Revenue sharing in small hydropower: is it worth it?

Investors and hydropower operators are reportedly showing increased interest in revenue sharing schemes. The following article looks at the business case for small hydropower to invest in catchment protection.

Author info

The authors are Johannes Hunink and Gijs Simons from FutureWater; Christoph Mor from GIZ; and Anton-Louis Olivier from Renewable Energy Holdings Proprietary Limited.
Email: j.hunink@futurewater.es
www.futurewater.eu

WHEN SMALL, RUN-OF-RIVER projects are developed and operated, the revenue stemming from sale of electricity rarely supports the protection of the catchment in which the hydropower project is located. This is despite the fact that its protection or particular land management activities upstream may benefit the profitability of the scheme, through more reliable and clean water supplies and thus higher generation and revenues.

There is increasing interest by investors and hydropower operators in revenue sharing schemes, that could enable this positive feedback to work. Some studies and pilots have bene carried out in different parts of the world, but mainly for large hydropower with reservoirs.

Above: **Photo 1: A small hydropower facility and agricultural lands in the Nyamindi River Catchment, Kenya**

There are three principal reasons why small hydropower has received less attention so far. First of all, obviously revenue streams are typically smaller than for conventional hydropower, and thus in many cases too small to leverage change at the catchment-scale. A second reason is that for small schemes, the electricity tariff paid to the hydropower producer under its power purchase agreement are generally relatively low so they are less willing to commit to these initiatives. Then, thirdly, for such schemes to work, there needs to be evidence and sufficient confidence that positive change is feasible: for example, in catchments that are in a relatively good state and are well protected, the gain is limited and probably not worth it, while in catchments with degradation trends, climate change and increasing water use, there is larger potential.

Recently, the GIZ-implemented International Water Stewardship Programme funded a study which aimed at getting insight in how these three factors play out for two pilot catchments in Sub-Saharan Africa (Kenya and Tanzania). The objective was to assess whether there is a business case for small hydropower developers/ operators to invest in Sustainable Land Management (SLM) activities in these two pilot catchments.

To meet this objective, the following questions were answered:

1. What are the costs of catchment degradation to hydropower operations?
2. Under which market conditions does it make economic sense to invest in catchment management?
3. What are the expected returns on investment?

Right: **Photo 2: Example of a location in the Kiwira Catchment where improved riparian management would be recommendable**

Study areas

The Nyamindi River originates from Mount Kenya, flows southward and drains into Thiba River. The upper part of the Nyamindi Catchment is largely comprised of the montane forests of the Mount Kenya National Park, bordered to the south by extensive stretches of agricultural land occupied by smallholder farms.

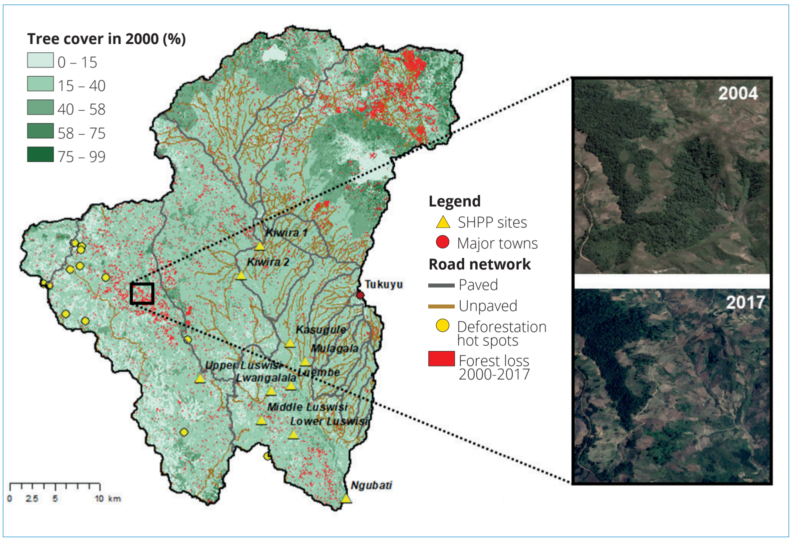
Despite their protected status, the forests of Mount Kenya continue to be affected by logging. In addition, an increasing number of people living around the periphery of the forest make daily trips up the mountain to graze livestock and collect firewood and non-timber forest products. In the entire catchment, forest cover has decreased by 18% between 1984 and 2014 while the extent of area under cultivation increased with over 9% in the same period. Additional points for water abstraction were constructed recently within the protected forests of the catchment. Although these provide piped water supply to communities downstream, they reportedly have limited impact on surrounding areas.

Two hydropower developers are currently active in the Nyamindi River Catchment, constructing a total of four small hydropower plants (SHPPs) with a total 20MW. The two developers will own and operate the projects for a 20-year concession period. The developers estimate capital costs of approx. US$88 million and an expected annual revenue in the order of US$6 million.

The Kiwira River Catchment is in the Mbeya Region of southwestern Tanzania. The catchment has a size of approximately 1900km^2 and forms part of the Lake Nyasa Basin. The Kiwira River rises in the Poroto Mountains flows into Lake Nyasa (also known as Lake Malawi).

The upper catchment covers several evergreen, high forest ecosystems, receiving abundant rainfall. Catchment-average rainfall is about 1800mm. The Mount Rungwe Nature Forest Reserve is a key area for conservation of residual tropical montane forest as well as endemic and endangered biodiversity. However, there is also considerable deforestation and several degradation hotspots were identified, as is shown on in Figure 1, due to poor catchment management.

Two developers are planning ten developments, of a total of some 48MW, with sites are ranging from 1.6 to 6.9MW. All projects follow a conventional run-of-river layout. The expected capital cost is in the order of US$200 million, expected revenues are at US$30 million per annum.



Above: **Figure 1: Map of degradation indicators in Kiwira catchment and zoom with example area where deforestation and road construction has taken place**

Approach

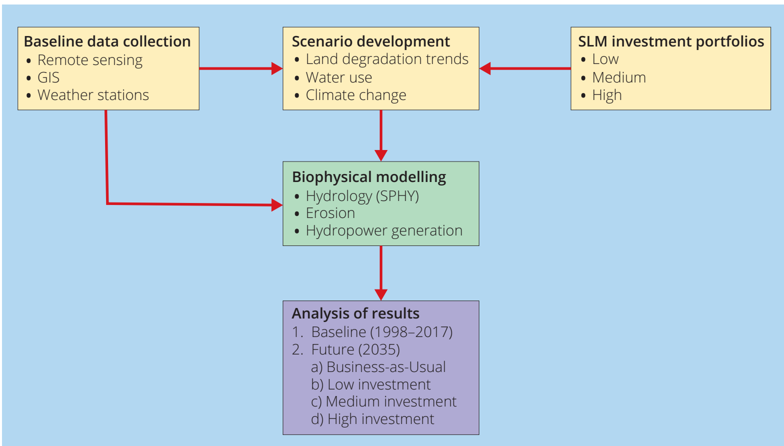
The study followed a three-step approach:

1. Satellite-based and stakeholder-informed identification of degradation hotspots and possible interventions. For the two catchments, satellite imagery, remote sensing-derived datasets and other GIS data such as land cover maps as well as stakeholder consultations and field observations were combined to assess land use and degradation trends.
2. Hydrological modelling-based assessment of impacts on hydropower. Baseline hydrological conditions were assessed using a hydrological simulation model. Any future changes in hydrology and hydropower generation were evaluated by running the model for a Business-as-Usual (BaU) scenario, accounting for land degradation trends, changes in water use, and climate change.
3. Economic assessment to assess Return on Investment for hydropower of interventions in the catchment. The impacts of three catchment investment portfolios (low, medium, high) containing different SLM interventions were quantified with respect to the BaU scenario. Each investment scenario was monetized in terms of revenue to the hydropower operator and evaluated against investment costs to investigate the viability of a business case.

Firstly, the analysis involves a baseline scenario, describing current conditions, operations, activities and energy output. Secondly, the Business as Usual scenario corresponds to what happens the next 20 years if no investments in improved catchment management are done (see Figure 2 for an outline of the analytical approach). The following trends are considered:

1. An increase in climate variability due to climate change, assessed for each catchment based on climate model outputs;
2. An increase in catchment degradation, based on the trends that were assessed using satellite imagery;
3. Changes in competing water use due to population growth, affecting water availability for hydropower generation.

Below: **Figure 2: Outline of the biophysical modelling component of the study**



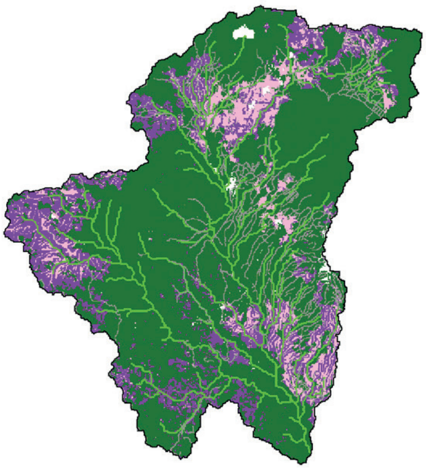


Figure 3: Map where SLM interventions could be implemented in the Kiwira Catchment

Then thirdly, investment scenarios include a mix of SLM interventions to be implemented at suitable locations to offset (partially) these negative impacts in the BaU scenario.

The set of interventions include: terracing, riparian management (see Photo 2), road erosion mitigation, forest conservation, among others. Figure 3 shows the map of where these interventions are proposed for the Kiwira catchment, depending on slope, soil and land use.

Results

The scenarios (baseline, BaU and the three SLM investment scenarios) were analysed using a hydrological model which includes an erosion simulation module (SPHY).

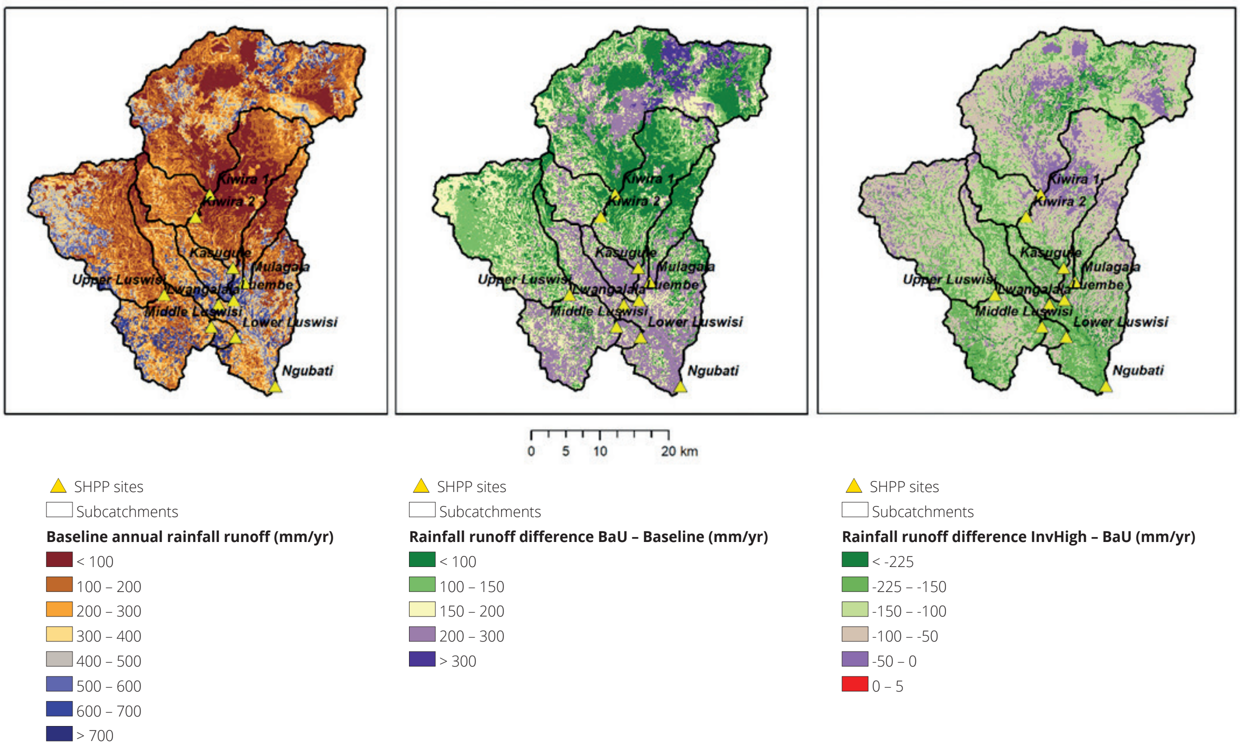
Key outputs of this model are: daily streamflows and sediment rates in any location of interest in the catchment. These are then used to calculate hydropower generation (MWh and USD) and costs related to sediments. Figure 4 shows an example of the type of outputs that the hydrological model can provide: spatial maps that indicate how in this case the BaU differs from the baseline in terms of runoff generation.

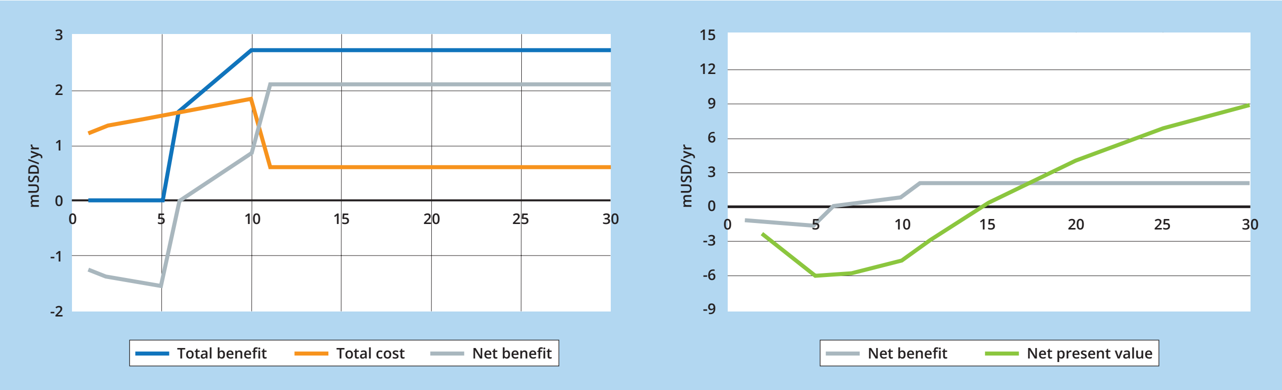
The outputs on flows, generated hydropower, revenues, and costs were integrated in a return on investment scenario, assuming a ten-year implementation period of the SLM interventions. Several assumptions on feed-in top-ups were done to analyse the sensitivity to this factor. Figure 5 shows total annual benefits and costs over time, the net benefit and the net present value (NPV). As is shown here, the NPV becomes positive within 15 years' time. This suggests that there can be a business case for this catchment and SLM investment scenario, as 15 years can be an acceptable horizon.

However, other scenarios gave less favourable outcomes. The two catchments are different in size, topography, climate and other biophysical factors, as well as installed capacity and trends. More details can be found in the full report . Summarising the results of both case studies:

- In the Kiwira, land degradation occurs in in a large proportion of the catchment so there is significant scope for implementing sustainable land management interventions. This makes this catchment relatively favourable for investing compared to the Nyamindi Catchment, where the potential for intervening is smaller.
- The projected installed capacity in the Kiwira is much higher than in the Nyamindi, as such benefits accumulate and are relatively higher compared to Nyamindi.

Below: **Figure 4: Baseline annual runoff in the Kiwira Catchment, and projected changes under the BaU and high SLM investment scenarios**





Above: **Figure 5: Total annual benefits, costs and net present value over time including continued maintenance after 10 years (in USD million) for the medium investment scenario for the Kiwira Catchment**

- Climate change will be detrimental to hydropower production in the Kiwira Catchment while for the Nyamindi Catchment, the projected increase in rainfall and streamflow turns out slightly positive, even considering the impact of land degradation.

The analysis further shows that the impacts of climate change on hydropower generation and revenue are in the same order of magnitude as the other negative anthropogenic factors: increased domestic water use demand in the catchment and land degradation due to poor conservation of natural areas and poor agricultural practices. But clearly under certain conditions, the SLM investments have the potential to offset these negative impacts.

An incentive

Overall, the two case studies have shown that:

- Total installed capacity can be a limitation on the viability of the business case: for a catchment with relatively low capacity, not enough revenue is generated for investing in SLM.
- Under current highly competitive market conditions for feed-in into the national grid, investments in catchment conservation cannot be financially justified, considering benefits for hydropower generation only.
- Under more favourable market conditions, e.g. provided through renewable energy programmes like the GET FiT Initiative, hydropower developers can find a viable business case to invest in catchment conservation. Under these favourable feed-in tariffs hydropower developers in the Kiwira Catchment will receive reasonable returns within their concession period. However, for the Nyamindi there is no clear business case, even under these favourable conditions.

From the above analysis it seems that the small hydro business case for investing in comprehensive catchment management and the implementation of sustainable land use management is weak. However, while weak there are sufficient and clear benefits for hydropower from improved catchment management to de-risk their investments and to guarantee sustainability on the long-term.

The most significant implication of possible future catchment degradation is that it creates uncertainty on future yields. Whether degradation might or might not take place and to what extent is typically not known to the developer at the time of financing. The same for a reduction in water quality which leads to higher operations costs and reduced generation because of increased down-time due to blocked screens.

Lenders, who normally finance a significant portion of the capital cost, are very concerned about any downside yield risk. As such the combination of these uncertainties can drive up the cost of financing the project and depresses the internal rate of return for the equity. This would provide an incentive for the developer to mitigate future flow risks if possible.

Financial mechanism to promote hydropower sustainability, need to include a larger range of stakeholders than just hydropower. An analysis like the one presented here can be used as a tool to engage with these stakeholders and to develop such financial compensation schemes.

The analysis further suggests that if electricity tariffs are subsidized through renewable energy initiatives, hydropower developers can be incentivized to invest in catchment conservation, to de-risk their developments, and leading to benefits for all stakeholders in the catchment including the developers themselves.. ●

References

[1] Simons, G.W.H., J.E. Hunink. 2018. The business case for small hydropower schemes to invest in catchment management: two case studies in Kenya and Tanzania. FutureWater Report 183.
The full report can be downloaded from **https://www.futurewater.eu/projects/improved-catchment-management-for-small-hydropower/**

Below: **There is increasing interest in revenue sharing schemes for small hydropower scheme**