

# The Human Security Dimensions of Dam Development: The Grand Ethiopian Renaissance Dam

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Large-scale dam development provokes strong emotions because of costs and benefits, whether potential or actual, to political, socio-cultural, economic, and environmental systems. Countries currently developing water resources through dam projects are doing so in response to poverty issues, coupled with pressures from population growth and changes to the climate, specifically, changes to water resources. The question of human security, a loosely defined term that covers the stability, safety, and access to opportunity of an individual and a related community now and in the future, as well as the environment upon which that individual or community depends, is a way of describing the scope of changes dam development causes in different sectors and at multiple geographic and temporal scales. Dam development has far-reaching diverse impacts that may include altering economic and social systems, providing a buffer against increasingly unknown challenges due to climate change, and potentially destroying ecosystems and traditional lifestyles. Dams may also be political symbols of national modernity, power, and identity.

Traditionally, dams have been assessed for immediate national economic and political benefits, excluding costs to local-level, often traditional, long-term river-dependent communities and environmental systems. Studies in recent decades, including the World Commission on Dams report, have considered the local-scale socio-cultural and environmental costs of dam development and found that these are often overlooked.<sup>1</sup> Subsequent studies have found that social and environmental costs extend well beyond the accepted impact area currently assessed by international standards.<sup>2</sup> Dam

development dominates landscapes and excludes many other uses of land and water resources. This indicates that dams are in conflict with the use of water resources in other sectors. Despite the conflicts and costs, in this century hydropower dams have re-emerged as a cornerstone of economic development plans, especially in China and Brazil, and most recently, on the African continent.<sup>3</sup>

Often, national-level modernisation needs outweigh the local desire to maintain traditional subsistence lifestyles, and in fact dam development is seen as an opportunity to bring general development benefits, such as formal education and health care, to otherwise underdeveloped or remote communities. Similarly, the exploitation of water resources is often more important for developing economies than the use and needs of environmental systems. Studies indicate that such priorities are determined by power inequities, differences of perception in different communities, and competing socio-cultural needs and water-resources uses.<sup>4</sup> The Grand Ethiopian Renaissance Dam currently being developed on the Blue Nile River in Ethiopia is one example of controversial dam development. The human security dimensions of this development include impacts of varying magnitudes in the economic, political, environmental, and socio-cultural spheres.

This paper examines the human security dimensions of the Grand Ethiopian Renaissance Dam development to determine whether this project is a mechanism for stabilising human security. During five months in 2012, I collected over fifty-seven field interviews with national and local community members in Ethiopia and subsequently analysed the data into four sectors of economic, political, socio-cultural, and environmental importance. I conducted empirical investigations at the Renaissance Dam site and in villages in the Blue Nile Valley affected by the dam. Results indicate that questions of social and development needs, perception, water-resources use, access to economic opportunities, and time-scale are dependent on the geographic scale and sector considered. These dependent issues may be visible to policymakers only when considering a *specific* scale and *specific* sector. However, hopes of and interest in development and change in the *general* areas of economics, education, environmental resources use, and health are common factors at national and local scales. The resulting differences in human security dimensions according to scale and sector highlight the need for a systemic approach to developing shared water resources, especially when the resource is shared across cultural and national borders.

Changes in water resource access, quality, and quantity have been noted as a key challenge to economic, political, environmental, and societal stability by several studies.<sup>5</sup> Collectively, timely access to, and safe quality and right quantity of, water resources are one definition of water security.<sup>6</sup> Water security models sometimes include human security components, and water resources security is arguably a necessary component of stable human systems. Systems related to individual, national, and international levels of scale are employed to describe and understand interactions concerning water resources security, while water resources management naturally lends itself to multi-scale consideration. Human security scholarship by the Copenhagen School states that the inclusion of different scales and sectors is important to understanding security of water resources and climate change.<sup>7</sup> Human security and water security may be seen as interrelated concepts.

At the start of the twenty-first century, human consumption constituted 54 per cent of all available renewable water resources and, with population growth, this percentage is projected to increase to 70 per cent by 2025 and to 90 per cent by 2030.<sup>8</sup> These consumption figures do not represent total potential demand as more than 1.2 billion people lack access to safe drinking water.<sup>9</sup> Before 1950 there were five thousand large-scale dams worldwide, by 2000 this number stood at more than forty-five thousand, and by 2006, five thousand more had been constructed to bring the total to over fifty thousand large-scale dams.<sup>10</sup> The use of water resources is divided between ecosystem, domestic, subsistence, municipal, agricultural, industrial, energy, cultural, and commercial demands, and is often allocated according to political interests. But these water resource allocations are threatened by contamination, climate change, groundwater exhaustion, uncoordinated and unsustainable development, imbalances of political power, lack of stewardship, and aging or inadequate delivery and treatment infrastructure. Moreover, rising demand is coupled with an estimated 2.4 billion people who lack access to proper sanitation.<sup>11</sup> Adding to this existing complexity, climate change may further stress water resource systems. Given current conditions, we are approaching a scenario where available water resources will not meet projected demands.

Countries that are not well-developed or industrialised have untapped natural resources in the form of water, minerals, forests, plants, animals, and land. The global market has room to exploit any of these resources. The resurgence of current dam development is due to several simultaneous factors, including: the need for reliable electricity for economic development; flood control; potential fluctuations in water resources due to localised climate change; the large potential of hydropower in underdeveloped river basins; the eagerness of emerging economies to avail themselves of the hydropower expertise of Brazil and China; population pressures; the quest for non-carbon-

contributing forms of energy development; and the desire of poor countries to develop through all available means. In the case of Ethiopia and the Grand Ethiopian Renaissance Dam, several of these factors were contributory to the project.

The Grand Ethiopian Renaissance Dam generated international media coverage during the summer of 2013 because of unilateral decisions by the Ethiopian government regarding development of the transboundary Blue Nile River. These decisions drew protests and calls for negotiations from the Egyptian government. The Blue Nile basin includes the countries of Ethiopia, Egypt, and Sudan. Egypt and Sudan, downstream countries, depend almost exclusively on Nile River water resources for domestic consumption, agriculture, industry, power generation, and national economies.<sup>12</sup> Most of the water in the basin arrives from the Ethiopian highlands: an estimated 82–95 per cent of the annual water contribution to the basin comes from the Blue Nile, Atbara, and Sobat tributaries in Ethiopia. The Blue Nile River alone accounts for 59–68 per cent of the water flow to the Nile River basin, depending on Ethiopia's highland monsoon season.<sup>13</sup>

The Nile River basin is shared by eleven countries: Sudan, Egypt, Ethiopia, and Eritrea in the eastern part of the basin; Uganda, the Democratic Republic of Congo, South Sudan, Kenya, Rwanda, Burundi, and Tanzania in the Equatorial part of the basin. Conflict, cooperation, and power-relations in the Nile basin have changed markedly over time, but their historical legacy still affects present-day geopolitics. Contractually, the countries of the basin, with the exception of Ethiopia, Eritrea, and South Sudan, are bound by the colonial-era motivated and designed 1929 Nile Treaty, modified in 1959 by Sudan and Egypt. Under the existing treaty, Egypt and Sudan divide the Nile water rights and water allocation between them. They have the right to develop these water resources within the bounds of their specified allocation. They also claim the right to legal recourse over the development plans of upstream countries in the Great Lakes region.<sup>14</sup> The treaty was designed before many of the riparian countries were independent states. In the decades since the treaty update of 1959, changes in politics, security, economics, populations, globalised practices, and the development drive of the riparian countries have combined to put pressure on the Nile River water resources.

International attention has turned towards the Nile River basin, where unrealised hydropower potential has the capacity to alleviate growing development needs in upstream countries. The scope of hydropower development has captured the imagination and subsequent action of governments, donor and lending agencies, and private industry. Aside from Kenya and Egypt, the Nile basin countries are some of the poorest in the

world and are on the Least Developed Countries list, but this is changing. The Grand Ethiopian Renaissance Dam is one of many water development projects planned for the basin.

In 1999, basin countries formed the Nile Basin Initiative that has succeeded in bringing them together in dialogue, inspiring the drafting of the Cooperative Framework Agreement (CFA) in 2007. But little to nothing has been done as yet on ecological or social development. The CFA aims to replace the existing Nile Treaty with a more equitable and reflective water-sharing agreement. Once the CFA is ratified, the Nile River Commission will be established to coordinate plans for developing Nile basin water resources in upstream countries.<sup>15</sup> The Renaissance Dam project is poised to move this process along. Ethiopia ratified the CFA in June 2013.

Since 2005, the Ethiopian government has moved its attention away from inter- and intra-national conflict and towards national economic development. The national economy has seen annual growth of 8 per cent and 10 per cent in recent years, though it is still largely dependent on agriculture. The population in Ethiopia doubled between 1990 and 2010 to exceed eighty million people. Ethiopia's growing economy and population, coupled with widespread poverty, have resulted in an increasing demand for development, and specifically, for energy. The formal government vision, the Goals and Transformation Plan (GTP), identifies several development initiatives to lift the population at large out of poverty before 2025, including an increase of domestic clean-energy electricity generation to 10,000 MW.<sup>16</sup> The Renaissance Dam is presently part of the GTP.

During interviews with officials and professionals in Addis Ababa and at the Renaissance Dam site, the following information was communicated regarding the project. The Renaissance Dam costs are in excess of US\$4 billion. To date, funds have been generated through domestic bond-selling and donations from the Ethiopian people both at home and abroad. The dam site is located less than twenty kilometres from the Sudanese border. The resulting reservoir will contain approximately sixty billion cubic metres of water, a volume twice that of Lake Tana, the largest lake in Ethiopia and source of the Blue Nile. Construction began in the autumn of 2011. Development related to the dam includes the construction of bridges and roads, electricity grids, and the expansion of towns with facilities for the displaced communities. Approximately twenty thousand people will be displaced by the dam project. About five thousand employees of the dam live onsite and this number will increase to twelve thousand at the peak of construction. The Ethiopian

Electric Power Company (EPCO), the organisation that administers all of Ethiopia's hydropower generating facilities, manages the project.

Interviews at EPCO indicated that the Renaissance Dam will have an installed generating capacity of 6,000 MW—sixteen turbines with 375 MW capacity each. Initial generation is planned for as early as 2014, with completion of the entire project targeted for 2017. Ethiopia aspires to be the green-energy hub of East Africa. In furtherance of this aim, EPCO has already signed contracts with Kenya, Djibouti, South Sudan, and Sudan regarding the sale of electricity. Dams and alternative energy-generating schemes are being developed across the country, to include solar, wind, and geothermal power, as well as the construction by a Chinese firm of transmission lines to convey the electricity. Eighty million Ethiopians have only 2,000 MW in a grid that covers less than 48 per cent of the country. In 1991, there was only about 200 MW online. The reservoir will have a five-kilometre buffer zone to mitigate the risk of an increase in malaria.

In meetings at the Ministry of Water and Energy, I was informed that the Blue Nile accounts for close to 50 per cent of all surface freshwater resources within Ethiopia, but to date has remained domestically underdeveloped. There is currently no comprehensive integrated water-resources management plan for the Blue Nile basin, nor adequate monitoring infrastructure, though erosion-prevention efforts and small-scale irrigation projects are managed through the federal ministries, local governments, and international development organisations. A US Bureau of Reclamation survey conducted in the 1950s found that the Blue Nile has the potential to provide about 10,000 MW of hydropower generated through a series of dams. The Grand Ethiopian Renaissance Dam is the first such dam attempted, though rescaled through subsequent assessments.

The site of the Grand Ethiopian Renaissance Dam is located approximately 700 km from Addis Ababa and 20 km from the Sudanese border in the Blue Nile River Valley. The location is remote, and because of the conditions of the roads, it takes more than seventeen hours to arrive from Addis or five hours from the nearest large town, Assosa. The two roads leading to the project site are not paved and require four-wheel drive or high-clearance vehicles. There are two bridges; one, called the Chinese bridge, will be lost in the reservoir; the other will remain, just downstream of the dam. There is no electricity in the nearby villages and very little in the way of permanent infrastructure.

The region is sparsely populated, mainly by the Gumuz and Berta ethnic groups as well as relocated Amhara. Approximately twenty thousand people will be relocated because of

the dam. Most of the people living in the valley are subsistence farmers, fishermen, and hunters. The relocated Amhara run small shops catering for the local communities and project employees. There is one town, downstream of the dam site, and several sizable villages upstream; in between, there are dozens of small family settlements. The area is affected by malaria. The Ethiopian government supplies free nets and medicine for the treatment of the disease. Since work on the dam began, a new clinic at the site provides free health services to the local communities.

The valley is a transitional climate as the topography slopes from the river gorge in the Ethiopian highlands to the lowland desert in Sudan. Temperatures can exceed 40 degrees Celsius in the dry season. EEPCO conducted both an environmental and social-impact assessment to catalogue the people and species in the area. The thorough social-impact assessment was carried out by EEPCO employees while the environmental assessment was conducted by an outside contractor and was, at the time of my reading it, incomplete.

The Blue Nile River is heavily laden with silt and brown in colour. This silt results from heavy erosion in the Ethiopian highlands. Despite government-driven efforts to mitigate erosion, there is high loss of topsoil to the river because of deforestation, overgrazing, and soil compaction from livestock and weather combined with the steep slopes of the highlands. Erosion has caused siltation problems at Sudan's Roseires dam and irrigation network just downstream of the Renaissance development site. Commissioned in 1966, the Roseires dam accounts for some 75 per cent of the electricity generated in Sudan. Recent efforts to mitigate erosion involved a heightening of the dam by ten feet; the consequent expansion of the impoundment reservoir saw the displacement of an additional 110,000 local residents. When silt collects behind a hydropower dam, it can impair its generating capacity by displacing water, reducing the potential hydrologic head (or power of the water flow), and damaging the turbines and infrastructure. Dredging is often used to solve the problem; sometimes the dam itself is modified, as in the case of Roseires, though this is very expensive.

Assessments of the human, socio-economic, and environmental impact of dam development vary according to who and what are considered, as well as the time duration in question. In this paper, the "who" is determined by the geographic scale of a community and whether that community is directly or indirectly dependent on the water resources. The "what" is determined by the sector of the overall system in society or the environment connected to the water resources. Sectors in this case include economic, political, environmental, and socio-cultural systems. The various time-scales cover short-,

mid-, or long-term costs and benefits to the sector and the community in question. Dam development may either threaten or stabilise human security.

National-level interviews were conducted in English with individuals mostly located in Addis Ababa, but also in Sodo-Walayta, Gondor, and Bahir Dar. Respondents were identified by occupation or as opportunity offered. Local-level interviews were conducted through a Gumuz- and Amharic-language translator in eleven communities affected by dam development. Some respondents had already been relocated downstream because of the footprint of the project camp. Additional data was collected from official documents, project reports, websites, news reports, visits to the dam site, and general empirical observation.

#### *National Level*

The general responses of the national-level interviewees were concerned with economic, socio-cultural, and political issues. The economic need for development is interwoven with the socio-cultural need to overcome poverty, and both of these issues are bound up with Ethiopia's geopolitical power in the region, and the political will of the government. The respondents' interviews included consideration of relations with Egypt and Sudan as part of the historical context of the decision to undertake the Grand Ethiopian Renaissance Dam project, as well as the state of Ethiopian domestic affairs.

Two important themes dominated the interviews conducted in Addis Ababa and Sodo-Walayta: that Ethiopia is a poor country that needs development, and that the dam is important to Ethiopia's identity and national mood. "We have the right to use this water," one interviewee said. "Egypt has capitalised on the fertile soils of Ethiopia and the water that originates in our country, but we as Ethiopians have not had this opportunity to develop, until now." The general attitude nationwide in Ethiopia is of the need for the country to develop out of poverty. Some interviewees were explicit that this development should not occur at the expense of downstream neighbours. Most interviewees believed that electricity was key to development. "Reliable electricity is necessary to attract investment, to build industry," stated one respondent. "You will find that 99.9 per cent of Ethiopians are for this dam, regardless of their ethnicity or politics," one representative of civil society assured me. Ethiopians are keen to move their country's identity away from the famines of the 1970s and 1980s, from reliance on the donor community, and towards self-sufficiency. Respondents were also emphatic about the contribution that each Ethiopian is making to the dam project, from farmers to businessmen.

National-level respondents tended to minimise the importance of the environment and of local communities in considering the impact of the dam. Many people assured me that the Blue Nile River Valley, where the dam development site is located, is a barren land.



Others minimised the negative impact on local communities, stating that the traditional ethnic groups living there are sparsely settled and need development assistance. Most respondents stated that both the environment and local residents would benefit from the dam. The establishment of a reservoir in a location with monsoon pulses in the river would possibly create abundant habitat for animals and birds, and a reliable source of water for local communities to fish and farm. Three respondents expressed concerns over a potential increase in water-borne disease in an already malarial region. Another raised the question of whether the dam would change the poorly understood migratory patterns of aquatic species. And many other respondents voiced worries about unsolved erosion problems upstream.

Domestically, the dam project is perceived as a unifying force across ethnically diverse and divided Ethiopia. (However, two respondents voiced one possible drawback: that the dam may become a political and strategic target in times of war.) In the short term, the Renaissance Dam may further the political goal of unification; in the mid term, it may meet the economic goals of income-generation and domestic electricity supply, and also offer socio-cultural benefits such as general development and poverty alleviation, if profits from the international sale of electricity are well-managed and equitably distributed; the unknown environmental costs will be long-term. In my opinion, the environmental costs will be high for Ethiopia, although the impact may be lower or even beneficial for the watershed. The benefits could include control of siltation and flooding, but also the storage of water in an area with lower evaporation rates than those in Sudan and Egypt.

#### *Local Level*

Local-level respondents were concerned with environmental, socio-cultural, and economic issues. The key finding from analysis of local-level interviews is that the river system and its tributaries represent the sole source of economic activity for local people, the centre of their culture, identity, and society. Most respondents understood that the dam project meant they had to move, but they expressed a desire to remain close to the water so as to be able to continue their way of life as fishermen, farmers, and collectors of gold. Local responses did not evince national or international perspectives. The local respondents are mainly subsistence farmers, with the exception of shopkeepers in larger villages who are not of Gumuz ethnicity and who have come from other parts of Ethiopia. Besides detailing how the use of water resources varies according to the rainy or dry seasons, many local people expressed the hope that the dam project would bring their children access to adequate healthcare facilities and education, even if they themselves had little to no formal education. Though some respondents felt that the project was initiated for the benefit of the Gumuz people, and were quite excited about possible new opportunities, some did not have a clear idea of what to expect from the project or why it

was happening on the river. Almost all expressed the hope that they would be able to use water in the future for small-scale irrigation and fishing. When I asked who used the river and related resources, I was repeatedly told that only the Gumuz people did so, but that anyone was welcome to come and fish or pan for gold if they knew how. No acknowledgement was made that the project was a use of the river. Information local respondents have is given to them through village council meetings or by word of mouth.

Local-level respondents explained that the seasonal levels of the Blue Nile dictate what types of crops are farmed and where; the types and amount of fish caught; the availability of places for gold-panning; and the ability to cross the river for market trade. Local communities use flood-recession agriculture in the dry season and rain-fed agriculture in the rainy season. Respondents cannot imagine a life without the river. “Everything that we need is in this river”; “All of my life is here, in the river”; “The river is like our second God, because it gives us everything we need for living.” These are just some of the strong expressions of local connection to the river.

Most respondents are willing to relocate, but do not want to move far from the new reservoir. Many of the men intend to fish in the reservoir. Almost all of the respondents look forward to the development opportunities they believe it will bring, including education, access roads and bridges, and healthcare clinics. Some respondents told me of benefits it had already brought, such as the new road, new bridge, and free clinic at the dam site. One woman I spoke with had already been relocated downstream; she said she was thankful that the project had moved her family to a new place and given her a *newtukul*—the simple house, round in shape, in which most rural Ethiopian people live, with a dirt floor, mud and straw walls, and thatched roof. Typically, *tukuls* must be rebuilt every few years; they are not permanent structures. The only problem she was experiencing was clarifying what land was hers along the riverbed for planting. The Gumuz people, as subsistence farmers on seasonally variable rivers, tend to have more than one planting spot—one for the dry season, and one for the wet season—but there is no formal land-ownership process.

In general, respondents understand that things will change because of the dam. Most felt optimistic about perceived new opportunities and flexible about relocation. Politically, the local-level respondents did not mention Egypt or Sudan, but did express a trust in the Ethiopian government’s plans. The environment is not a separate entity from their lives, but the centre, and changes to the environment will have long-term effects on cultural activities and livelihoods. The period of adjustment following relocation from the river into centralised villages will also have short- and mid-term socio-cultural consequences. When the reservoir is flooded, gold-panning and flood-recession farming will cease

because these are done on the riverbanks. Local people are aware that the environmental system is poised for change with the dam, but are open to using the water in a different way with the government's help. The local economic sector is in greatest jeopardy in the short term, but the situation can be eased by federal government efforts to retrain locals in new agricultural and fishing practices.

The case of the Grand Ethiopian Renaissance Dam demonstrates the complexity of the challenges that dam development presents for human security at different scales and in different sectors. The interviews reveal differing attitudes depending on respondents' geography in relation to the river, their dependence on the river, and individual or community priorities. Dam development creates changes that are not necessarily beneficial to related human and environmental systems. In fact, water development usually results in a multiplicity of unforeseen changes as well as predicted and regrettable shifts in the mid and long term. Rivers are dynamic systems, and the surface water that we can see and use is only part of the entire water in a river system. Rivers are connected with climate, precipitation, ground water, and ultimately (in many cases) the ocean. The hydrology can be extremely temporal, express a pulse, change course and flow according to physical precipitation or climatic events, or to changes in ground water. Rivers host a myriad of biologically dependent systems, and also affect non-biological systems. The latter include economic, political, environmental, and socio-cultural systems. In the case of local communities, the river can play the central role in their society, culture, and economy. Forcing change, through development, can result in immeasurable and unforeseen changes to these dependent or affected systems, unless the systems are resilient and adaptive. But, even the most resilient and adaptive systems have a tipping point—the point at which a system is irreversibly altered into a new state—and this is largely unpredictable. Resulting change can be a cost or benefit, depending on the system and the scale considered.

On an international scale, the Grand Ethiopian Renaissance Dam has the opportunity to stabilise human security in the economic, political, and socio-cultural sectors. This is possible if Nile basin countries cooperate on basin-wide development plans aimed at using water resources for agriculture and electricity generation, and at connecting energy and transportation networks. The project may set a precedent in the basin, one that transcends the limitations of the established Nile Treaty which confines water rights to Egypt and Sudan, and that allows upstream countries the right to develop domestic water resources. There is potential for cooperation on joint development projects for flow management, sediment control, and the establishment of a more extensive regional

electricity grid. Flow management brings the benefits of flood control, reduction in evaporation losses, and the prevention of sediment build-up in downstream reservoirs behind the Rosaries, Merowe, and High Aswan dams. Given the existing infrastructural alterations on the Blue Nile downstream, it is not clear how the Renaissance Dam could significantly alter ecosystems downstream of Sudan's Blue Nile state. More research is needed on the local communities and ecosystems in this largely undocumented stretch of the Blue Nile River. There is also the possibility that the Renaissance Dam could provoke conflict if basin countries do not work together, if Ethiopia continues to act unilaterally, and if shared benefits are not well understood or recognised.

On a national scale, the Renaissance Dam has the potential to stabilise human security in Ethiopia. The dam's hydroelectric potential can triple the current megawattage available to the domestic grid; the project itself has eased ethnic divisions to create a pan-Ethiopian sense of self; and it may enhance the economic development that Ethiopia is experiencing in the absence of internal and external conflict. The Renaissance Dam is one step on the way to fulfilment of Ethiopia's aim of becoming economically self-sufficient. However, it represents a loss and destabilising factor to human security in the environmental sector, the extent of which is currently unknown. This environmental cost may become an economically destabilising factor if erosion continues unabated to shorten the lifespan of the dam's production. The Ethiopian government is currently devising a basin-wide approach to watershed management that has the potential to address erosion concerns. The dam could also reduce human security in the area of human health via a potential rise in malaria. At present, malaria is a seasonal problem in the basin, and people live in scattered settlements, which inhibits the spread of disease. Resettlement plans will concentrate people together in new settlements and water will be present year-round, creating a double risk of an increase in malaria regardless of the Ethiopian government's supplying of free nets and medicine and its plans to establish a five-kilometre buffer around the reservoir.

On a local scale, the Grand Ethiopian Renaissance Dam could stabilise human security in the economic and socio-cultural sectors. The development brought by the project will offer new opportunities to local communities in the form of access to markets, education, and healthcare. The resettlement plans include the provision of permanent structures such as schools and clinics, supplied with water and electricity. But the development could also destabilise economic and socio-cultural human security. Local communities will lose their traditional livelihoods of flood-recession farming, gold-panning, and fishing in the river. The current local use of water resources has been sustainable for generations, an example of long-term use. Local dwellers just over the border in Sudan are also an unknown factor. Research is needed to determine how many people currently rely on

subsistence practices and the measures necessary to help these communities adapt to regulated flow regimes and other disruptions of flood-recession farming and/or river fishing. The environmental sector will be completely altered on a local scale. How this will affect ecosystems reliant upon cyclical water-flow patterns is unknown. Environmental costs could be mitigated by creating a conservation zone around the reservoir that makes exception for the existing communities. To address problems of erosion and siltation, a basin-wide strategy of erosion prevention and reforestation could be introduced and sediment gates installed at the base of the dam.

In order for dam development to maximise benefits and minimise costs to human security on the local, national, and international scales, dam development could be managed in line with the systemic and complex approach exemplified in this study. This requires that each sector and scale be considered separately for a comprehensive set of possible solutions to potential costs and to understand how and when each sector is dependent upon another. In the case of internationally shared rivers, and even culturally shared rivers, an emphasis on cooperation, planning, and benefit-sharing across scales, communities, and sectors, is vital to human security and multi-scale stability.

#### ENDNOTES

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