figure 2: The Cahora Bassa Dam with only one of its eight sluice gates opened.

With a built-in capacity of 2075MW the primary goal of the Cahora Bassa project was to produce hydro-electric power to neighbouring countries, such as South Africa [26,38]. From the damaging impacts early power production [24]. To the excessively

regulated releases of its waters into a flood dependant system. The Cahora Bassa dam management is centred around the economic implications of its hydro-electric power with little regard for environmental flow requirements and socio-economic costs [14,19-26].

Flow regulation

Traditionally the Zambezi River had a highly seasonal flow with a clear low flow in winter and a high flood-inducing flow in summer [4,22,44]. The Cahora Bassa dam has changed this through releasing stored water for power generation during the dry season and using the high flood-inducing summer flows to fill the reservoir in preparation for the low winter flows [23,57]. Even though the Kariba dam is also on the Zambezi, the flow pattern entering the Cahora Bassa reservoir is seasonal, unlike its releases that are regulated and constant [13] (Figure 3). The lower Zambezi no longer follows the natural flooding regime with the floodplains remaining dry throughout the hot summer in all, but the wettest years [8].

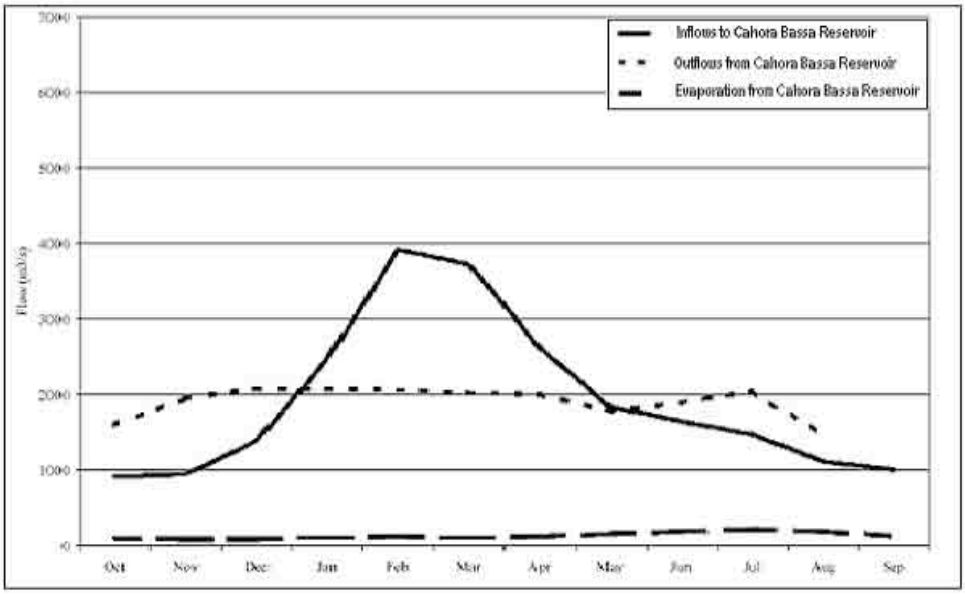

Figure 3: The solid line indicates the seasonal inflow to Cahora Bassa reservoir, while the small doted line shows the regulated outflow from Cahora Bassa reservoir [13].

The regulated flow from the Zambezi has caused drying of wetlands which were once fed by the flood water from the Zambezi [5,7,24]. In the past the Don Anna Bridge had more then 10 of its pillars in the Zambezi River, but nowadays only four pillars usually touch the water (Figure 4). Dry

channels and branches along the Zambezi are becoming more common, many of which have become completely disconnected from the main river channel (figure 10) [24]. The river has changed form a multiple channel river with constantly changing bars and Braids to a single main channel river with stable islands, bars and braids [24]. The silt-hungry water released from the Cahora Bassa dam erodes river banks and deepens the river bed as it accumulates much needed silt [10,24]. The deepening of the river bed further prevents flood waters from breaking banks and feeding much needed water into the drying floodplains [9,13,24,26]. As time passes bigger and bigger floods will be needed in order to meet flow requirement for the wetlands and floodplains, making rehabilitation of the lower Zambezi more and more complicated [26].

Figure 4: Dona Anna Bridge taken on the same day of the year, but the picture on the left was taken in 1975 and the picture on the right was taken in 1997 [26].

The drying floodplains have made a once remote, wet and harsh landscape accessible to people. Consequently, uncontrolled hunting and poaching on the floodplains has escalated to alarming levels [13,29], reducing the huge buffalo herds by 95% since 1970 [8]. The remaining herds are concentrated in the areas where small-scale seasonal floods still occur due to small unregulated rivers originating from the Cheringoma Plateau [13]. Even the elephant populations once occupying the permanently flooded swamps deep in the delta interior have become accessible to hunters and poachers and are now nearly non-existent [13,29]. The same is true for the once abundant herds of waterbuck, sable antelope and zebra [1,13,29].

The drying floodplains have far-reaching consequences for biodiversity, and populations of large animals are not the only ones at risk [24,26,35]. The drier floodplains have reduced the amount of

diverse herbaceous wetland species and allowed for woody savanna invasion. The remaining herbivores can no longer control plant growth, further changing the vegetation [59].

Estuarine and coastal fisheries

The estuarine and coastal fisheries habitats that are linked to the Zambezi play an important role in the local and national economy [30,38,41]. From the rich fish life and lucrative prawn industry to the extensive mangrove and Papyrus wood used in local construction, the estuarine delta habitats are vital for the regions livelihood. The drastic reduction in nutrient-rich sediment load (up to 70% [24]) coupled with the weak summer flows has caused the delta to recede and allowed for salt water encroachment from the ocean, deceasing the delta's productivity (e.g. prawn catches down 60% [34]), size (e.g. 40% reduction in mangroves areas [27]) and health [1,58,60].

Prawns

Mozambican prawns are internationally renowned and play a major part in the national revenues [41]. The regulated flow of the Zambezi River in conjunction with the loss of nutrient-rich sediment has had a devastating effect on prawn populations and catches [30,34,41]. An estimated 10 to 30 million dollars a year is being lost due to decreased catch rates (Figure 5) [30,34]. Adult prawns lay their eggs at sea. These develop into larvae which in the dry season, when the river flow is weak, are pushed by the stronger ocean tides into the mangroves and other freshwater areas of the delta. With higher levels of nutrients than the marine habitat, this well-protected environment supports strong growth of juveniles into adult prawns [34,41]. During the flood season the stronger river flow pushes adult prawns out to sea where they lay their eggs and restart the cycle [34,41].

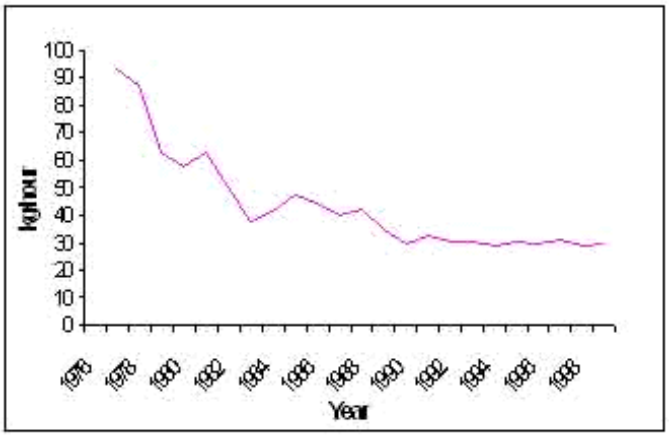

Figure 5: Graph showing a 60% decrease in catch per unit effort of prawns during the last 20 years. Based on data from Hoguane [34].

An additional explanation for the reduction in prawn populations could be the exploitation of prawns by commercial fishing fleets [41]. Measures such as mesh size, a longer closed season and decreased total allowed catches were implemented in the mid-1980's [41]. However, these protective measures have not resolved the decreasing prawn populations and the general consensus is that the main cause of the decline is due to the regulated flow and nutrient-poor sediment loads [34,41]. Interestingly, communications with prawn fishermen indicate that the highest catch rates in the last 20 years occurred after the 2000 and 2001 floods, supporting the flow and sediment hypothesis [41,44].

The current flow pattern from Cahora Bassa is too strong during the dry season, preventing larva drifting into the delta, and too weak to push juvenile prawns out to sea in the wet season [34,41]. Studies have shown that a small flood during December or January would increase prawn catches by 20% [34,55]. In addition to affecting the flow, the Cahora Bassa and Kariba dams serve as large sediment traps and negatively affect the nutrient levels of the Zambezi River. Today, nutrient-rich sediment flows of the lower Zambezi depend on inputs from the unregulated Luia River, the Shire River and runoff from the Cheringoma Plateau [13,26].

Freshwater Fish

Fish forms a vital part of the diets for communities living along the Zambezi River Valley [61]. Not only is fish a rich source of protein, it is one of the few sources of protein available to these communities. Due to the drastic decline of large mammals, a once abundant source of meat is no longer readily available to the rural poor. Freshwater fish also play a vital role in markets along the Zambezi [39,61]; in the lower Shire tributary three species make up 90% of commercial catches [61]. In general the three most important fish to local markets along the Zambezi are Mozambique tilapia (*O. mossambicus*), Manyame labeo (*L. altivelis*) and the tigerfish (*H. vittatus*) [61]. All three species are highly dependant on flood regime and have been reported to be on the decline along the lower Zambezi [39,61].

For example, Mozambique tilapia (*O. mossambicus*) is found throughout the river and uses the flooded vegetation on the floodplains as its main source of nutrients to allow for growth from

juvenile to adult stages during the flood season [61]. It then returns to the main channel as the waters start to reside. It has been shown that benefits to freshwater fish populations can be directly proportional to the extent of flooding [39,61].

Estuarine bottom fish and crabs

As with freshwater fish, bottom fish (such as catfish) and mangrove crabs are a vital source of food for local residents and are very important for coastal markets [55]. In addition to this mangrove crabs have an important ecological niche as detritivores that consume and break down decaying matter, essential for a healthy estuarine system. They also have been shown to play a vital role in the diets of many inter-tidal bird species [55].

Both bottom fish and mangrove crabs are highly dependant on the seasonal floods and the nutrient rich sediment the floods bring. Productivity of both species is assumed to be proportional to the mangrove flooded area, which has shown a 40% decrease [27]. This in turn has had an adverse affect on bottom fish and mangrove crabs, for which catches seem to have decreased in the last 20 years [13,44].

In nutrient-poor seas, such as in the tropics, estuaries carrying large amounts of nutrients and sediments are localized areas of high productivity, but have been shown to be very fragile systems. For example the Nile River used to be responsible for large phytoplankton blooms in the eastern Mediterranean during its annual floods, which in turn supported a highly productive prawn and sardine industry. This changed dramatically after the Aswan Dam was built in 1965 [48]. If changes in the present management of the Cahora Bassa dam are not implemented this is mostly likely the future for the Zambezi.

Social impacts

The social implication of the Cahora Bassa Dam has been nothing short of devastating[38]. During construction workers had unacceptable living conditions. Workers were stuffed into galvanized tin shacks (around 12 per 2 x 4 meters) that boiled during the day and froze during the night [38]. The workers were not given blankets and did not have access to toilets or basic amenities. Life loss due

to unsafe working conditions was a common occurrence [38]. As with the case of most dams, forced displacement is one of the main social impacts [48]. More than a year before impoundment of the river, Cahora Bassa had already displaced over 42 000 people [38]. This total does not include individuals that fled to neighboring countries or were lost in many slums and camps surrounding Tete and other major cities.

Presently the environmental degradation caused by the Cahora Bassa and the unnatural flow releases; is causing serious cultural changes and livelihood problems [14,38,43,44,56]. Century old, environmentally sustainable traditions that have evolved around the natural functioning of the Zambezi system are now ill-adapted to the changes caused by Cahora Bassa [38,43,44]. The average annual rainfall along the lower Zambezi is only 600 mm [22,37], mostly falling during the summer months. Droughts occur regularly, often with detrimental consequences to crops [43,44,45].

To compensate for these harsh conditions, communities farmed several fields located in different micro-ecological zones, using indigenous agronomic system, most important of which was flood recession farming [38]. During the wet season, beginning in December ending in March, receding flood waters deposited nutrient rich sediment (locally referred to as makande soils) along the floodplains [38,44,45]. The rich, dark makande soils of the floodplains are the most desirable agricultural sites in the region and played a vital role in the food security [38]. In preparation for the predictable flood season the communities planted in higher ground fields [38].

The regulated flow from the Cahora Bassa traps these nutrient rich sediments and holds back the seasonal floods. This prevents flood recession farming and drastically reduces productivity of the floodplain; causing major food insecurities [22,44,46]. The lower productivity of the floodplains in conjunction with the forced over-use of the high ground field has increased the field rotation rate and therefore the slash and burn techniques to clear the dense vegetation [8,38]. These burns often get out of control and have detrimental roll-over effects on the regional diversity.

Settlement patterns

In the past the highly predictable flood regime of the Zambezi River allowed for the development of settlement patterns that were in sync with the rivers natural functioning. The regulated flow regime

now present in the lower Zambezi has caused major changes in the settlement patterns of the communities living along the river [14]. The lower summer flow and lack of flooding has promoted permanent settlement of riverbanks, consolidated sandbars, and floodplain areas that were formerly only seasonally occupied [14,56]. Settlement in these areas was one of the main reasons why the 2000-2001 floods were so severe; with over 700 individuals killed in one year and over 500 000 made homeless [3,14,16,26,47,52]. These numbers could have been far worse if it were not for the fast and extensive rescue operations by South Africa and others [3,16].

In comparison to the past, there were more than 10 floods during the 20th century that exceeded the magnitude of the 2000-2001 floods in the Zambezi Delta region [14]. Many of these floods did not result in loss of life or significant economic damage [14]. The ability of the Cahora Bassa to hold back most floods has caused the communities along the Zambezi to lose their flood memory [14,26,44]. This prevents communities being able to manage their risks as the floods are unpredictable as only the largest of floods are not being held back by the Cahora Bassa [14,26]. Even though the water entering the reservoir was usually more than what the Cahora Bassa dam was releasing [16,50], its past flow patterns have made the communities along the Zambezi far more vulnerable to be negatively impacted by floods [14,26,52].

Heath Issues

The changed settlement pattern that has made communities more vulnerable to major floods and increased the number of people directly affected by major floods also has serious health implications. During the 2000 floods more than 500 000 individuals were made homeless and this placed high concentrations of people in refugee camps with inadequate sanitation, food and water supplies. These conditions caused major health problem such as cholera, typhoid, polio, hepatitis, and various gastrointestinal diseases [18].

Normally water born diseases are the major cause of illness in developing countries [18]. For example, both malaria carrying mosquitoes and schistosomiasis infected freshwater snails depend on stagnant water bodies [18]. Large floods serve to flush stagnant water bodies [18,24,]. This not only increases the water quality of these water bodies and replenishes the water table, but tends to reduce the productivity of vectors such as mosquitoes [18]. These floods also increase fish stocks

that feed on these vectors, further decreasing their numbers [39,55,61]. In areas where the water bodies have completely dried out, water born diseases would decrease significantly [18]. However, this has forced the communities in these dry areas to be more dependent on the Zambezi River for bathing, drinking, and other domestic activities, causing closer settlement to the river (i.e. increasing flood risk) [18]. This has also increased exposure to many pathogens and has been suggested as one of the reasons for the many crocodile attacks [18].

Crop losses

In addition to the large, natural floods that manage to over power Cahora Bassa, small, unpredictable floods during the dry season are further increasing food insecurities along the Zambezi [43,44,45]. Cahora Bassa regularly releases stored water during the dry season for hydroelectric power generation and under the request of other influential users such as the sugar plantations and the large ferry boats [26,43]. The bigger releases are often during winter when water flow is low and the users are more demanding [43]. Unfortunately it is also during these times that the most intense floodplain farming occurs, so when the dam releases flood these fields, the losses are severe [38, 43]. During one of the visits a community lost 50% to 80% of their crops and losses were registered as far down as Caia [43,44]. At times crops are lost, to these small dry season floods, just a week or two from the planned harvesting [43,44]. If the communities were aware of these mini-floods or if these releases were predictable the communities could harvest the fields in preparation or even in time with the planting of the fields to benefit from these mini-floods. At present these releases are just further escalating the food security problems along the Zambezi.

Figure 6: Fields 500km downstream from Cahora Bassa that were flooded by a dry season release during October 2003.

Mphunda Nkuwa

Exploring Zambezi's hydroelectric potential is seen as an important component in unlocking the vast development potential of the region and Mphunda Nkuwa is the first step toward this goals.
The Mphunda Nkuwa hydroelectric Dam is to be built on the Zambezi River just 70km downstream from Cahora Bassa at an estimated cost of 2.5 billion American dollars [28]. This 101m high dam will produce a maximum of 1348 MW of hydroelectric power and has serious implication on the future heath of the Zambezi River [28,42,43,46].

There is no doubt that Mozambique is in disparate need of development. The war for independence and the 15 years civil war has destroyed the little infrastructure that existed. Less the 5% percent of the Mozambican population as access to electricity [66]. Water and sanitation levels are among the lowest in the world and food security is a major problem. Large dams can potentially provide solutions in terms of power supply, flood control and irrigation for agriculture, but more often then not fall short of their goals [49].

Figure 7: Sketch of the Mphanda Nkuwa Dam by UTIP.

Economic Risks

Any Dam project costing around 2.5 billion American dollars is a risk, especially for a poor third world country like Mozambique. It is well known that Dams are notorious for significant cost overruns, under-achieving projected economic targets and exhibiting poor financial cost recovery [49]. Mphanda Nkuwa project promoter's state that power produced is directed towards export and domestic energy heavy industries [28]. At present the region has no energy heavy industries, leaving South Africa as the only other strong market for the power [37,42].

Eskom has the monopoly in the Southern African region in terms of power supply and the situation of Cahora Bassa can serve as a good example of the problems of supplying a glutted market [37]. Cahora Bassa sells it hydroelectric power to Eskom (South Africa) at well below the market price (2c to 3.9c South African cents, three times less than the market value and considered to be the

cheapest exported electricity in the world) [37]. Eskom is able to keep the price so low because of its surplus of electricity and lack of alternative markets for Cahora Bassa [37]. This poses serious questions about the economic viability of Mphanda Nkuwa [28,42].

It is clear that power production is not the main problem in Mozambique, which has a total estimated power consumption of around 350MW (less than 20% of Cahora Bassa's production) [66]. Instead supply is what is lacking in Mozambique and the Mphanda Nkuwa project does not address this issue, stating that the project will not be a source of significant rural electrification [28]. Furthermore, the project is only expected to create around 30 permanent jobs, but affect thousands negatively along the Zambezi [28].

Environmental and social implications

The Zambezi has suffered severely from the already existing Cahora Bassa dam, leaving outstanding environmental and social devastation. The Mphanda Nkuwa project not only does not address or help resolve these outstanding environmental and social issues, but hinders current attempts to apply prescribed releases in order to restore downstream conditions [28]. In fact it has been suggested that it could make outstanding impacts irreparable [26,28,42]. If Cahora Bassa were to alter its regulated releases to prescribed releases to meet minimal environmental flow requirements, the Mphanda Nkuwa project would be negatively impacted [28,42]. As stated by Mphanda Nkuwa Feasibility Study, "prescribed releases would reduce the total energy produced by the project and therefore, its economic viability" [28]. Mphanda Nkuwa will not only fail to solve present problem from existing dams, but place further obstacles in the way of solving them.

Figure 8: Floodplain by Chitongolo near to the proposed Mphanda Nkuwa Dam

More than 90% of the total Zambezi catchment runoff is controlled by Kariba, Kafue Gorge, and Itezhitezhi Dams [35]. Cahora Bassa has caused an estimated 70% reduction in sediment transport during floods [24]. Mphanda Nkuwa will further exacerbate the situation as it will dam the Luia River, one of the last unregulated catchments with an approximate 28 000km^2 drainage area [33]. The actual amount of sediment load is still unknown, but the contribution to nutrient rich sediment deposits down stream during the rainy season is believed to be highly important.

Mphanda Nkuwa's suggested mid-merit energy production release scheme has also caused some concerns as it causes daily mini floods. According to the Feasibility Study, "intermittent turbine operation with large daily variation in flow and level would reconfigure the river channel… Reconfiguration of the channel would have significant consequences for the ecology of the river, recession farmland and in-channel activities of local residents." [28] The detrimental impacts on fishing activities and floodplain farming would further exacerbate food security in the region. Ecologically the negative impacts of intermittent turbine operation can be as severe as documented in the EIA's example: "the Orange river in South Africa, between the Gariep and Van Der Kloof dams and directly downstream, receives twice-daily flow pulses for hydropower generation has been described as 'an ecological desert'[28].

Questions around the seismic assessment have also been raised. The estimated "upper bound" magnitude of 6.1 on the Richter scale was based on a short 42-year record [46]. This is much lower (<30 times less energy) then the two adjacent seismic zones that had an "upper-bound" magnitude of 7.1 and 7.3 Richter scale [36]. It is unusual for such large differences in adjacent seismic zones [36]. The prehistoric Bilila-Mtakataka fault scarp in Southern Malawi has been judged by its discoverers to be physical evidence of the largest known normal-faulting earthquake to strike on the continent [36]. This fault is considered to be dangerously close to the projected dam site [36]. Furthermore, the active Estima fault passes through the reservoir at just 25m from the dam wall [46]. This increases the chance of reservoir triggered earthquakes. Currently these are just some of the concerns raised by experts [36], but unfortunately no concrete assessments and conclusions can be made by independent experts due to the fact that the technical report, "Joint Venture, 2001, Report 024A", is not physical available to the public.

Mitigating risks

Based on the negative record of large dams and the present experiences of the Cahora Bassa dam, great concerns around the construction of Mphanda Nkuwa have been raised by academic and civil society [9,13,26,36,38,43,47,54]. The World Commission on Dams (WCD) report was the most in-depth global multi-stakeholder review evaluating the impacts, risks and successes of large dams to date [65]. One of the main goals of the WCD report was to help stakeholders make decisions around large dams and identify the needs, options and risks [65]. Based on the findings a set of guidelines in the form of seven strategic priorities were developed in order to aid better decision making and decrease the common risks/problems associated with large dams [65].

The WCD places a high importance on gaining public acceptance, local knowledge and indigenous people's rights [65]. The Mphanda Nkuwa project did not have a significant public participation process [42]. Public hearings were held only in the area of the proposed reservoir, and based on interviews during 2001 in the same areas [42]. Most individuals had at most a weak understanding of the project and a high number knew nothing at all [42]. Even after our capacity building project that ended in 2004, it is clear that a lot more work is required before the affected communities will have the capacity to participate in an efficient and empowered manner [43].

At present no benefit sharing is evident and most of the cost will be suffered by the rural poor. Not even a clear compensation plan has been developed [42]. It has been stated by UTIP (technical unit for implementation of hydropower projects that it is "something a potential investor has to negotiate with the locals" [33].

Mphanda Nkuwa does not comply with any of the seven strategic priorities and largely ignores the WCD guidelines, which seems to suggest that it is following the bad path of past dams [42]. The project has a controversial intermittent turbine operation that causes daily mini floods [28]. It blocks the little remaining sediment and prevents possible restoration of the lower Zambezi through prescribed releases [26]. All six options addresses by the EIA were dams and even then the EIA concludes that enlarging Cahora Bassa's spillway as being the best option [28,42]. This option could also allow for a partial restoration of the natural flood conditions of the lower Zambezi [28]. The project also has raised concerns around its geotectonic placement and seismic assessment. Its low

level of public participation and lack of benefit sharing places questions on its contribution to alleviating poverty in the region [42]. Based on the present information and the manner that the project has been carried out, major changes have to occur before Mhpanda Nkuwa dam can become beneficial to Mozambique's development and its general population.

Past, Present and Future

The lower Zambezi valley functions around the seasonal flood regime of the Zambezi River. As with all eco-systems, the Zambezi system is the product of thousands and thousands of years of evolution, with floods as a vital factor in its functioning. From ancient cultural practices, such as flood recession farming, to the biological synchronization and dependence of its ecosystems, floods are the core to the past, present and future health of the Zambezi valley. Floods bring the nutrient rich sediment, feed much needed water to drying floodplains, flush out stagnant water bodies and clears channels, branches and tributaries.

The construction of Kariba and Cahora Bassa dams has caused major hydrological changes along the lower Zambezi. The dams have adversely affected downstream communities and eco-systems.

Figure 9: The Zambezi River entering the Indian Ocean

The drying of floodplains has made flood recession farming difficult and increased animal poaching. The lack of floods has decreased fish stocks and caused up to 30 million dollars a year in losses in the shrimp fisheries. Permanent settlement in riverbanks, consolidated sandbars and floodplain areas, that were formerly only seasonally occupied, has caused devastation and loss of life during major floods. This has decreased a community's ability to manage flood risk. This coupled with small unpredictable dry season floods that wash away crops has caused a

change in the view of the role of flood in many communities. The once seen blessing of floods now has a dark cloud of negativity forming around it.

Despite all the information around the negative impacts of river regulation [31,40,53,62]; and ever increasing studies showing the negative impacts of the Cahora Bassa dam and the possible solutions on how to correct many of these impacts [4-6,23,30,63,64]. No changes have been made to apply any of these suggestions or even include them in future dam projects for the Zambezi. Cahora Bassa is still controlled by the Portuguese and managed in the same manner as originally planed in the 70's and 80's. "As a result, Cahora Bassa has the dubious distinction of being the least studied and possibly least environmentally acceptable major dam project in Africa." [15]. Unfortunately, the commonly known problems associated with dams are not being addressed by current practices and will only exacerbate the problem as seen by the Mphanda Nkuwa dam project. In addition to the Mphanda Nkuwa dam a further 5 dams are being proposed for Mozambique. It is vital that Mozambique develop a decision support system, based on WCD report, in order to identify and decrease some of the risks associated with large dams

Figure 10: Blocked branch of the Zambezi River.

Currently EIA's are seen a forced procedure and not as a process to reach the best decision for a more sustainable and equitable development. Within government circles environmental considerations are seen as anti-development and a luxury that only developed countries can take into consideration. Other major hurdles for the a sustainable Zambezi valley is a lack of coordination between different sectors, the bias of water management towards certain economic sectors (hydropower, navigability and industry), lack of public participation and development models strongly influenced by present practices in developed countries, which are too reliant on mega-projects.

However, there are positive developments occurring, which are addressing some of these issues and progress has been made during the last few years. Extensive research, such as the Marromeu Management Plan, is helping understand the Zambezi system and develop a restoration plan for the lower Zambezi. Increased social awareness from capacity-building projects has aided communities along the Zambezi to get organized and interested in participating in the developments that affect them. New water policies and a National Water Strategy are currently being developed, with the potential of including a more holistic, integrated view of future developments. Intentions of creating a Zambezi Commission, ZAMCOM, could increase communications between neighboring countries along the Zambezi River. After extensive awareness by civil society and NGO's around the WCD report, government is considering to start a multi-stakeholder process to review the WCD report. As mentioned earlier this report this has the vast potential to identify and decrease some of the risks associated with large dams. Without good guidelines and decision support systems dams will continue to hinder sustainable development and fall short of their promised potential.

Reference

1. ANDERSON, J., DUTTON, P., GOODMAN, P. AND SOUTO, B. 1990. Evaluation of the wildlife resource in the Marromeu complex with recommendations for it's further use. *LOMACO*, Maputo, Mozambique. 52pp.
2. BALEK, 1977: *Hydrology and Water Resources in Tropical Africa. Developments in Water Science*, 8.; Elsevier Amsterdam, 208 pp.
3. BBC NEWS, 2001: Mozambique floods worsen; *BBC Online*; http://news.bbc.co.uk/1/hi/world/africa/1194245.stm; Wed, 28 Feb, 2001; Accessed 29 Sep, 2005.
4. BEILFUSS, R.D. 1997. Restoring the flood: a vision for the Zambezi Delta. *The ICF Bugle* 23(4):1-2.
5. BEILFUSS, R. D. & DAVIES, B. R., 1998: Prescribed flooding and Wetland Rehabilitation in the Zambezi Delta, Mozambique. In: Streever, W. (ed.): *International Perspectives on Wetland Rehabilitation.*; Kluwer Publ., Dordrecht.
6. BEILFUSS, R.D. 1999. Can this river be saved?: rethinking Cahora Bassa could make a difference for dam-battered Zambezi. *World Rivers Review* 14(1): 8-11.
7. BEILFUSS, R.D. 2000. Piecing together the story of an African floodplain: water, wetlands, and Wattled Cranes. *The ICF Bugle* 26(1): 1-3.
8. BEILFUSS, R. D., 2002: Cranes, sedges and a dry Zambezi, *NEWS FROM THE PERCY FITZPATRICK INSTITUTE*, Aug/Sep, 19 pp.
9. BEILFUSS, R. D., 2003-2005: Researcher for International Crane Foundation and world renown expert on the Zambezi River system, Various interviews and personal communication with JA!.
10. BEILFUSS, R. D., 2005: Water quality; Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September, 2005, pp9.
11. BEILFUSS, R.D., AND DAVIES, B.R. 1999. Prescribed flooding and wetland rehabilitation in the Zambezi Delta, Mozambique. Pages 143-158. In: An international perspective on wetland rehabilitation (Ed. W. Streever). Amsterdam: Kluwer Academic Publishers.
12. BEILFUSS, R.D., DUTTON, P. AND MOORE, D. 2000. Land cover and land use changes in the Zambezi Delta. Pages 31-106 in J. Timberlake, ed. Biodiversity of the Zambezi basin wetlands. Volume III. Land Use Change and Human Impacts. Consultancy report for IUCN ROSA. Bulawayo: Biodiversity Foundation for Africa and Harare: The Zambezi Society.
13. BENTO, C., 2002-2003: Curator of the Museum of Natural History (Maputo) and founder member of Justica Ambiental, Presentations given to National Directorate of Water (DNA) and Ministry for Coordination of Environmental Affairs (MICOA), and personal communication. This information is based Dr Bento extensive research along the Zambezi and ongoing research in collaboration with Dr Beilfuss from the International Crane Foundation.
14. BENTO, C., 2005: Settlement Patterns; *Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September*, 2005, pp9.
15. BERNACSEK, G.M. & S. LOPEZ. 1984. Cahora Bassa. Page 62 in J.M. Kapetsky and T. Petr, eds., Status of African reservoir fisheries. Technical paper no. 10. FAO, Rome, Italy.
16. CHRISTIE, F. & HANLON, J., 2003: *Mozambique and the Great Flood of 2000*; Oxford Press.

17. Communiqué from the Workshop on the Sustainable Utilisation of the Cahora Bassa Dam and the Valley of the Lower Zambezi, Songo, 29 September – October 2, 1997
18. CUAMBA, N. & AUGUSTO, G., 2005: Public health; Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September, 2005, pp6.
19. DAVIES, B. R., 1975: Cahora Bassa hazards.; *Nature Lond*. 254: 477–478.
20. DAVIES, B. R., 1975: 'They pulled the plug out of the Lower Zambezi', *African Wildlife*, 29, 2 , pp. 26–28.
21. DAVIES, B. R., 1979: Stream regulation in Africa: A Review in: WARD, J. V. & STANFORD, J. A. (eds): *The Ecology of Regulated Streams*: 113–142.; Plenum Press, New York.
22. DAVIES, B. R., 1986: The Zambezi River System.; In: DAVIES, B. R. & WALKER, K. F., (eds): *The Ecology of River Systems*. Monogr. Biol. 60: 225–267.; Dr. W. Junk, Dordrecht.
23. DAVIES, B. R. (ed.), 1998: *The Sustainable Utilization of the Cahora Bassa Dam and the Valley of the Lower Zambezi*.; Proceedings of the Cahora Bassa Workshop, Songo, 29 September – October 02, 1997.; Arquivos do Patrimonial Cultural, Maputo, 48 pp.
24. DAVIES, B. R., BEILFUSS, R. D. & THOMS, M. C., 2000: Cahora Bassa retrospective, 1974–1997: effects of flow regulation on the Lower Zambezi River; *Verh. Internat. Verein. Limnol*. 27: 1-9.
25. DAVIES, B. R., HALL, A. & JACKSON, P. B. N., 1975: Some ecological aspects of the Cahora Bassa Dam.; *Biol. Conserv*. 8: 189–201.
26. DAVIES, B. R., 2002-2005: Professor at the University of Cape Town and world renown expert on the Zambezi River system, Various interviews and personal communication.
27. DUTTON, P., 1996: Natural Environment Consultant, Unpublished notes and comments made to Prof. Davies based on Aerial surveys, Beira
28. Environmental Impact Assessment (EIA), Feasibility Study, Mepanda Uncua and Cahora Bassa North Project, Technical Unit for the Implementation of Hydropower Projects (UTIP), Joint Vemture LI-EDF-KP, Mozambique, 2001.
29. FUNSTON, P. & BILAS, E., 2005: Large Mammals; Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September, 2005, pp6.
30. GAMMELSRØD, T. 1992. Variation in shrimp abundance on the Sofala Bank, Mozambique, and its relation to the Zambezi runoff. Estuarine and Coastal Shelf Science, 35: 91-103.
31. GORE, J. A. & PETTS, G. E., (eds), 1989: *Alternatives in Regulated River Management*.; CRC Press Inc., Boca Raton, Florida, USA, 344 pp.
32. HALL, A. & DAVIES, B. R., 1974: Cabora Bassa: Apreciação global do seu impacto no Vale do Zambeze.; *Rev. Mens. Econ. Moçamb., Lourenço Marques* 11: 15–25.
33. HILLMANN, C. & TAREDAL, I., 2003: FIVAS Results from a study trip; *The Mepanda Unkua Project – a planned regulation of the Zambezi River in Mozambique*; June 23 – July 18, Tete.
34. HOGUANE, A. M., 1997: Shrimp abundance and river runoff in Sofala Bank – the role of the Zambezi.; *Workshop on The Sustainable Utilisation of the Cahora Bassa Dam and the Valley of the Lower Zambezi, Songo, September 29 – October 02*, 1997, 16.
35. HUGHES, R. H. & HUGHES, J. S., 1992: *A Directory of African Wetlands*: 657–688. – World Conservation Union, Gland, Switzerland and Cambridge. UK/UNEP, Nairobi, Kenya/ WCMC, Cambridge, UK.
36. HARTNADAY, C., 2003: Professor at the University of Cape Town and world renowned expert on African geotectonics, E-mail communication.
37. HUYSSTEEN, A., 1997: Eskom holds whip hand in tariff negotiations; *Financial Mail*, 07 Nov and Cahora Bassa - 'Will be viable only if SA pays more'; *Financial Mail*, 11 Dec
38. ISAACMAN, A. & SNEDDON, C., 2000: Toward a Social and Environmental History of the Building of Cahora Bassa Dam.; *Jou. South. Afri. Stud*., Vol 26, N 4,
39. JACKSON, P. B. N., 1986: Fish of the Zambezi system. – In: DAVIES, B. R. & WALKER, K. F. (eds): *The Ecology of River Systems. Monogr. Biol*. 60: 269–288. – Dr. W. Junk, Dordrecht.
40. JUNK, W. J., BAYLEY, P. B. & SPARKS, R., 1989. The flood pulse concept in river floodplain systems. – In. DODGE, D. P. (ed.): *Proceedings of the International Large River Symposium*. Can. Spec. Publ. Aquat. Sci. 106: 110–127.
41. JUSTIÇA AMBIENTAL, 2003: Informative Paper - *Why are prawns in the Sofala Bank declining?*; Funded and prepared for Siemenpuu.
42. JUSTIÇA AMBIENTAL, 2003: Report on "How does Mphanda Nkuwa comply with the World Commission on Dams"; Funded and prepared for IRN.
43. JUSTIÇA AMBIENTAL, 2003-2004: *MPHANDA NKUWA: Dams and Development Capacity-Building project*; Funded and prepared for Siemenpuu.
44. JUSTIÇA AMBIENTAL, 2003-2005: *Zambezi trip reports and interviews*; Part of various projects.
45. JUSTIÇA AMBIENTAL, 2004: *Report on the workshop on integrated water management in the Zambezi*; Funded and prepared for OXFAM.
46. JUSTIÇA AMBIENTAL, 2005: *Seimicity Report*; based on temporary access to the "Joint Venture, 2001, Report 024A"; Funded and prepared for Green Grant.
47. LEMOS, A. D., 2001-2005: Founder member and director of Justica Ambiental; Various interviews and personal communication based on over 5 years of experience in working with social issues along the Zambezi.
48. NIXON, S.W. 2003. Replacing the Nile: Are anthropogenic nutrients providing the fertility once brought to the Mediterranean by a great river? Ambio, 32: 30-39.
49. MCCULLY, P., 1996: *Silenced Rivers: The Ecology and Politics of Large Dams*.; Zed Books, London and New Jersey.
50. MULLER, M., 2001: Cahora Bassa Role in Mozambique Floods - Flood criticism, a one-sided discourse; *Mail & Guardian*, South Africa, 2 Apr.
51. OLIVIER, H., 1970: *Great Dams of Southern Africa*.; Purnell Publ., Cape Town.
52. PAGE, D., 2001: Floods 'a predictable disaster'; *Mail & Guardian*, South Africa, 20 Mar.
53. REES, W. A., 1978: The ecology of the Kafue Lechwe: As affected by the Kafue Gorge Hydro-electric Scheme.; *J. Appl. Ecol*. 15: 205–217.
54. RIBEIRO, D. D., 2001: *Tete Workshop on the World Commission on Dams and Mphanda Ukuwa Dam*. Prepared for Livaningo, Maputo
55. SILVA, R. P., 2005: Estuarine and coastal fisheries; Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September, 2005, pp3.
56. SCUDDER, T., 1996: Caltech, Unpublished notes and personal communication to Prof. Davies
57. SUSCHKA, J. & NAPICA, P., 1990: Ten years after the completion of Cahora Bassa Dam.; In: *The impact of large water projects on the environment. Proceedings of an International Symposium, 21–31 October, 1986*: 171–203.; UNEP and UNESCO, Paris.

58. TIMBERLAKE, J., 1998. Biodiversity of Zambezi Basin Wetlands: review and preliminary assessment of available information. Phase 1. Final report. IUCN-ROSA, Harare, Zimbabwe.
59. TIMBERLAKE, J., 2005: Vegetation communities; Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September, 2005, pp7.
60. TINLEY, K. L. & SOUSA DIAS, A. H. D., 1973: Wildlife reconnaissance of the MidZambezi Valley in Moçambique before the formation of the Cabora Bassa Dam.; *Vet. Moçamb. Lourenço Marques* 6: 103–131.
61. TWEDDLE, D., 2005: Freshwater fisheries; Workshop on water management for the Zambezi Delta – Evaluation of Scenarios, Maputo, 5-6 September, 2005, pp4.
62. WARD, J. V. & STANFORD, J. A. (eds), 1979: *The Ecology of Regulated Streams*.; Plenum Press, New York and London, 398 pp.
63. WHITE, R., 2001: Managing Water Disasters and Minimizing the Vulnerability of Mozambique to Floods; Paper was presented to the "*6th Annual Water Africa 2001*" conference held 18-19 September 2001.
64. WILSON, K., 1997: Preliminary estimates of the potential for modifying water discharges from Cahora Bassa to ameliorate environmental impact and maximize socioeconomic benefits in the Zambezi Basin.; *Workshop on the Sustainable Utilisation of the Cahora Bassa Dam and the Valley of the Lower Zambezi, Songo, 29 September – October 2*, 1997, 4 pp.
65. World Commission on Dams (2000) Dams and Development: A New Framework for Decision-Making, The Report of the World Commission on Dams (London, Earthscan Publications).
66. World Water Forum, 2004: The Mphanda Nkuwa Dam project: Is it the best option for Mozambique's energy needs?; Final Report for WWF, Intermediate Technology Consultants Ltd.