Received: 21 January 2020 | Revised: 26 May 2021 | Accepted: 30 May 2021
DOI: 10.1002/rra.3849

RESEARCH ARTICLE

WILEY

The nature of our mistakes, from promise to practice: Water stewardship for sustainable hydropower in Sub-Saharan Africa

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Funding information
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Grant/Award Number: International conference on water stewardship for

Abstract

The role of hydropower in the renewable energy mix for Africa's green development is widely recognised and underpinned by respective government and development partner funded initiatives. However, the growing demand for energy must be balanced with considerations for resource protection and benefit sharing of water resource developments with vulnerable human communities. An international conference on water stewardship for sustainable hydropower brought together key stakeholders in Nairobi, Kenya. This paper aims to synthesise the key messages of experts who attended the conference, presents the emerging body of good practice policies, plans and action in developing sustainable hydropower in Sub-Saharan Africa, and provides recommendations for the way forward. Outcomes of the conference include considerations, planning for sustainable resource development, resource protection considerations, sharing of resource development benefits, and putting the promise into practice. This discussion describes the nature of our planning and management mistakes in the past, presents good practice options and how to implement sustainable hydropower in the future.

KEYWORDS
hydropower, sustainable development, water resources, water stewardship

1 | INTRODUCTION

Humanity depends on the natural environment and the services it provides. We are exposed to its exchanges, and as a result our societies, economies and businesses experience a mix of risks and opportunities (e.g., Costanza et al., 1997). With up to at least two-thirds of Africa's feasible hydropower potential waiting to be tapped (IHA, 2018), the growing demand for power must be weighed against water scarcity and the need for water resources to be managed sustainably. Hydropower has an immediate and direct dependence on both global and local ecosystem services, but also has the potential to cause significant environmental impacts with extensive consequences upstream and downstream of the development, at times leading to destructive social impacts at large spatial scales (Moran, Lopez, Moore, Mueller, & Hyndman, 2018).

Against this backdrop an international conference on water stewardship for sustainable hydropower was held in June 2018 in Nairobi, Kenya. The conference brought together key hydropower stakeholders from concerned government agencies, scientists, private sector financiers, developers and operators, civil society and development partners. The objectives of the conference were to: (a) promote the water stewardship approach to the hydropower industry, showcasing responsible hydropower development in the region, and (b) create interest, influence policies and renewable energy portfolio development, and (c) stimulate the involvement of hydropower developers and operators in water stewardship initiatives.

Typically, a water stewardship approach (WWF, 2013) forges a multi-stakeholder platform for action, including concerned government agencies, private sector and civil society groups, and includes the following sequence of actions: (a) an inclusive and integrated risk assessment; (b) coordinated and often joint action to overcome water and related risks by maintaining ecological integrity of the supporting systems, and (c) ensuring equitable allocation of benefits and business continuity.

Consequently, the discussion at the conference clustered around four interrelated themes: (a) stakeholder engagement, (b) climate and water risks, and the resulting decision making under uncertainty, (c) strategic and system-scale planning and water allocation, and (d) resource protection and benefit sharing. In the context of the conference themes listed above, this paper aims to synthesise the key messages of experts who attended the conference; present the emerging body of good practice policies; suggest plans and actions for developing sustainable hydropower in Sub-Saharan Africa; and it provides recommendations for future sustainable management of the sector in the future.

2 | POTENTIAL FOR SMALL HYDROPOWER DEVELOPMENT

Access to electricity in Sub-Saharan Africa remains limited and uneven, with only 42% of the households having access to electricity (World Bank, 2018a). However, the role of hydropower in the renewable energy mix for Africa's green development is recognised and underpinned by respective government and development partner funded initiatives (IHA, 2018). Consequently, the sector is developing rapidly. In Africa, there is an estimated feasible hydropower potential of 1.5 million GWh per year, with less than 8% of this potential currently exploited (International Commission on Large Dams, 2011). Today in the Sub-Saharan Africa region there are more than 3,327 large dams that have the potential to affect river connectivity (Figure 1) (Grill et al., 2019; Lehner et al., 2011; Mulligan, Saenz-Cruz, van Soesbergen, Smith, & Zurita, 2009). Of these dams prior to the boom in hydropower development to meet the potential for Sub-Saharan Africa's hydropower capacity >200 new hydropower projects have been initiated (Zarfl et al., 2015), with expectations for more

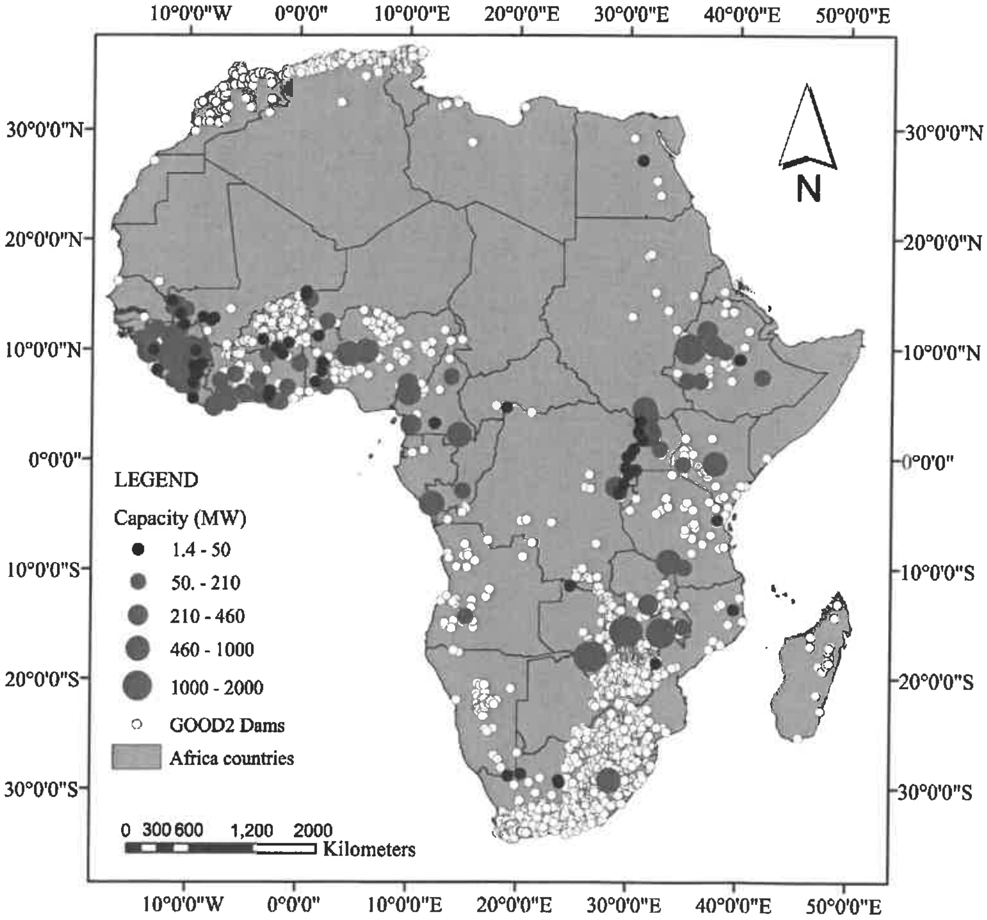

FIGURE 1 Existing dams in Africa (GOOD2, Zarfl, Lumsdon, Berlekamp, Tydecks, & Tockner, 2015) and planned hydropower dams with associated capacity in Mega Watts (MW, Mulligan, van Soesbergen, & Saenz, 2020)

rapid growth in the future (Figure 1). Of these planned dams there exist a mixture of projects ranging from the Mujila Falls Mini development in the Zambezi Basin proposed to produce 1.4 MW of electricity, to the Grand Inga project on the Congo proposed to produce 44,000 MW.

The importance of reliable and affordable energy supply as a foundational requirement for business investment is widely acknowledged, with increasing energy availability directly linked to increased GDP growth (Bayar & Özel, 2014). This is particularly the case in rural settings. However, while electricity has been made available for uses such as lighting, access to information, comfort and entertainment, it is not sufficient by itself to trigger economic development. It is the productive use of renewable energy that triggers economic development through enhancing income generation at the local level (Rycroft, 2018; AEEP, 2015).

The historical model of vertically integrated state-owned utilities with large centralised power generation plants is now complemented by multiple smaller scale, decentralised, renewable energy independent power producers (IPPs). The power market in 49 Sub-Saharan African countries is well suited to the introduction of such smaller scale generation plants:

1. 35 countries in Sub-Saharan Africa have a total installed power generation capacity of less than 1,000 MW.
2. 14 countries have less than 100 MW installed power generation capacity.

In such situations, smaller scale power plants (less than 50 MW in capacity, highlighted in Figure 1) are considered to have better cost-benefit ratios than larger thermal plants depending on imported fossil fuels. This is demonstrated by the presence of IPPs in 22 Sub-Saharan African countries, although not all of these IPPs utilise renewable energy methods. In Sub-Saharan Africa today the IPP market is dominated by solar photovoltaic (PV) projects due to: (a) PV resource is suitable for a greater variety of locations, (b) there is a very competitive environment with international participants, and (c) prices often are less than USD 0.07/kWh at present prices (Moner-Girona et al., 2016). However, there remains considerable scope for hydropower. Drivers of the competitive nature of smaller scale hydropower developments include (consider Bekele & Tadesse, 2012): (a) small hydropower plants can be developed at the local scale, and are attractive to local investors and developers - in contrast to PV developments, which are generally dominated by large international developers, (b) weak electricity grids especially in remote areas, where small hydropower has very specific advantages over PV, (c) small hydropower plants are a more stable and less variable source of generation than PV, (d) small hydropower plants contribute to power grid and local network stability, which PV does not, and (e) small hydropower power generation is more suited for remote locations and smaller grids compared with PV.

Provided that the market environment will remain reasonably supportive, we hypothesise that a significant number of small hydropower plants will be developed across the region in the near- to mid-term future (<20 years). For these projects to be sustainable the developers and operators will need to ensure the long-term security of their water sources (assurance of supply). As such local IPPs can (and will have to) play a significant role in supporting and sustaining socio-ecological systems (Ng & Nathwani, 2012). The main elements for their success will include the need to:

1. Adopt new approaches to risk assessment and decision making under uncertainty;
2. Apply inclusive and system-scale planning; and
3. Consider water source protection and benefit sharing of the development of these resources as integral parts of the business strategy.

3 | RISKS AND OPPORTUNITIES

In the context of sustainable water resources development, Poff et al. (2015) suggest: "Securing the supply and equitable allocation of fresh water to support human wellbeing while sustaining healthy, functioning ecosystems is one of the grand environmental challenges of the twenty-first century, particularly in light of accelerating stressors from climate change, population growth and economic development". These principles are applicable to the development of a sustainable hydropower sector, particularly in Sub-Saharan Africa.

Dam development, including dams for hydropower developments is a major contributor to social, economic and ecological impacts (Zarfl et al., 2019). Dams negatively affect water availability for human and natural ecosystems (Richter, Postel, Revenga, Lehner, & Churchill, 2010), and indirectly affect geomorphic processes (Grill et al., 2019) and nutrient cycling. Dams alter water quality of ecosystems and often facilitate the spread of water borne diseases and the proliferation of invasive species (Johnson, Olden, Zanden, & Vander, 2008; Lerer & Scudder, 1999; Zarfl et al., 2015). Dams also alter habitat characteristics and cause the fragmentation of fish migration pathways resulting in losses in biodiversity and disrupted ecosystem processes (Grill et al., 2019; Zarfl et al., 2015). As a result, the excessive development of dams, and their associated socio-ecological impacts undermine many Sustainable Development Goals (Zarfl et al., 2015). Hydropower developments must, therefore, be carefully managed on appropriate scales, importantly considering trans-boundary, upstream and downstream consequences, and consider best practice methods to mitigate socio-ecological impacts to ecosystems (Dickens, Smakhtin, McCartney, O'Brien, & Dahir, 2019).

Water resources planners, including hydropower developers have established methods to assess hydrological and associated economic risk to their commonly large and long-term investments. However, these risk assessments historically have prioritised energy production opportunities, without adequate consideration of distributive and inter-generational justice, and environmental and social consequences (Moran et al., 2018).

The sustainable development of the hydropower sector in Sub-Saharan Africa is also complicated by data availability and socio-

4 | PLANNING FOR SUSTAINABLE RESOURCE DEVELOPMENT

In 2015 the countries of the world committed and became signatories to the United Nations Agenda 2030 on Sustainable Development (UN, 2015). This Agenda represents the world's most measured and ambitious attempt to achieve a sustainable future. The Agenda also recognises that the consequences of not succeeding will be detrimental for the world and its people. Water resources management falls under Sustainable Development Goal (SDG) 6, which calls to "ensure availability and sustainable management of water and sanitation for all." Good practice methods to achieve SDG 6 advocates water resource management based on balancing the protection and use of water resources. This includes indicators designed to monitor the resources itself while others are designed to monitor the sustainable use of these resources.

It is, therefore, important to take a step back, and determine how the benefits of sustainable resource use can be leveraged both for economic growth and social development. This requires the involvement of multiple stakeholders concerned with the management of the resources, including the private sector, civil society, government and academia to ensure that the diverse values of users within catchment are taken into account. Stewardship practice involves the progressive improvement of water resource management, resulting in sustainability through the management of shared water resources in the public interest (WWF, 2013). This is achieved through collective action with all stakeholders, and is becoming common among the water resources management realm when considering how private and public sector interests in a basin can be managed together (WWF, 2013). The concept of stewardship can also be applied in the context of hydropower in the region, to ensure that the communities both up- and downstream of an investment are afforded a voice in the hydropower planning process and provided with an equitable share of its benefits.

In this context inclusive, system-scale planning can become a central and dynamic planning tool for hydropower development. It enables the identification of the most beneficial development and investment portfolios across selected sectors and societal values. It also makes more inclusive planning possible and increases investment security (Opperman et al., 2017). System-scale planning for water resources includes the following characteristics:

1. At larger spatial scales – for example, a river basin, region, or country.
2. At an early stage – early enough to influence inter-sector consolidation of objectives and aspects of distributive justice, (macro-) economic indicators, siting decisions and environmental considerations such as biodiversity, river connectivity and sediment dynamics.
3. Comprehensive – integrating environmental and social resources into the planning and analysis (informed by consistent stakeholder engagement), rather than doing a top-down plan and subsequently running it through an EIA process.

System-scale planning goes beyond a strategic or cumulative impact assessment and includes opportunities to consider a range of trade-off decisions that result in the identification of scenarios that can most effectively balance between selected performance indicators for energy, livelihoods, social equity, protection of ecosystems and/or the economy for a country or region. By deepening the knowledge of all participating stakeholders a system-scale approach has the potential to support more transparent and inclusive planning.

5 | RESOURCE PROTECTION CONSIDERATIONS

Many investors from a range of economic sectors are investigating investment opportunities in societal values derived from natural capital (landscape, biodiversity, wellbeing) that can yield economic growth and or reduce the risk associated with other resource developments (Biggs et al., 2015). The practice of payments for ecosystem services is an example of a mechanism where both business and society secure a benefit for the other. Natural capital valuation is an approach that can be used to demonstrate, compare and compensate relative contributions of use and protection scenarios.

Natural Capital, Nature Based Solutions and Ecosystem Services are all terms that are used to describe the realised or potential benefits we obtain from ecosystems (Costanza et al., 2014; Maes & Jacobs, 2015). The concepts have been in development for some years, with the Millennium Ecosystems Assessment (MEA, 2005) defining ecosystem services in a holistic way, and more recently the World Water Development Report (WWAP, 2018) is devoted to the concept of Nature Based Solutions with a focus on water resources. All of these concepts are based on the premise that the environment, or nature, provides a number of resources that society makes use of and may even be reliant on. There are numerous accounts of how society is placing too great a pressure on these resources. Indeed, the Global Footprint Network (GFN, 2017) calculates that we currently use 1.7 planet Earths to support humanity's demand on Earth's ecosystems, suggesting that society is now eating into its reserves and thus is facing a bleak future. Society is now faced with the task of managing the Natural Capital so that it can be used sustainably for the advantage of society today and into the future.

Environmental flows (e-flows) are an example of how the Natural Capital concept can be implemented (Arthington, 2015) that has particular relevance to hydropower. *Environmental flows describe not only the quantity, timing, and quality of freshwater flows but also levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, livelihoods, and well-being* (Arthington et al., 2018). And according to a recent World Bank guidance document (2018b) "e-flows should be a subset of the natural flow regime of the river, taking into account intra-annual and inter-annual variability of flow, and should not be limited to simple minimum low flow specification. E-flows should consider natural movements of sediment and the lateral and longitudinal migration of biota." Thus the focus is on water-political challenges (TNC, 2015; World Bank, 2018b), including: (a) limited reliable environmental data, (b) weak resource governance, and rapidly changing social, political and economic conditions, (c) financial and human resource constraints, and (d) accelerating resource development including land use changes, particularly in areas of rapid deforestation and/or unchecked catchment degradation (TNC, 2015). A recent review of the decision making process undertaken as part of the Future Resilient African Cities and Lands (FRACTAL) research project identified at least three additional drivers of increasing uncertainty that provide a challenge for decision makers (Taylor, Butterfield, Bharwani, Taylor, & Devisscher, 2017), including; (a) the increasing complexity of resource supply, demand and socio-ecological and economic impacts, (b) the necessary shift away from linear models of decision making towards more holistic socio-ecological and economic models, and (c) the rise of "risk" as a central concept for dealing with uncertainty.

In response to these drivers of increasing complexity in the sector in Sub-Saharan Africa, a range of different decision-making processes and methods have been developed that include normative or prescriptive considerations, and descriptive approaches (Taylor et al., 2017). For example for climate change impact assessments, top-down (or model data focused) or bottom-up (water resource or society evidence based) approaches have been established, the two methods being characterised as climate model analysis-based and vulnerability analysis-based respectively (Brown, 2011). Limitations exist in the traditional top-down approaches, according to Brown (2011) "A central issue in top-down approaches to planning under climate change uncertainty is the use of general circulation models (GCM) projections. They provide forecasts of the future that are potentially informative but also have significant uncertainties and unknown reliability." Assessing the projection reliabilities poses difficulties because the actual climate outcomes are uncertain. The uncertainty majorly lies in that the projections are based on current understandings of climate responses to increasing greenhouse gas emissions (Brown, 2011). Bottom-up approaches that focus on the resources itself or vulnerable communities being affected, first assess the climate related risk and vulnerabilities for a particular system, or systems, according to some desirable outcome or performance requirement (Poff et al., 2015). A number of bottom-up approaches exist, but in general all the approaches begin with a stakeholder engagement and assessment of socio-economic systems (see Figure 2). A system is characterised and its response to climate variation is identified, based on a climate sensitivity analysis (Brown, 2011). In the final stages of bottom-up approaches the most relevant vulnerabilities of the systems are identified and management prospects are identified to mitigate as much as possible these vulnerabilities.

The use of a bottom-up approach as opposed to a traditional top-down approach for decision making is particularly appropriate where it is recommended that alternative and more collaborative approaches to knowledge production and decision-making be adopted (Polk, 2015). A bottom-up approach also allows for the efficient allocation of scarce resources to focus in on the most critical aspects of uncertainty relevant to decision making for the specific system as part of a decision tree framework proposed by the World Bank (Ray & Brown, 2015). This approach has been applied, for example, in assessing the climate change risk for water supply in the Turkwel Basin in Kenya (Hirpa, Dyer, Hope, Olago, & Dadson, 2018) and the City of Lusaka in Zambia (Ilunga, Cullis, Dadson, Hirpa, & Bharwani, 2017). A bottom-up approach to decision making under uncertainty also provides opportunity for improving the resilience of a system, particularly when integrated with an improved understanding of the role and importance of non-physical aspects such as social and ecological systems. These can then also be utilised to provide more flexible opportunities for adaptively managing future changes in conditions.

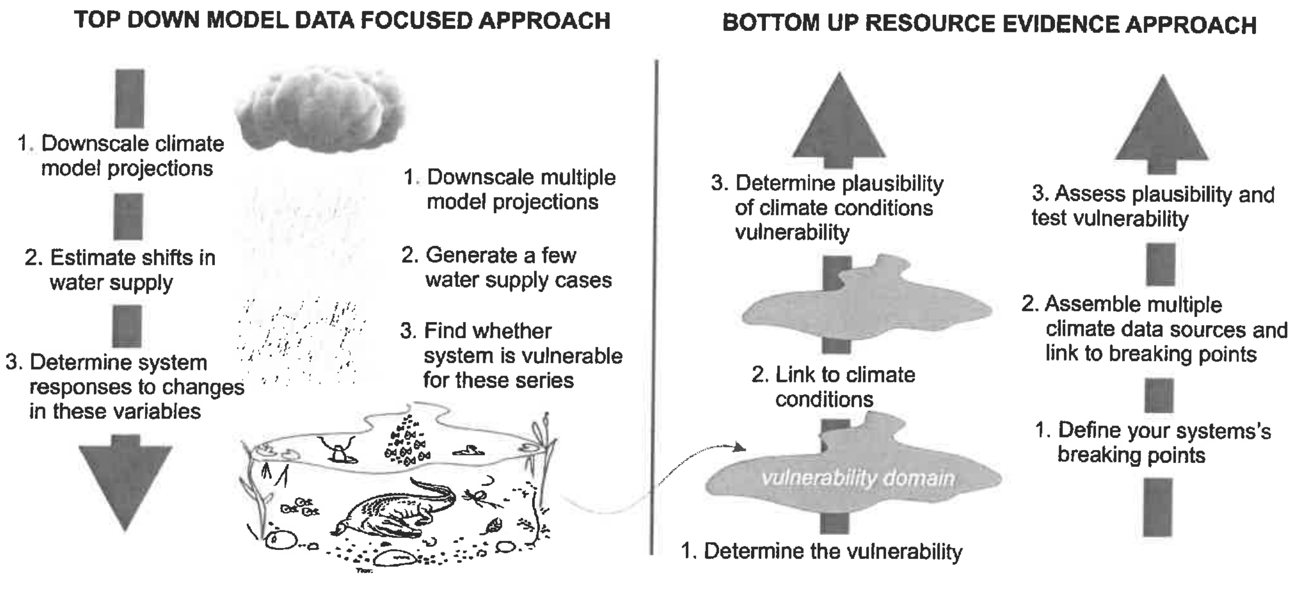

FIGURE 2 A comparison of top-down versus bottom-up method for the assessment of climate change risks that could be applied to support decision making processes for hydropower development in Africa

related ecosystems and the society that is dependent on these ecosystems (Arthington et al., 2018).

To manage e-flows first it is necessary to characterise the flows required to meet the definition above, and then for water resources managers to implement procedures to ensure that abstractions and other perturbations do not exceed the set limits for the system. All water in excess of the e-flow is available for allocation, which resource managers can allocate to users such as domestic water supply, agriculture and industry. The diagram below (Figure 3) offers a simplistic view of what an e-flow is. E-flows and possibly basic human needs (in some countries 20 L per person per day) form the foundation for water resource management and in many countries are the only quantities of water that are guaranteed by legislation as a prior right.

A key component of e-flows is achieving a sustainable balance between the protection of water resource and the needs of society to use them. This is a trade-off that needs to be made by society, in the context of regional use and protection scenarios/opportunities, and needs to be informed by evidence that describes the ecosystem. Ultimately the decisions on how to manage this balance is socio-political, with society deciding what constitutes an acceptable risk to the ecosystem, above the sustainability threshold, in terms of the benefits that are gained from the ecosystem. The more the ecosystem is "used", the greater the risk becomes that it may fail to provide further resources, in which case both the ecosystem and society will have suffered loss. By putting e-flows in place, and only using the "allocable" amounts that do not impinge on the e-flows, society will be ensuring its own future as the ecosystem will continue to produce benefits for society.

From the emergence of e-flow determination procedures in the early 1990's many methods have been established and reviewed (Tharme, 2003; Petts, 1984; Moyle, Williams, & Kiernan, 2011; Adams, 2014 for example). Available methods can be grouped into four main categories including: (a) hydrological, (b) hydraulic rating, (c) habitat simulation (or rating), and (d) holistic methods (Tharme, 2003). These methods differ in their complexity, uncertainty, cost and time resources required for implementation. For planning purposes, the hydrological, hydraulic rating and habitat simulation are most suitable. During the build-up to development, holistic methods are then recommended as greater certainty in the results is required (O'Brien et al., 2018). PROBFLO, a recently developed holistic e-flow method is one such approach that applies a regional scale ecological risk assessment approach that incorporates Bayesian Networks and the relative risk model to determine the e-flows to a range of water ecosystems (O'Brien et al., 2018; O'Brien & Wepener, 2012). The method is suitable for application at multiple spatial scales; and its outputs include a framework for the consideration of social and ecological trade-offs, to better balance the use and protection of water resources for sustainable development. Holistic e-flow methods for hydropower development have been designed not only to determine minimum flows to maintain ecosystems but integrate the probable socio-ecological consequences of multiple stressors so that sustainability can be achieved for a given case study (Horne, Webb, Stewardson, Richter, & Acreman, 2017). Multiple stressors associated with dam construction, land-use and climate change have all been identified as important co-drivers of ecosystem degradation with hydropower developments and should be integrated into e-flow assessments for development (World Bank, 2018b).

6 | BENEFIT SHARING WITH SOCIETY

Larger dams for hydropower generation, irrigated agriculture, industrial production and flood control are now occupying more than half of the river systems around the world (Nüsser & Baghel, 2017). These developments have triggered unequal developments and have been criticised for the large social and environmental impacts that they have on the surrounding communities, raising questions of social and environmental equity (WCD, 2000). Along with the need to address these concerns through new paradigms of integrated water resources management and sustainable hydropower development, the concept

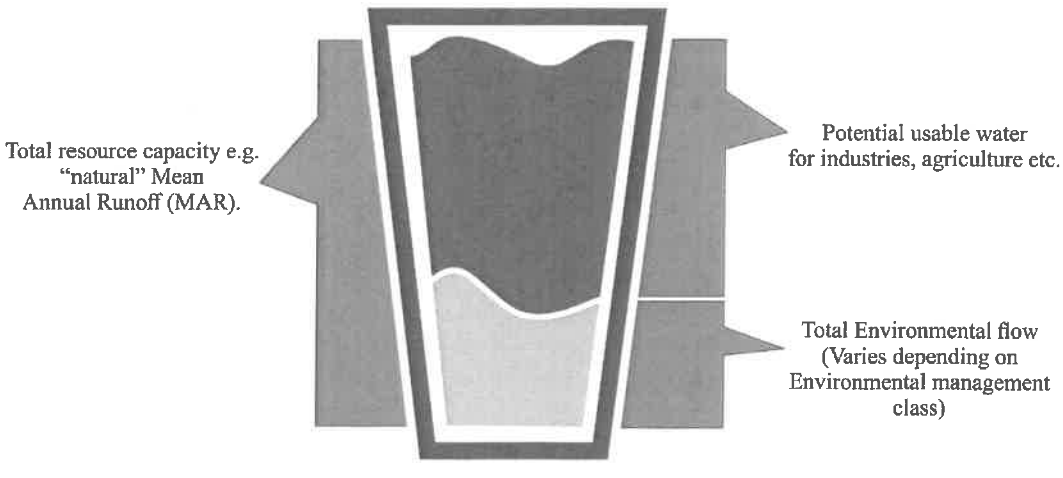

FIGURE 3 A schematic view of all of the portioning of available water in a resource, depicted as available water in a glass. The environmental flows and water available to use through allocation indicated

of benefit sharing in hydropower has emerged since the 1990s as a new paradigm (Wang, 2012).

Benefit sharing, in general, can be understood as monetary and non-monetary (UNEP, 2007) efforts made by project proponents that go beyond the obligatory requirements of compensation and mitigation with a clear focus on enhancing community development (Lillehammer, San, & Dhillion, 2011; Shrestha et al., 2016). However, benefit sharing also becomes a means to obtain the "social license to operate". This is especially so in politically sensitive areas, where expectations and demands emerging in the local communities around hydropower projects need to be appropriately addressed (Lillehammer et al., 2011). As such benefit sharing can be seen as a strategic tool rather than an optional add-on.

The benefits shared in hydropower development range from the participation of affected communities in modifying project design and operation, to providing monetary benefits through royalties, equity sharing, community development or non-monetary benefits in the form of employment and by providing various water rights, etc (Shrestha et al., 2016).

7 | PUTTING THE PROMISE INTO PRACTICE

The more than 80 participants of the conference exchanged knowledge and experience from across the world with a strong focus on Sub-Saharan Africa were given as follows:

1. Shift project-by-project management focus to regional, system-scale planning;
2. Foster inclusive participatory planning processes;
3. Re-invest some of the proceeds of hydropower generation into catchment protection and community development;
4. Break down institutional "silos" and unblock barriers to sustainable hydropower investment;
5. Look beyond energy and water by engaging in stewardship of natural resources;
6. Bring clarity through unifying terminology and concepts;
7. There is a range of good water resources management practices and tools, use them;
8. Stimulate the productive use of renewable energy in the local economy.

Shift project-by-project management focus to regional, system-scale planning: current ad-hoc, project-by-project approaches have tended to overlook the cumulative effects of hydropower developments on regional scales. Considering the system on a regional, and or basin scale, can optimise hydropower planning, ensure sustainability and improve stakeholder participation, where all stakeholders that are affected by developments are included. A systems approach allows well-informed decisions on the trade-offs by examining alternative development scenarios and sequencing. Strategic environmental assessments of policies, plans and programmes enable later project level environmental impact assessments to take into account wider effects as well as creating data and information to make better decisions. A systems approach also allows for not only the vulnerabilities but also the resilience of upstream and downstream ecosystems to be better understood, including the ecosystem goods and services they provide, and create the basis for the environment to be considered as a water user with rights.

Foster inclusive participatory planning processes: Historically stakeholder engagement in water resource planning, including hydropower development, has involved few sectors of society and resource regulation. Including interested and or affected stakeholders, environmental and conservation organisations is recommended. This is proposed to reduce the post-development objections in the hydropower sector and improve the image and sustainability of the sector as a whole in the region. In addition, we recommend the establishment of mechanisms that invest some of the proceeds of hydropower in catchment protection and community development: In many regions of the world, small scale hydropower potential is being depleted by worsening catchment conditions as flows drop off during the dry season and increased sedimentation reduces hydraulic performance as it affects machinery. Country and system specific mechanisms such as royalty payments that are directed towards catchment protection and community development have the potential to extend the efficiency and life of hydropower facilities. These mechanisms should be in place prior to the feasibility assessment of any developments so that developers integrate these costs into the project from the start. Currently, too often these mechanisms are not in place.

Break down institutional "silos" and unblock barriers to sustainable hydropower investment: Observed technical bias, institutional loyalties and governmental will across the energy and water sectors combine to hamper coordination and collective action in the hydropower sector in the region. There have also been experiences of over complicating potential effects of hydropower developments. Partnerships and approaches that integrate sector interests and decentralise implementation to multiple spatial scale levels can unblock investments by simplifying decision making. We also recommend the requisite simplicity approach, in this region where financial and specialist human resources are limited, this advocates doing as much as is necessary only.

Look beyond energy and water by engaging in stewardship of natural resources: Stewardship approaches bring together a partnership of the private sector, the public sector and civil society so that the social and economic benefits of hydropower can be balanced with sustainable development objectives. Stewardship that fosters participation by bringing together all parties, has a role to support a transition towards effective monitoring, compliance and in the long-term to strengthen the regulatory role of the public sector and improve underlying governance.

Bring clarity through unifying terminology and concepts: The understanding and scope of terms such as benefit sharing, mitigation, compensation, E-flows, ecosystem resilience and so on vary significantly and create a barrier to collective and informed decision making. Simplified and unambiguous definitions, concepts and open-source repositories for good practice methods need to be established, to facilitate understanding and coordination.

There is a range of good water resources management practices and tools, use them: we have identified a range of good water resources management practices and tools that are available to facilitate the sustainable development of a hydropower sector in the region. These include integrated water resources management principles, benefit sharing opportunities and use and protection management methods etc. These good practices should be adopted by stakeholders to contribute to the sustainable development of the hydropower sector in the region.

Stimulate the productive use of renewable energy in the local economy: Having access to clean and reliable energy enables communities to both deepen and move beyond traditional economic activities. As such the productive use of renewable energy becomes a powerful motor of rural development.

Outcomes of the international conference on water stewardship for sustainable hydropower included an emerging body of good practice policies, plans and action to direct the developing hydropower sector in Sub-Saharan Africa. This included considerations of the vast potential for sustainable small hydropower in the region, risk and opportunity considerations, planning for sustainable resource development, resource protection considerations, benefit sharing with society and putting the promise into practice, which have been discussed in this paper. This discussion is intended to describe the nature of our planning and management mistakes in the sector, good practice promises and how to implement this practice. We have identified responsibilities for multiple stakeholders of the hydropower development sector in Africa including; developers, regulators, conservationists and other managers, scientists, beneficiaries and other impacted and or affected human communities, especially vulnerable African communities who should all participate in the sector and benefit from it. Importantly regulators must consider regional cost-benefits of developments and never sacrifice sustainability for short term economic development. While developers and local stakeholders will be obligated to address local sustainability requirements, developments must always be undertaken with consideration of the regional management and or conservation implications of resource development, with contributors from regulators. Here we have identified the importance of considering collaborative stewardship of natural resources, Integrated Water Resources Management approaches in the region and other good practice measures such as those identified in environmental flow management approaches in the region and sustainable resource management considerations. These should make a considerable contribution to the sustainable development of the hydropower sector in the region.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the funding provided by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH for the international conference on water stewardship for sustainable hydropower was held in June 2018 in Nairobi, Kenya. Additional fruitful exchanges are acknowledged with and important contributions from: Hans Beuster, Joao Costa, Cristina Diez Santos, Christina Enders, Frank Faraday, Charles Karangwa, Enock Kiminta, Peter Kityo, Andre Lammerding, Hamisi Mikate, Francis Mutua, Lemmy Namayanga, Christopher Oludhe, William Rex, Callist Tindimugaya and James Wainaina Ndung'u.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

DATA AVAILABILITY STATEMENT

This manuscript provides a synthesis of existing data pertaining to the sustainable management of hydropower activities in Sub-Saharan Africa. In this manuscript references are made to all metadata considerations. No additional sources of data is available.

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How to cite this article: O'Brien, G. C., Mor, C., Buhl-Nielsen, E., Dickens, C. W. S., Olivier, A.-L., Cullis, J., Shrestha, P., Pitts, H., Baleta, H., & Rea, D. (2021). The nature of our mistakes, from promise to practice: Water stewardship for sustainable hydropower in Sub-Saharan Africa. *River Research and Applications*, *37*(10), 1538–1547. https://doi.org/10.1002/rra.3849