Climate & Development Knowledge Network

FUTURE CLIMATE FOR AFRICA

POLICY BRIEF

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Key messages

- The economic feasibility of large hydropower schemes is largely affected by rainfall levels and runoff.
- Most large dams are planned on the basis of hydrological data from the past 30–50 years ~~but not taking~~ into account the future changes in rainfall and river flow that will result from climate change.
- Climate change accentuates the risks related to the development of new hydropower schemes because continuation of current trends in rainfall and river flows can no longer be assumed. Where new hydropower is assessed to be the best choice, policy-makers and planners should place more emphasis on investing in hydropower schemes that maximise flexibility and that embrace adaptive management.

Using climate change data for large-scale hydropower planning in sub-Saharan Africa

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Introduction

Sub-Saharan Africa lags behind all other regions of the world in terms of people's access to electricity.[1] The World Bank has asserted that promoting the development of hydropower would lower the generation costs of electricity, reduce carbon emissions and help to insulate countries in sub-Saharan Africa from increases in the price of fossil fuels.[2] However, ~~in sub-Saharan Africa,~~ hydropower makes up just under 20% of the installed generating capacity. Despite a considerable exploitable hydropower potential ~~(technically speaking)~~ of about 1,750 TWh/year, and the opportunity to ensure energy security through hydropower generation, only 5% of the potential is currently tapped. Based on planned schemes, the hydropower generating capacity in Africa could almost quadruple over the next 20–30 years.[3]

Hydropower generation is the energy source that is most likely to be affected by climate change and climate variability because the amount of electricity generated is directly related to the hydrological regime. However, the impacts of climate change upon hydrological cycles are complex and poorly understood in most low income countries.[4] This brief covers the implications of climate change for large-scale hydropower, as opposed to micro- and pico-scale hydropower schemes.

Climate change is a particular threat to hydropower schemes because many existing and planned schemes could still be in operation in 50 or even 100 years' time, when the effects of climate change could in some cases be substantial.[5] Long-lived infrastructure, such as hydropower schemes, is generally less adaptable to climate change because altering it retrospectively is challenging.[6] For example, adapting a hydropower dam to the impacts of climate change may require it to be raised in height or to increase the size of its spillway, neither of which is usually technically or economically feasible. However, assets with a short lifespan (e.g. less than 20 years) can be replaced with better-suited assets more easily as the climate changes.

The potential for flexibility at the planning stage of hydropower schemes is relatively high, with many different

About FCFA

Future Climate for Africa (FCFA), is a new five-year international research programme jointly funded by the UK's Department for International Development (DFID) and the Natural Environment Research Council (NERC). The Programme will support research to better understand climate variability and change across sub-Saharan Africa. More information is available at http://www.nerc.ac.uk/research/funded/programmes/fcfa/ The programme will focus on advancing scientific knowledge, understanding and prediction of African climate variability and change on 5 to 40 year timescales, together with support for better integration of science into longer-term decision making. CDKN is responsible for coordinating the FCFA scoping phase – an 18 month exercise uses six case studies in sub-Saharan Africa to evaluate the needs of science users in the context of the capabilities and limitations of current science. This brief is the fifth in the series.

What are Climate Services?[7]

Climate services involve the production, translation, transfer and use of climate knowledge and information in climate-informed decision-making and climate-smart policy and planning. Climate services ensure that the best available climate science is effectively communicated with agriculture, water, health and other sectors, to develop and evaluate mitigation and adaptation strategies. Easily accessible, timely and decision-relevant scientific information can help society to cope with current climate variability and limit the economic and social damage caused by climate-related disaster. Climate services also allow society to build resilience to future change and take advantage of opportunities provided by favourable conditions. Effective climate services require established technical capacities and active communication and exchange between information producers, translators and user communities.

potential solutions available to meet the desired objective – each of which can be evaluated against future climate change scenarios. Once a hydropower scheme is in place, flexibility is more limited and must rely on managing the residual risks, which cannot be offset at the design phase.

Large dams have been shown to contribute to greenhouse gas emissions in certain cases, through release of methane, in particular as documented in the case of Brazil's Tucurui Dam.[8] The potential contribution of planned large hydro schemes to greenhouse gas emissions is a separate topic, not covered in this brief.

The impacts of climate change on hydropower schemes

Numerous studies have indicated that hydropower economics are sensitive to changes in precipitation and run-off.[9] Most hydropower projects are designed on the basis of 'recent' historical hydro-meteorological data (typically a 30–50 year historical time series of flow data) and the assumption that future hydrological patterns (i.e. average annual flows and their variability) will follow historical patterns.[10] However, the notion that hydrological patterns will remain 'stationary' (unchanged) in the future is no longer valid.[11]

The future performance of hydropower schemes is likely to be affected by climate change. The future risks (and opportunities) that could cause this include:

- Changes in quantities, as well as spatial and temporal patterns of rainfall and river flows could increase or decrease the period in which turbines can operate at full capacity.
- Increased evaporation rates from reservoir surfaces could reduce the water available for power generation.
- Increases in sediment loads in rivers, as a result of more intense rainfall and land use change could lead to greater silt loads and raise sedimentation in reservoirs that can lead to loss of storage and damage to turbine blades.
- Increased flood magnitudes as a result of climate change could lead to a higher probability of dam failures as a result of spillways not being able to pass the flood flow safely. This has the potential to increase the number of people at risk downstream.

Global climate models show that the mean annual run-off in East Africa is likely to increase, while run-off in Southern Africa is likely to decrease for the period 2081–2100, relative to the period 1986–2005. Although these global climate models show that run-off is likely to increase in East Africa, the rainfall here is highly variable and hence increases in annual precipitation will only raise hydropower generation if the excess run-off can be stored.

The use of climate change information in the planning of hydropower schemes

A recent scoping study conducted for the World Bank noted: "Most hydropower/reservoir operators do not see climate change as a particularly serious threat. The existing hydrological variability is more of a concern, and the financially relevant planning horizons are short enough that with variability being much larger than predicted changes, the latter do not seem decisive for planning".[12] The issue may be that many policy processes in African countries do not recognise that managing hydropower schemes for climate variability can improve the return on investments. Both Pottinger[13] and Iimi[14] claim that climate change impacts are rarely explicitly considered when planning hydropower projects. Cole et al. state: "[it] would appear that the siting of hydropower dams is often a process dominated by political and fiscal considerations, lobbying, corruption and compromise".[15]

There are numerous reasons why climate change is not taken into account in the planning of hydropower schemes. River flows in sub-Saharan Africa display high levels of variability across a range of spatial and temporal scales. Future trends in river flows and rainfall related to climate change will need to be large and prolonged over time, in order to enable formal attribution, and to create conditions beyond those which have already been experienced during modern times.[16]

This has important consequences for the management of hydropower schemes under future climate change scenarios. The planning horizon for hydropower schemes rarely stretch beyond 2050.[17] In most parts of the world, including sub-Saharan Africa, it is only after the 2050s that climate-driven changes in rainfall and river flows are expected to emerge from natural variability.[18] Hence, if the planning horizon of water resources projects is of the order of 25 years, this means that when planning a hydropower scheme, the natural variability of the existing hydrological regime is often within the variability of the climate change projections.

Policy, institutional and cultural issues can impede or advance the integration of climate change adaptation in the planning and design of hydropower schemes. Technical solutions by themselves are of no practical value unless they are supported by people with the power to make policies – and to ensure that the policies are implemented through appropriate governance and institutional processes.[19]

Given the many problems confronting African countries, there is a tendency for governments and policy-makers to focus on relatively short-term policy interventions. Research by the International Research Institute for Climate and Society found that, outside South Africa, nowhere in sub-Saharan Africa is climate change systematically integrated into longer-term planning and investment decision-making. In much of sub-Saharan Africa there would also appear to be a lack of effective institutional arrangements to facilitate the generation, analysis and systematic integration of relevant climate information with other pertinent information in a form that planning and operational agencies can use.[20]

Another factor is that in recent years, the China Exim Bank has become a significant new financier of power infrastructure in sub-Saharan Africa. Over the period 2001–2006, Chinese financing commitments to the sub-Saharan African power sector averaged US$1.7 billion per year, which is equivalent to around 0.2% of the region's GDP and more than official aid and other private investment combined. The major focus of Chinese support has been the development of six large hydropower projects with a combined generating capacity of over 7,000 MW. Once completed, these projects should increase the region's installed hydropower capacity by 40%.[21] It would appear that Chinese water projects do not fully consider the possible effects of climate change.[22] This may be why Chinese financed hydropower schemes in sub-Saharan Africa do not appear to take account of climate change in their planning and design.

Conclusions and recommendations

Conclusions

The evidence available suggests that although historical hydro-meteorological data are used in the planning and design of hydropower schemes, the impact of climate change is rarely taken into account. Several studies to assess the effects of climate change on hydropower performance in sub-Saharan Africa have been carried out.[23] They have either been carried out after the hydropower scheme has been constructed or as academic exercises. The evidence available suggests that, as a matter of course, climate change is not taken into account in the planning of hydropower schemes. This was a view also reached by Rydgren et al. who carried out a study for the World Bank in 2007 addressing increases in climate-driven variability in the assessments of hydropower projects.[24] There appear to be numerous reasons why climate change scenarios are not used in the planning and design of hydropower schemes in sub-Saharan Africa:

- The majority of new hydropower developments in sub-Saharan Africa are being financed by Chinese investments. ~~There is some evidence to suggest that these projects do not require the impacts of climate change to be taken into account in the planning and design of new schemes.~~
- Planning horizons for new hydro-power schemes generally do not extend beyond the year 2050. The natural variability of rainfall and river flows is such that it is only after 2050 that climate change-driven impacts begin to emerge. There is pressure on many sub-Saharan African countries to develop new sources of renewable energy, and there is a tendency for governments and policy-makers to concentrate on the short-term and not to integrate climate change scenarios into the planning of long-lived infrastructure such as hydropower schemes.
- Taking into account climate change scenarios in the planning of long-lived infrastructure is a relatively new phenomenon.
- It would appear that some stakeholders find existing climate services and downscaled climate change scenarios for sub-Saharan Africa difficult to access or understand, and therefore they tend to be underused. Dinku et al. also found that in Ethiopia, water resources management decisions are often linked to religious and cultural

beliefs. Many water managers were reluctant to use probabilistic climate forecasts because they did not want to appear to be 'wrong'.[25]

- In much of sub-Saharan Africa there would also appear to be a lack of effective institutional arrangements to facilitate the generation, analysis and systematic integration of relevant climate information with other pertinent information in a form that planning and operational agencies can use.[26] There are also governance issues in trans-boundary river basins in sub-Saharan Africa. Tensions between managing water within natural boundaries and managing water within national borders proliferate and competing political and economic interests between countries in trans-boundary river basins, while widely deliberated, are challenging to resolve.[27]
- Often it is difficult for water managers and hydrologists to use climate change projections in the planning and design of hydropower schemes. An expert meeting on the needs of water managers for climate information in water resources planning, convened by the World Meteorological Organization in December 2006, reported: "information on future climate variability and climate change is only rarely used by water managers in decision-making processes. There was a general observation that the state of the art of climate prediction is not yet at a level where it can be used directly".[28]

Policy recommendations

The following policy recommendations are related to climate services for the planning and design of hydropower schemes in sub-Saharan Africa:

- **Integrate climate services into policy-making.** There is a need to integrate climate services into national and regional policies in sub-Saharan Africa in order to influence the development of hydropower schemes.
- **Improve institutional coordination.** Better understanding is required of the institutional, policy and technical constraints to effective use of climate information – so that these hurdles can be overcome.[29]
- **Incorporate climate change scenarios into the planning and design of new hydropower schemes.** Climatic uncertainty as the result of climate change should be incorporated into hydropower design as a matter of course; this will help avoid over- or under-designed infrastructure and financial risk, and improve the resilience of long-lived infrastructure.
- **Place more emphasis on investing in hydropower schemes that maximise flexibility.** A premium should be placed on hydropower schemes that maximise flexibility and operations that embrace adaptive management.
- **Assess new hydropower schemes within the context of comprehensive catchment-wide planning using a range of climate change scenarios.** New hydropower schemes should be considered in the context of the whole river catchment, taking into account how climate change will influence river flows, and how future flows must meet competing demands for energy, the environment and water supply for domestic, agricultural and industrial uses.
- **Develop guidelines to help policy-makers, planners and designers incorporate climate change into the planning, design and operation of hydropower schemes.** There is a need to develop guidelines for incorporating the risks posed by climate change into the planning, design, appraisal and implementation of projects. The African Development Bank is currently developing succinct climate change guidelines, which will enable water sector task managers to integrate climate change considerations into project cycles, seek access to additional funding and incorporate adaptation and mitigation components in projects/programmes. The guidelines will also help build capacity on the implications of climate change and practical mitigation and adaptation measures, with specific details on the planning, social, environmental, financial and technological aspects.[30]
- **Use the outputs from the downscaling of global climate models in the planning of hydropower schemes.** Predicting the effects of climate change on hydropower schemes relies on climate variables projected from downscaled results of global climate models. For hydropower schemes, rainfall and temperature must be converted into river flows at specific points to be able to assess climate impacts on the schemes. There is a need for relatively simple, easily accessible and widely agreed downscaled rainfall and temperature data series to assess future climate change scenarios for sub-Saharan Africa. These data could then be used by hydrologists in the planning of new schemes. This could also help provide a consistent approach to incorporating climate change into the planning of new schemes across the continent.
- **Build capacity in the use of climate services and climate change projections.** Existing climate services and downscaled climate change scenarios for sub-Saharan Africa need

to be made more user-friendly as they are not widely used at present. This could be one reason why they are not widely used. There is need for an increase in capacity building that focuses on the use of down-scaled climate change projections, particularly in the planning and design of large hydropower schemes.

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